Issues in Preschool Concept Mapping: An Interaction Design Perspective

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Abstract

This thesis reports on a research project that applied the existing knowledge of concept mapping as theorised by Joseph D. Novak in the area of early childhood education. It reports on the investigation of educational issues from a design perspective.

Concept maps are knowledge representation tools that promote meaningful learning. Novak claimed that young children could quickly learn to make concept maps. He theorised that the human skills for concept mapping are developed by 3 years of age. However, current scholarship that reports on various models of concept maps, by young children, all lack the crucial element of Novak's concept map template, linking phrases. In this doctoral project, I developed a designed prototype that allowed preliterate children to add the crucial element. This thesis contributes to the areas of early childhood education, concept mapping, and interaction design.

The intent of the designed tool was to allow preliterate children to represent the elements of concept maps with mastered communication skills (e.g. spoken and iconic languages). With this tool, I sought to contribute to current understandings of the issues in preschool concept mapping and the types of suitable child-friendly alternatives to Novak's template.

Drawing from several disciplines I argue that making knowledge explicit with a concept map requires representational and cognitive skills that young children have not yet mastered. These skills are concept labelling with written language and concept organisation with hierarchy. The poor performance of these skills with mapping tools currently used in preschool has been used to underpin arguments that young children cannot build Novak's concept maps.

To investigate these issues in the classroom a Bridging Design Prototype (BDP) was developed with structuring features that: 1) promoted children to label concepts with verbal and/or symbolic language, and 2) scaffolded children's control over the cognitive skills needed for organising such concepts. The BDP method is original to this research and grounded in user-centred design and learning principles.

Case studies were performed in two preschools where twenty-one 4.6- to 6-year olds alone, with peers, and/or teachers, used the BDP to represent concepts and propositions with verbally-labelled symbols. In turn, these symbols were mapped in the following ways: 1) organised in a sequential pattern with arrows, clusters and/or hierarchically, and 2) edited, revisited and shared. Teacher instruction was found to be effective when it promoted student autonomy, and ineffective when student participation was heavily mediated.

An outcome of this applied research was that some preschool children were able to generate mapping structures that incorporated linking phrases. This result suggests that young children's ability to communicate concepts with maps is limited by their literacy skills rather than their stage of development. The results presented in this thesis suggest that the conflation of available tools and the cognitive ability of young children are not tenable.

Child autonomy during the mapping activities promoted active inquiry, meaning negotiation, and transformed teachers into partners, which are concept mapping-related interactions rarely reported in preschool. Finally, the active participation of children at different developmental stages (preliterates, emergent writers and special needs children) is further evidence of the inclusive and scaffolding features of this tool.

The research outcomes show that some preschool children can represent and manipulate the constitutive elements of a concept map with suitably designed authoring tools. While modest, these outcomes are promising, considering interactions with the BDP were limited to one session of less than 50 minutes.

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Student Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of my knowledge, it contains no material previously published or written by another person except where due reference is made in the text of the thesis; and where the work is based on joint research or publications, discloses the relative contributions of the respective workers or authors.

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Chapter 1 – Introduction

> In public discourse the [United Kingdom's early years] workforce is constructed as the solution to society's ills - policy makers state that in focusing on the young child (and the educators/carers of young children) a raft of social phenomena can be addressed: Government has long recognised the collective interest in ensuring that children get a good start in life: it is in the nation's social and economic interests: children are the citizens, workers, parents and leaders of the future. It is in everyone's interests that children are given the opportunity to fulfil their potential (Osgood 2006, p. 1).

According to Hill (2004) and Ryan (2008) to achieve such broad aims, 21st century early childhood education will require learning tools and strategies that empower autonomous learning processes in the children of knowledge-based societies. This thesis centres around the use of concept mapping as one such learning tool, and in particular, on Joseph Novak's concept map template. Concept maps are tools for organising and representing knowledge that promote meaningful learning by facilitating knowledge retention, preservation, and sharing (Novak 1998).

While there are existing ways for teachers to implement concept maps, these concept maps do not meet the requirements as set out by Novak. This research specifically sets out to develop a concept mapping tool that meets Novak's criteria. The research focuses on preschool age children. It proposes a design solution to the gap that exists between Novak's claims in regard to young children's ability to construct maps and the value of this tool to empower autonomous learning processes and the ability of teachers to take up that approach within existing classrooms. As such, the focus of the research is upon a distinctly practical outcome.

To understand what this research does it is important to note what it does not do. It does not provide a clinical evaluation of the effectiveness of the tool. Nor does it provide a comprehensive analysis of scholarly debate around the value or otherwise of concept mapping in early childhood classrooms.

This research adopts the Organisation for Economic Co-operation and Development (OECD) definition of research as: 'Any creative systematic activity undertaken in order to increase the stock of knowledge... and experimental development work leading to new devices, products or processes' (OECD 2009). In doing so it puts forward the Bridging Design Prototype (BDP) of a tool for preschool concept mapping and the rationale for the appropriateness of this tool in early childhood literacy education.

The intention of the research underpinning this thesis has from the beginning been premised on the application of existing knowledge in new ways. The thesis takes the existing knowledge as set out by Novak and applies it to early childhood education. Current knowledge suggests that it is not possible for preschool age children to build Novak's concept maps. Even if one child was able to do this then the existing theory is challenged. The thesis identifies pre-literacy as a possible factor. The findings presented in this thesis are gained from a limited number of participants and suggest that further research is required to assess the generalisation of my findings.

The principal outcome of the research is a functional prototype designed and developed using Bridging Design Prototype method (BDP method) as a design philosophy. This thesis combines current interpretations of preschool age children's ability to construct a particular type of concept map (Novak's concept maps) and user-centred design methods to underpin the work of the designer with the key expert community (chapter 5). The prototype was used in real classrooms and the interactions of the children and the teacher with it were recorded using notes, audiotapes, photographs and video (chapters 7 and 8). The data did not require the depth of analysis of case studies as it was looking at the functionality of the designed tool. While the method of analysis has some commonality with case study analysis (chapter 6), it utilises a design appropriate method called 'rapid ethnography' that is an approach supported by Norman (1990). Norman suggests designers to use applied observation and testing when designing a product for a user community, but at the same time, to use these research methods to find fast answers that can inform the product development (chapter 3).

Research outcomes have opened up new worlds of knowledge that can positively impact preschool environments in the promotion of meaningful learning, active inquiry, and meaning negotiation with the aid of a suitably-designed, child-friendly alternative to Novak's concept maps.

In the next section, I present background information for the research. I define concept maps, briefly explain their origins, present Novak's theoretical accounts and also his controversial claims on instruction and development. Then in the following sections, I define the research problem, my research contributions, the study focus, and the methodology outline. This chapter concludes with sections in which I present where the relevant literature is discussed and the thesis structure.

Background

A brief introduction to concept maps

Concept maps are tools or templates for organising and representing knowledge. It has been demonstrated that they are effective for the promotion of meaningful learning as they facilitate knowledge retention, preservation and sharing. This is made possible by the template's structural design and its basic application rules. Chapter 2 includes an analysis of the template design.

Novak's concept mapping template is comprised of concepts that are enclosed in boxes or circles. These enclosures are related to each other via connecting lines. The conceptual relationship between two or more concepts is given by linking phrases placed on the line. This template enables map creators to construct a hierarchical representation of a piece of knowledge where the most general concept is at the top, followed by more specific concepts in order of relevance. The conceptual relationships provide the map with its appearance and hierarchical shape. This template structure, argues Novak, permits the human eye to differentiate concepts and linking phrases, see how these concepts are connected to form conceptual relationships and also how they are hierarchically distributed (Novak 1998; Novak n.d.; Novak & Gowin 1984). Figure 1.1 presents concept maps about 'molecules'. Figure 2.5a presents a concept map about 'plants'.

By following Novak's simple rules for making maps, the creator can 'download': make an external representation of knowledge held in his/her cognitive structure. The template enables users to: 1) organise, retain, share and preserve knowledge, 2) use prior knowledge to construct new knowledge, and 3) promotes engagement by enabling the generation of their own ideas at their own pace (Novak 1998; Novak n.d.; Novak & Gowin 1984).

Concept maps, Coffey *et al.* say (2003), differ from other types of mapping systems, such as knowledge maps, conceptual graphs, and mind maps because of: their grounding in Ausubel's Assimilation Theory of learning, their semantic and syntactical (structural) organisation, the nature of the concepts that comprise the nodes, and the unconstrained nature of linking phrases. In the next sections, I present three theoretical ideas underpinning concept maps which are also relevant to my research.

The concept map template: a visual representation of three aspects of Ausubel's Assimilation Theory

Novak and his research group developed the concept map template in the 1970's at Cornell University for the purpose of tracking changes in children's science concepts (Novak & Cañas 2006a). This development took place within a 12-year longitudinal study. In that study the same group of children where tracked from grade 1 through grade 12. The template was developed to facilitate researchers of that study to visualise conceptual changes in the children's cognitive structure due to instruction. The labels 'cognitive structure' (Ausubel 1968), 'schemas' (Piaget & Inhelder 1977), 'mental models' (Norman 1990), 'conceptual frameworks', or 'knowledge structures' (Novak 1998) are employed in the literature for what many experts define as '… a representation of a person's knowledge that includes both the definitions of a set of domain-specific concepts and the relationships among those concepts' (Dorsey et al. 1999, p. 31).

That is, the concept map template was devised so that it was possible to clearly see patterns and changes in conceptual relationships of each individual student at grade 1, 2, and so forth until grade 12. In the following paragraph, Novak and Cañas (2006a) explain the development process of this template. The paragraph content reveals that this tool is actually a visual interpretation of three aspects of Ausubel's Assimilation Theory.

> As our longitudinal study progressed, we were accumulating hundreds of interview tapes. As we transcribed the tapes, we could observe that propositions used by students would usually improve in relevance, number, and quality, but it was still difficult to observe specifically how their cognitive structures were changing. Our research team considered various alternatives we might explore, and we again reviewed Ausubel's ideas regarding cognitive development. Three ideas from Ausubel's Assimilation Theory emerged as central to our thinking. **First,** Ausubel sees the development of new meanings as building on prior relevant concepts and propositions. **Second,** he sees cognitive structure as organized hierarchically, with more general, more inclusive concepts occupying higher levels in the hierarchy and more specific, less inclusive concepts subsumed under the more general concepts. **Third,** when meaningful learning occurs, relationships between concepts become more explicit, more precise, and better integrated with other concepts and propositions. In our discussions, the idea developed to translate interview transcripts into a hierarchical structure of concepts and relationships between concepts, i.e., propositions. The ideas developed into the invention of a tool in 1972 we now call the *concept map* (bold added) (Novak & Cañas 2006a, p. 177).

The concept maps of Figure 1.1 belong to Novak's longitudinal study and were drawn '… from interview transcripts for one average instructed student at the end of grades 2 and 12. Note that while new concepts such as 'atom' are assimilated into her cognitive structure, she also has acquired some new misconceptions' (Novak & Cañas 2006a, p. 177). Comparison of these maps, and the ones of the grades in-between, show how changes of the concept 'molecule' occurred in Amy's cognitive structure. Novak and his research group tracked and analysed these changes to support their research claims about learning and instruction.

Following the same approach, I prepared a concept map based on the interview transcripts of a conversation that a Reggio Emilia teacher sustained with her children (the transcript was published in Cadwell 2003, pp. 26-30). Figure 1.2 shows propositions that I illustrated from the verbal responses that the children gave to their teacher in response to the question 'what is the food chain?' Figure 1.3 is a hypothetical concept map that I constructed with these propositions. The concepts enclosed in boxes with white background, 'plankton' and 'killer whale', were spoken by the children Luke, Alex and Archie. To avoid modifying these children's ideas, I built the concept map at the intersection of these common concepts. The linking phrase ‘e.g.’ was used to clarify when a child further explained a concept using an example.

The exercise of building a map from interview transcripts revealed to me that the constitutive elements of a concept map are part of preschool children’s verbal speech. Therefore, an age appropriate concept mapping tool is needed for allowing these children to autonomously organise knowledge with this kind of map (see Figure 1.3). While it is unusual to place findings in the introduction of a thesis, I do so here, as these results were drawn from the early stages of the research and became background to the substantive study.

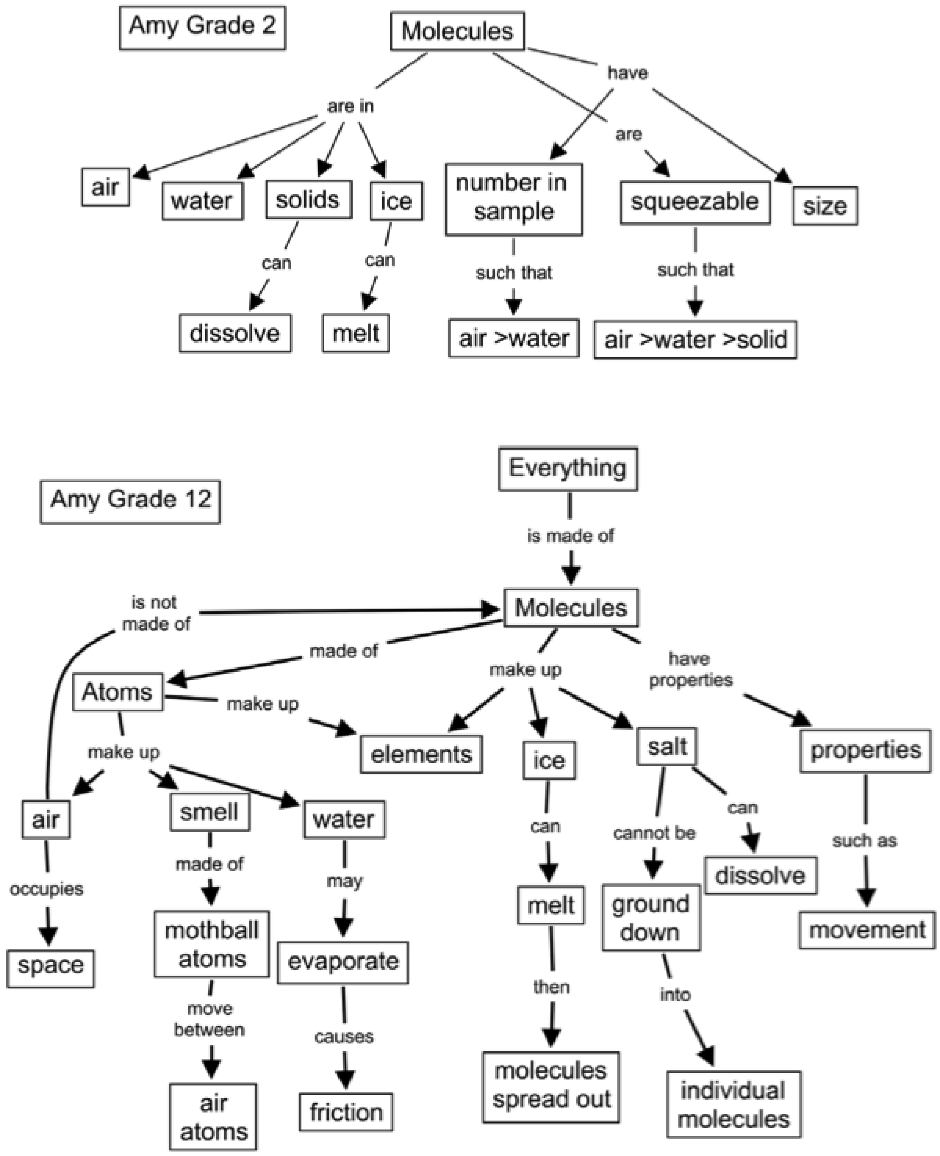


Figure 1.1 – concept maps about ‘molecules’ of Amy at grade 2 and 12

As you can infer from reading about the origins of concept maps, assisting knowledge representation and acquisition for individuals or groups of people was a later application of this tool. There is a plethora of scholarly literature demonstrating how experts from diverse areas of education and business have employed concept maps and researched their effectiveness for more than 35 years. They have been used for tracking conceptual changes, collating and sharing information, meaning negotiation, evaluation, as advanced organisers, among many other uses. The same literature demonstrates that concept maps promote meaningful learning by facilitating a learner/person to represent and manipulate knowledge held in their head or cognitive structure (Cañas & Novak 2006; Cañas, Novak & González 2004; Cañas et al. 2008; Coffey et al. 2003; Mintzes, Wandersee & Novak 2005; Novak 1998; Novak 2004; Novak & Gowin 1984; Novak & Wandersee 1991; *Reference list in CmapTools website* 2003; Torres & Marriott In press). This thesis does not investigate or challenge the veracity of these attributes, as it is irrelevant to the problem I investigated.

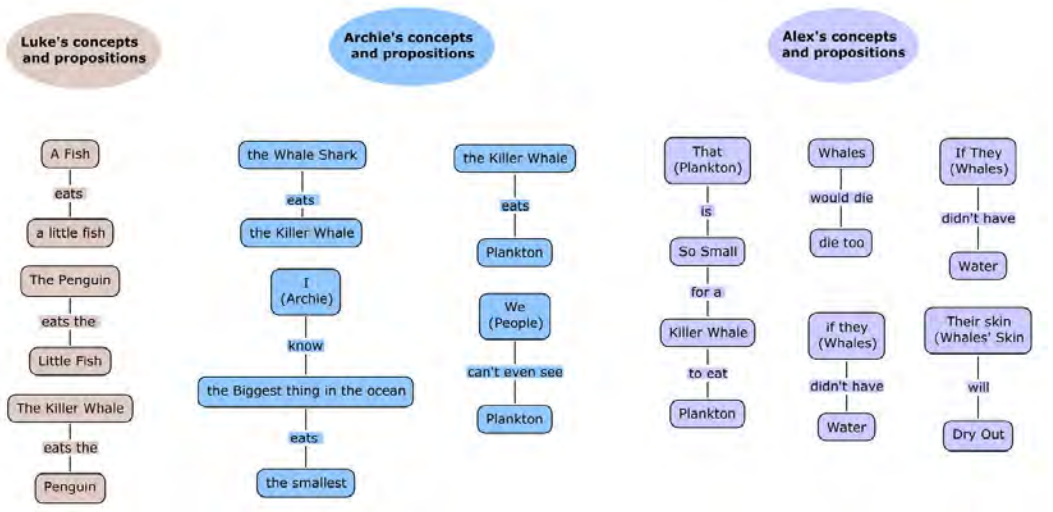


Figure 1.2 – propositions of each child about 'what is the food chain?'

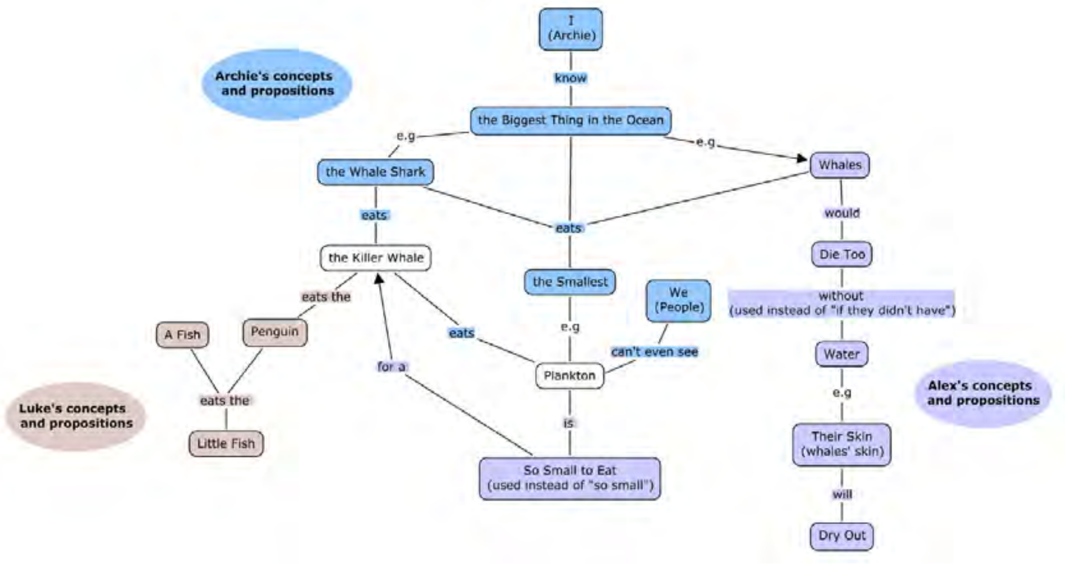


Figure 1.3 – hypothetical concept map about the question 'what is the food chain?'

Theoretical accounts supporting Novak's claim

> Our research and more recent studies by many others in countries all over the world, has shown that young children learn quickly how to make good concept maps, whereas secondary school or university students often have difficulty, partly as a result of years of habit with rote learning (Novak & Wandersee 1990) (Novak 1998, p. 31).

The above citation is taken from a special issue of the *Journal of Research in Science Teaching* (Novak & Wandersee 1990). This issue was devoted to a range of perspectives on concept mapping. It reported studies that referred to people using concept maps and other mapping techniques with elementary, high school and university students. I should note here that Novak was most likely referring to elementary school children when he stated that young children could be good at making concept maps. The interest of early childhood experts on concept mapping has been driven by the underlying theories of concept maps and Novak's claim that concepts can also be labelled with symbols such as + or %. See chapter 2 for more information on preschool concept mapping.

It is important to highlight that Novak offered theories, but has neither researched children's use of symbols when labelling concepts, nor their ability to make concept maps. I argue that his claim, '…young children learn quickly how to make good concept maps…' (Novak 1998, p. 31) is supported by his explanations of how people learn, informed comments on child development, informal observations of young children, and research results from using concept maps with early elementary age children.

A careful reading of relevant sections of Novak (1998) and Novak and Gowin (1984) provides support for the idea that preschool age children can learn how to make concept maps. These authors stressed that after age 3, humans are capable (biologically) of thinking with concepts, processing learning via concept formation and assimilation, learning meaningfully and finally have the same capacities (or abilities) for using and interpreting symbols. These cognitive and representational capabilities are required for building concept maps. Therefore, this means preschool age children are biologically capable of building maps as stated by Novak, because young children are usually considered of preschool age between the ages of 3 and 6. '…In many countries there is a preschool cycle for the over-3s that is perfectly incorporated into the education system' (Unesco 2005, p. 78).

While only briefly described in this section, these key biological capabilities are revisited in chapter 4, as they informed the design guidelines and requirements of the BDP for preschool concept mapping. In the section 'conclusions' of chapter 9, I comment on how these capabilities performed in my case studies and in the context of Novak's claim.

People think with concepts

'People think with concepts' (Novak & Gowin 1984, p. 2). The components of knowledge are concepts and propositions (Novak 1998): A concept is 'a perceived regularity in events or objects, or records of events or objects, designated by a label' (Novak 1998, p. 22). Labels for concepts can be words or symbols. Propositions are relationships between concepts and explain how events or objects work or how they are structured. The propositions of Figure 1.2 were originally expressed with spoken words. I represented these propositions with written words within a concept map structure. They are an example that preschool age children think with concepts.

Children and adults use the same processes for learning

Underpinned by the work of researchers such as Vygotsky (1962), Ausubel and McNamara, Novak theorised on the concept acquisition abilities of young children and used anecdotes to explain how 2 ½- to 6-year olds acquire concepts such as 'annoying', 'underbrellas' *[sic],* and 'grocery shopping'. Through a discovery–reception learning process, involving the use of verbal language, these children showed how they integrated new knowledge (or new concepts) into their cognitive structure. His anecdotes explain that in a situated context and through asking 'Why', these children learned or pursued meanings for concepts and propositions (see chapter 4 in Novak 1998). Novak used these anecdotes as further support for his view about human learning:

> There is, in my view, no difference in the process the child uses to learn names for things or events than that which adults use to construct new concepts. Both are fundamentally meaningful learning processes. It is part of the genetic capacity of every normal human being to construct their own idiosyncratic concept meanings from regularities observed in events or objects. Older learners and more sophisticated learners (such as researchers) also construct concepts from records of events or objects. And concept meanings grow as concept labels are linked to one another to form propositions or statements about events and/or objects (Novak 1998, pp. 40-41).

The concept maps that represent the knowledge Amy held about molecules in grade 2 and in grade 12 (see Figure 1.1) are examples of the difference in sophistication. From this we can assume that the younger the child, the less sophisticated their concept maps will be. Thus, we would expect preschool children's concept maps to be less sophisticated than Amy's grade 2 map and may look more like the map of Figure 1.3. In the case study phase of this research (see chapters 7, 8 and 9), I present and discuss mapping structures of the children who participated in the case studies.

The processes for meaningful learning

Novak and Gowin (1984) explain that the fundamental idea of Ausubel psychology is that learning takes place by the assimilation of new concepts and propositions into existing concept propositional frameworks held by the learner, be they adult or child.

This learning process is what Ausubel called 'meaningful learning' – as opposed to rote learning.

Ausubel says that 'meaningful learning' occurs through a process of concept formation and concept assimilation. The learning process of concept formation mainly occurs from 0 to 3 years. It involves the learning of primary concepts that are acquired via discovery-learning, interacting with older children and adults, intensive repetition and imitation. After age 3, people acquire knowledge via the learning process of concept assimilation. 'As the child builds cognitive structure, he or she can acquire secondary concepts by the process of concept assimilation' (Novak 1998, p. 41). See chapter 4 for learning more about these learning processes.

In an earlier section of this chapter, I quoted Novak and Cañas (2006a) in which they explain that a concept map is a visual representation of the process of concept assimilation – one of the processes for meaningful learning. Symbol-based maps of young children do not replicate this fundamental characteristic of Novak's template, as they do not make explicit how a map owner assimilates concepts into his/her cognitive structure. This thesis explains how I sought design solutions for this issue in the design phase of the research (see chapter 4). The case study phase presents mapping structures that were created with the BDP and make explicit how children incorporated concepts into their cognitive structures (see chapter 8).

Conditions for meaningful learning

Meaningful learning requires three conditions (Novak & Cañas 2006b):

1. **Meaningful material:** The material to be learned must be conceptually clear and presented with language and examples relatable to the learner's prior knowledge. The knowledge to be learned must be relevant to other knowledge and must contain significant concepts and propositions. 'Concept maps can be helpful to meet this condition, both by identifying large general concepts held by the learner prior to instruction on more specific concepts, and by assisting in the sequencing of learning tasks though progressively more explicit knowledge that can be anchored into developing conceptual frameworks' (pp. 3 - 4).

2. **Relevant prior knowledge:** The learner must possess relevant prior knowledge. This learning condition can be met after age 3 for virtually any domain of subject matter. S/he must know some information that relates to the new information to be learned in some significant way. '...[I]t is necessary to be careful and explicit in building concept frameworks if one hopes to present detailed specific knowledge in any field in subsequent lessons. We see, therefore, that conditions (1) and (2) are interrelated and both are important' (p. 4).

3. **The learner must want to learn:** The learner must choose to learn meaningfully, must consciously and deliberately choose to relate new knowledge to prior knowledge that s/he already knows in some significant way. This is the one condition that a teacher or mentor has only indirect control of. They can facilitate this condition by motivating the students to choose to learn meaningfully with adequate instructional and evaluation strategies, instead of teaching them to memorise concept definitions, propositional statements or computational procedures. Wanting to learn is fostered by 'instructional strategies that emphasize relating new knowledge to the learner's existing knowledge...' (p. 4) and promoted by 'evaluation strategies that encourage learners to relate ideas they possess with new ideas...'(p. 4).

Using and interpreting symbols

<u>Coding meanings with written and symbolic labels</u>

> Human beings are unique from all other animals in their ability to perceive regularities in objects and events and to code these regularities with labels. These labels for regularities in events or objects are usually words (some 460,000 in the English language), but may also be signs such as +, -, Σ, Δ, and so forth (Novak 1998, p. 21).

The roles of the Preschool include teaching children to code meanings with symbolic languages for representing and communicating knowledge. 'Culture is the vehicle through which children acquire concepts that have been constructed over the centuries' (Novak & Gowin 1984, p. 4) and schooling is one of these cultural vehicles. Schools are not all the same and they teach different kinds of knowledge representation and communication tools. Preferred tools are selected according to schools' curricula and teaching philosophies.

> …the events in a classroom are influenced by students, instructional materials, teachers, the school and the community social climate, and a host of interactions among them that vary over time. There is tremendous richness in the extent and variety of teaching and learning events in the classrooms, which makes it difficult to observe consistent regularities and hence to form concepts and theories about teaching and learning… (Novak & Gowin 1984, p. 12).

In this thesis I present examples of how the event of teaching preschool concept mapping is interpreted by varied cultures at a country and classroom level, and of how preferred teaching philosophies shape the way Novak's maps are taught and understood in those cultures. In chapter 2, I review literature concerning the use of concept maps in different cultures and countries. In chapters 7 and 8, I present examples and analyses of the use of concept maps in two cultures and countries.

<u>Recognition of visual information for learning and recall</u>

The facilitation power of concept maps relies on the human capacity to recognise visual information.

> … Whereas most humans have notoriously poor memory for recall of specific details, their capacity for recall of specific visual images is remarkable – we can easily recognize our close friends in a gathering of hundreds or in a photograph of a group. It would be extraordinarily difficult to program a sophisticated computer to make similarly reliable recognitions. Concept mapping has a potential for enlisting this human capacity for recognizing patterns in images to facilitate learning and recall. Much research is needed on this issue… (Novak & Gowin 1984, p. 28).

In the five experiences reported in chapter 2, the educators do not explicitly report if their alternative approaches for preschool concept mapping have the potential for enlisting young children's capacity for recognising patterns in images to facilitate learning and recall. In my analysis of these experiences for the purpose of designing a suitable alternative to Novak's concept map template, I only dealt with this topic tangentially.

The study of Novak's theoretical accounts has shown that the biological readiness of preschool age children to build concept maps is high. The assumption of Novak then is that they could quickly learn to make concept maps, because they are not yet habituated to rote learning (see quote at the beginning of this section). Rote learning is new knowledge acquired by verbatim memorisation and arbitrarily incorporated into a person's knowledge structure (also called cognitive structure) without interacting with the knowledge that is already there (Novak & Gowin 1984). Habituation to use rote learning as a style for knowledge acquisition takes time.

> While it is true that some students have difficulty building concept maps and using these, at least early in their experience, this appears to result primarily from years of rote-mode learning practice in school settings rather than as a result of brain structure differences per se. So-called "learning style" differences are, to a large extent, derivative from differences in the patterns of learning that students have employed varying from high commitment to continuous rote-mode learning to almost exclusive commitment to meaningful mode learning. It is not easy to help students in the former condition move to patterns of learning of the latter type (Novak & Cañas 2006b, p. 7).

It has been difficult to ascertain whether preschool age children would find the activity of concept mapping even easier than elementary or higher education students, as there have not been any appropriate tools to overcome these children's inability to use written language. This language is required for representing concepts and linking phrases within a map. It will only be possible to investigate Novak and Wandersee's claim (see citation at the start of this section) once a suitable alternative template has been developed allowing these children to employ the cognitive and representational capabilities that were presented in this section. Chapters 3, 4 and 5 document the design phase of this research.

Novak's perspective on instruction and development

In this section, I present commentaries of Novak in which he expresses the view that with appropriate instruction, children can acquire knowledge that is considered beyond their developmental stage. With this view, he opposes Piaget's theory of developmental stages, which says that people's ability to learn certain types of knowledge is age or developmentally bound. As my intention with this research is enabling the testing of Novak's views through a designed tool, I do not argue his views on instruction and development in this document.

Novak (1998) spent four decades examining the complex interplay between developing cognitive structure and school learning. His studies raise questions about Piaget's Development Theory and its application in the design of effective instruction for learning. Summed up in *The Psychology of the Child* (Piaget & Inhelder 1977), Piaget proposed that children undergo four major developmental stages: sensory motor stage (ages 0 to 2 years), preoperational stage (ages 2 to 7 years), concrete operations stage (ages 7 to 11 years), and formal operational stage (age 11 or 12 years onward). Novak continues 'my own studies, and my interpretation of other studies, led to a lack of enthusiasm for Piaget's developmental stage theory at best' (p. 45). To argue this point he interprets research reported by Nordland and colleagues (1974) in which children performed similarly in seven Piagetian conservation tasks despite age and developmental differences. 12-year olds (grade 7 children and considered in concrete operational stage) and 17-year olds (grade 12 and considered to be in formal operational stage) performed correctly on eight Piagetian conservation tasks: number, continuous quantity, substance, area, length, weight, volume clay, volume cylinder (see Figure 4.6 in Novak 1998, p. 46). This data, he concludes, makes '... it very difficult to argue that cognitive development as indicated by Piagetian tasks follows the scheme proposed by Piaget' (p. 45).

Novak finds that it is more valid and more parsimonious to interpret this kind of data through Ausubel's (1968) Assimilation Theory of learning and development. By parsimonious, Novak means that Ausubel's principles explain, in an economical and simple manner, a variety of events in education, in every domain of subject matter and for all age groups (see Novak 1998, p. 96 for an explanation of the principle of parsimony).

Also Novak considers that Vygotsky's ideas are much more powerful for educators than those of Piaget's. The emphasis of his ideas on the special contribution that school learning can play, in contrast to Piaget, was evident in our studies. The ideas of Vygotsky that Novak relates to his own studies are summarised in this paragraph:

> …our hypothesis is the notion that, although learning is directly related to the course of child development, the two are never accomplished in equal measure or in parallel. Development in children never follows school learning the way a shadow follows the object that casts it. In actuality there are highly complex relations between developmental and learning processes that cannot be encompassed by an unchanging hypothetical formulation (Vygotsky 1978a, p. 40).

Novak (1998) states in many occasions 'inadequate prior preparation or inappropriate instruction' is responsible for bad performance of the strategies for learning. Piaget's developmental stage theory, he continues, has been used as a 'convenient scapegoat' by teachers and other school people for justifying issues related to ineffective instruction. Novak disagrees with using students' developmental readiness to explain inadequate prior preparation or inappropriate instruction. Many researchers are now showing the power of children's thinking in a variety of areas: language development, philosophy, science (Macnamara 1982; Matthews 1980, 1984; Chi 1983; Carey 1985; Donaldson 1978; Novak & Musonda 1991 in Novak 1998).

> Based in the collective body of knowledge, it seems reasonable to conclude that by age 3, all normal children can think hypothetically and deductively ("formal operationally" in Piaget's [1976, p.24] terms) in domains where they have acquired adequate conceptual and propositional frameworks. Obviously, older children and adults in general possess much richer and more varied knowledge structures than most young children, so there are cognitive development differences between younger children and older children or adults. Nevertheless, the educative potential of even young children is probably greater than we observe under current educational practices (Novak 1998, p. 47).

Here we see that Novak (1998) prefers Ausubel's theory for designing instructional materials rather than Piaget's because he finds 'greater power and relevance in Ausubel's (1963, 1968) ideas for understanding issues and applications' (p. 47).

Novak further explains that he and his research group saw 'increasing power and relevance of the theory for innumerable educational events in every domain of subject matter and for all age groups' (p. 96), as the theory is relatively simple and can be applied to a wide range of educative events. In their work in research and instructional innovation, they found that the principles of Ausubel's theory have been found to be fundamental to understanding a wide range of phenomena occurring in educative events. The previous section of this chapter introduces Ausubel's principles for meaningful learning.

Novak cites Bloom (1968, 1976, 1981 in Novak 1998) as a strong proponent of the idea that students of all ages can learn much more than they currently achieve using traditional schooling practices.

Despite the logic in Novak's commentaries, Piaget's theory has strong foundations in preschool education (see chapter 4). As an illustration, the teachers of the five experiences that I analysed for identifying issues in preschool concept mapping (see chapter 2) often cite Piaget to explain why children may find it difficult or impossible to make Novak's concept maps. Their experiences and instructional styles are examples of the tension that exists between instruction and development.

This doctoral research does not investigate these tensions, as it is beyond its scope. I leave it to early childhood experts to debate the tensions instruction vs. stages of development in preschool concept mapping. However, and despite my research goal being limited to offering a suitable child-friendly alternative to Novak's concept map template, the research results clearly show that the children who participated in the studies were capable of autonomously building concept maps, able to operate the features of the BDP for preschool concept mapping, but unable to actually build a Novak's map because instruction was inexistent or unsuitable. The section 'capable of concept mapping' of chapter 9 discusses this further.

The research problem

Novak and Gowin (1984) claim that the power of concept maps relies on the template elements. It means that the absence of any of its constitutive elements (concepts or linking phrases or connecting lines) affects the mapping process and the later interpretation of the concept maps (see Figure 2.1 and Figure 2.2). They also claim that the linking phrases in the maps are what make this technique a meaningful learning activity. This is based on the understanding that people are capable of reading the linking phrases, and can therefore interpret how the concepts within the map are related to each other. Active inquiry, meaning negotiation, and representation of organised knowledge, which are key characteristics of concept maps, depend heavily on these components. Yet, if we agree with Novak's and Gowin's logic, then the absence of linking phrases and/or concepts in symbol-based maps created by preschool children (see chapter 2), means that there is no way of accessing the level of their understanding (Gomez 2006).

The concept map facilitates learners' representation, organisation, and recollection of knowledge. The brain organises knowledge in hierarchical frameworks and the template facilitates the human brain during the assimilation process: the concept map presents the knowledge to be processed in small chunks of information (concept → linking phrase → concept), hierarchically arranged in graphical format that facilitates spatial recognition, which enhances memory. The combination of both, the chunks and the position of each chunk of information in the template, is what facilitates the knowledge acquisition process. It is also a structure that is easy to use because it presents simple rules.

When interacting with a concept map, and to establish a conceptual relationship, the literate brain interprets this pattern, concept → linking phrase → concept. An interaction problem with this template, or pattern, arose when preschool teachers modified Novak's map by removing written words and linking phrases, and as a substitute for these, taught preliterate children to map with unlabelled symbols. The brain, literate or preliterate, cannot interpret a symbol → symbol pattern, since a symbol can stand for either a single concept or a conceptual relationship. Symbolic maps using this pattern prevent autonomous knowledge representation. This is the core issue that the concept mapping tool for preschool developed in this study needed to address.

Four arguments can be drawn about the concept mapping issues in preschool:

- Novak's concept maps facilitate knowledge retention, preservation and sharing only if all the constitutive elements, concepts and linking phrases, are present. The visual representations (the boxes and the connecting lines) only work if they contain concepts and linking phrases.

- Hierarchy is relevant for organising a piece of knowledge to make it easier to grasp but on its own is not sufficient to show the knowledge one holds in the head.

- Only labelled concepts within a map can be shared, used in later projects and interpreted.

- Symbol-based maps cannot be considered concept maps by definition because the symbols, representing concepts, are not labelled and linking phrases are missing from the structure. Figure 2.5b shows a symbolic map produced within a concept mapping session. However, the map cannot be considered a Novak's concept map, as the map-readers cannot access the knowledge behind the images. The visual content of the symbol-based maps does not explicitly show the map-owner's knowledge.

As explained in the section 'background' of this chapter, Novak states that everyone, young children, older children and adults, acquire knowledge via the processes of concept formation and concept assimilation, and communicate that knowledge with concepts and propositions. I argue that young children are unable to make concept maps because they are preliterate. In this thesis I used the concept 'preliterate' when referring to those children who cannot read and/or write, and used the concept 'emergent literate' when referring to those children who use what some teachers call 'kindergarten writing'. However, I acknowledge that current and contemporary perspectives of literacy in early childhood would use the term 'emergent literacy' in reference to children who are preliterate or emergent literate.

Novak's concept mapping tool requires labelling concepts and linking phrases with written language and organising those map elements hierarchically. Preliterate children neither yet read and write nor use hierarchy to organise conceptual knowledge, and consequently, they are unable to represent concepts and linking phrases within a map. In chapter 2, I explain this problem in detail.

The research claim

For more than a decade experts have developed child-friendly alternatives to Novak's concept map template and reported on their educational value (see chapter 2). These alternative tools have enabled preschool children to represent knowledge with symbol-based maps. Despite this, I argue that symbol-based maps require heavy teacher mediation during the building process and many hours of instruction in order to succeed. Such a way of concept mapping is contrary to the underlying theories of Novak's concept maps and lessens their value and impact as effective tools for knowledge representation and organisation.

My overarching research claim is that solving children's representational limitations during map building may enable the investigation of the significance and effectiveness of Novak's concept maps in the preschool classroom. If we accept that children's inability to build maps is that they cannot yet represent concepts with written language and organise them using hierarchy, then such inability may be resolved by designing a tool that addresses those issues. The designed tool should not only facilitate preschool children to represent the constitutive elements of concept maps (concepts, linking phrases, and connecting lines) with mastered representation skills (e.g. spoken and iconic languages), but also include structuring features that support the skills that have not yet reached full development. Such a tool may help further our understanding for the reasons behind the slow incorporation of this learning tool into the preschool classroom. By taking this approach, I assert, Novak's claims (see section 'background') and EC experts' claims (see chapter 2) can be evaluated for confirmation, criticism or refutation.

I discuss the reasoning behind my overarching claim and selection of features for the designed tool in the section 'analysis of the gaps from an interaction design perspective' of chapter 2. Chapters 4 and 5 of the research's 'design phase' present the development of this tool whose features should:

- Make children's conceptual and propositional knowledge explicit
- Facilitate manipulation, retention, sharing and preservation of knowledge
- Facilitate teacher instruction

- Promote children's autonomy during map building
- Promote the children's use of multiliteracy.

Research contributions

My thesis documents research contributing to the emergent area of preschool concept mapping. It reports on the development of an age appropriate concept mapping tool and the successful production of mapping structures by preschool children in two classroom settings. By following this approach, I sought to improve our understanding of the issues in preschool concept mapping and the types of suitable child-friendly alternatives to Novak's template. In my view, the existence of a suitable tool may allow for effective investigations of Novak's claim and the claims of EC experts using concept maps with their children (see chapter 2).

Contribution to preschool concept mapping

The research reported in this thesis contributes to the body of scholarship concerned with the ways children learn and communicate conceptual knowledge. In particular it contributes to the solution of problems associated with preliterate children's abilities to make concept maps, by identifying what makes concept mapping difficult in preschool. This study aimed at:

- Enabling preschool age children to build Novak's concept maps with a child-friendly alternative template
- Enabling early childhood experts to effectively investigate the significance and effectiveness of concept maps in the classroom.

This doctoral work contributes to the body of scholarship interested in enhancing, diversifying, and renewing the early childhood education research culture and practice in Australia and worldwide. Concept maps have been documented to be successful as a knowledge representation and acquisition tool and a good strategy for promoting meaningful learning.

Contribution to interaction design

The Bridging Design Prototype method, a product of the research, was used to develop functional prototypes that the user community agreed to incorporate in classroom activities. This prototyping method can be replicated, outside educational realms, due to its underlying design principles. The section 'methodology outline' of this chapter provides a brief introduction to its main components. Chapter 3 presents all aspects involved in the emergence of this prototyping method.

Focus of the study

This study was limited to the investigation, development, and testing of a suitably designed BDP for preschool concept mapping that allowed children to make Novak's concept maps and that facilitated teacher instruction with this learning tool. I report how research participants, children and the teachers, employed this tool; and how its features enhanced preschoolers' interactions with concept maps. Finally, I report on the extent to which this mapping tool permitted participant children to retain, preserve and share knowledge – the characteristics of concept maps. This project looks at the moment of engagement only. While I suggest implications for learning, I cannot make claims about its impact.

The study does not challenge Novak's concept mapping theory or the theories and approaches that early childhood educators use in the classroom. On the contrary, it assumes their claims and approaches as valid. The research outcomes inform the expert and theoretical claims, and expand our understanding of the issues surrounding the application of this learning tool in the preschool classroom.

Neither was intended to test Novak's claims nor the learning claims of EC experts reported in chapter 2, as this pursuit was beyond the scope of my research. The focus of my research was to develop a learning tool that enabled groundbreaking results, and in consequence, interesting and meaningful discussions among these experts in the future.

Methodology and method outline

Most researchers within the area of preschool concept mapping come from backgrounds in education or psychology, a design perspective underpins this research. I argue that the Design discipline provides an alternate way of approaching the issues identified, as well as constructing effective solutions.

> ... As it has taken shape around us today, design has become a form of inquiry: a way of interacting with the world to investigate the environment in which human beings are directly involved and the surroundings in which they are indirectly involved. Indeed, it is a way of investigating what it means to be human at a time when technology, the complexity of organizations, and expanding knowledge of natural phenomena threaten to overwhelm us (Buchanan 2005, pp. 4-5).

Specifically, I used an interaction design perspective to investigate solutions that could address the research problem, which entailed preschool children's inability to perform certain behaviours (e.g. representing and organising conceptual knowledge) with a product (e.g. Novak's concept map template).

> ... Interaction design may be defined as the study and exploration of how people relate to other people through the mediating influence of products... Indeed, its application in government services, not-for-profit agencies, for-profit service companies, and education is just beginning. It promises to have great impact on social activities and social life as the work of designers gains greater recognition (Buchanan 2005, pp. 12-13).

Kolko's (2007a) definition appears to expand Buchanan's definition:

> Interaction design is the creation of a dialogue between a person and a product, service or system. This dialogue is usually found in the world of behavior – the ways someone may hold his knife and fork while cutting into a steak… (p. 11).

I designed the research as a three-phase project to investigate behavioural issues in the activities of preschool concept mapping. According to the goals, one or more of the following areas could inform each phase: user-centred design, child learning and development, concept mapping, and early childhood research methods.

The complex relationship between the research phases made it difficult to write a traditional methodology followed by method. Rather than repeat the rationale in each phase I have made the choice to include the rationale / methodology in chapters 3 and 6. Thus, while calling aspects of my research by phases tend to mask the interlocking nature of these phases.

- **Conceptualisation phase,** chapter 2, explains and identifies interaction design issues in preschool concept mapping, underpinned by a user-centred design philosophy. Chapter 3 includes a rationale for the use of this philosophy.

- **Design phase** presents the rationale underpinning the design method (chapter 3) and reports on the development of a functional prototype for addressing the interaction design issues found in the conceptualisation phase (chapters 4 and 5). Original to this research and underlined by principles of user-centred design and a learning theory, the Bridging Design Prototype method (BDP method) was employed in the development of such prototype. The BDP features had to meet the needs of this research as well as of the user community, teachers and children in the classroom.

- **Case study phase** presents the rationale underpinning the research method (chapter 6), reports on the observations and data gathered from teachers and children interacting with the BDP for preschool concept mapping in classroom settings (chapters 7 and 8), and presents a results discussion (chapter 9). Literature in early childhood education research informed the selection of methods employed in the exploratory case studies. The analysis of the data gathered in these studies was performed from an interaction design perspective and to find out if the interaction design issues identified in the conceptualisation phase were addressed by the BDP developed in the design phase.

The design phase and the case study phase of this research are two separate smaller projects within a larger project that constitutes the doctoral research. The design phase, together with its design methods, was important for developing a tool that could be incorporated in classrooms. Once an appropriate tool had been developed I was able to move to the case study phase. This phase achieves the goal of undertaking observations in real classroom settings.

Thesis structure

While a traditional thesis would commence with a literature review, such an approach was not possible within this thesis. The areas of scholarship from which I draw relate to the themes of each of the research phases (see previous section) as well as the review of Novak's concept mapping theory. Therefore, I embedded the literature throughout the thesis aligning that literature with the phases of the research.

Conceptualisation phase

As I have already stated this thesis does not challenge Novak's claim (see section 'background' of this chapter), rather it looks to develop a design solution. In this phase I identify the gaps in preschool concept mapping and use them to inform the design decisions. To understand the reasons for the issues in preschool concept mapping from a design perspective, I draw knowledge from the areas of user-centred design and concept mapping.

Chapter 2 – concept mapping in preschool

It presents the analysis of five educational experiences to identify issues in preschool concept mapping. This analysis included a profile description followed by an explanation of the gaps found from a user-centred design perspective: symbol-based maps neither make children's knowledge explicit nor facilitate its organisation, retention, sharing or preservation. These concept mapping-related interactions, crucial for meaningful learning, can be re-stated if children are presented with a tool that enhances autonomy and control over every aspect of the map building. The analysis concentrated around five experiences because only these experiences were publicly available during the conceptualisation and design phases of this research.

Design phase

In this phase I designed a solution for preschool concept mapping that teachers would agree to incorporate into classroom activities with their children. At the same time this design solution had to facilitate the interactions or behaviours identified as pivotal for concept mapping in the conceptualisation phase. User-centred design and learning philosophies informed the prototyping process to achieve a design solution that met both criteria.

Chapter 3 – the Bridging Design Prototype method (BDP method)

It introduces the development of the BDP method as a prototyping method for investigating difficult-to-access and technologically disinclined user communities, such as the preschool community. It presents its underpinning user-centred design and learning philosophies, which in turn, informed the selection of requirements for the development of functional prototypes that a user community can incorporate into their activities while a researcher uses them for observation. Finally, this chapter explains how the BDP method was applied in the implementation of a BDP for preschool concept mapping.

Chapter 4 – identifying guidelines, design requirements and features for the BDP: a literature review

It describes how I employed expert literature on concept mapping, child learning and development, child knowledge representation, and teacher facilitation to understand the source of the gaps between theory and practice in preschool concept mapping. I explain through this literature review how I learnt about the user community's prior knowledge regarding theories, methods and instruments for classroom activities. I adopted this approach, as I was unable to interact with the users in their natural setting during the design phase. My understanding of this literature I present in the form of theoretically grounded guidelines that informed the selection of design requirements and features that were employed in the implementation of the BDP. Research goals and claims, guidelines, design requirements and features are summarised in Table 4.2.

Chapter 5 - prototyping a BDP for preschool concept mapping

It reports on two prototyping cycles based on the design requirements presented in chapter 4. An important condition for the final prototype was that I could incorporate it in any preschool classroom. In prototyping cycle one I developed low-fidelity prototypes, which I used to clarify the profile of the user community and the type of BDP that this specific user community was willing to incorporate in the classroom. Based on the results of prototyping cycle one, in prototyping cycle two, I expanded the design requirements reported in chapter 4 by developing requirements to address the teachers' needs of my specific user community. The expanded requirements were applied to the development of the interaction and interface elements of a tangible BDP. Prototyping cycle two was finalised with a pilot case study in which the tangible BDP was tested for its functionality.

The relevance of the pilot study is limited to the design phase. During this phase, I could not interact with my user community in their natural setting. Therefore, I pilot-tested the tangible BDP in a New Zealand household and discussed the results of this pilot with different members of the relevant user community. The pilot results together with expert comments provided enough information showing that the BDP was ready to be incorporated in real preschool classrooms.

I developed the features of the BDP for preschool concept mapping so that I had a tool to gain entry to an Australian and/or a New Zealand preschool – my countries of residence at the time (see chapter 5). However, this country-specific requirement made the BDP accessible to a wide preschool audience, as it is comprised of features and materials that can be found in practically every preschool in the world. During the case study phase, I gained entry to an Australian preschool in which I performed the first case study, and to an American preschool in which I performed the second case study. The second case study occurred while I was a research visitor at an American university. See chapter 6 to learn more about the location of research.

Case study phase

In this phase I evaluated the designed solution for preschool concept mapping in two preschool settings. I used the case study research method, as understood by the early childhood community, to facilitate my observations of teachers and children using the BDP for preschool concept mapping in real classroom activities. The results of the case studies were analysed and discussed from an interaction design perspective, according to the interactions or behaviours identified as important for effective preschool concept mapping in the conceptualisation phase.

Chapter 6 – the research method

It reports the research method employed in the case studies. It introduces the case study method, which is the qualitative research method that I chose to investigate my research problem in classroom settings. In this chapter, I explain the reasoning behind the choice of this methodology, the methods used to gather data about the teachers and children in the classrooms, and themes of the content analysis. Finally, I describe the approach to find a preschool willing to participate in the research, and the ethical implications.

Chapter 7 – case study one

It reports on the case study that was performed in a state-run preschool in Australia. It explains that I played the role of the researcher and the teacher in this study, as the classroom teacher did not use the BDP herself. It also explains that I observed nine children, age 4 to 5.6, using the BDP during free-play time. Due to my inexperience of teaching I did not instruct these children on Novak's concept maps. Instead, I introduced activities involving concept labelling and its organisation with arrows. I report the results of three children showing that mastery level of the skills required for operating the BDP influenced these children's autonomy and control over the concept mapping-related activity. I conclude saying that child-autonomy was brought to the activity when the required interactions were met and instruction was effective. Verbal labelling of symbols made children's conceptual and propositional knowledge explicit.

Chapter 8 – case study two

It reports on the case study that I performed in a laboratory preschool based at a university in the United States. I report on how the teachers incorporated the BDP into a collaborative classroom activity. Two teachers and 18 children, age 5 to 6, participated in the study. I was able to instruct one of these teachers in Novak's maps, however in the end, these teachers used their own mapping techniques. I analysed the content of the maps created by children and teachers together: they represent knowledge organisation in the form of clustering and hierarchy; reveal conceptions and misconceptions, formal and idiosyncratic knowledge. I also report on evidence of knowledge retention and identification of missing concepts and unexpected interactions, the participation of an autistic child and a 6-year old writing for the first time. I conclude saying that the study results show that child autonomy was brought to the activity when the required interactions were met and when instruction was effective. Peer-to-peer collaboration and active learning were two interactions that the teachers found important and unique characteristics of this tool.

In chapters 7 and 8, the results of the case studies indicate that the BDP for preschool concept mapping:

- Helps preschool teachers to find out what children actually know.
- Promotes children to rehearse knowledge organisation and self-regulation, which are cognitive skills required in mapping.
- Provides easy to use and manipulate features.
- Enables the identification of the main obstacles of the promotion of concept mapping in preschool.
- Enhances children's autonomy and teacher facilitation during map building, which in turn, transformed teacher opinions about the relevance of concept mapping.

Chapter 9 – discussion, future work and conclusions

It discusses the results of the case studies. The discussion centred on the interactions that the BDP enabled in relation to concept mapping. Children's ability to operate the BDP using prior knowledge, or after effective instruction, increased autonomy. To support this claim, I present evidence in the case studies where this occurred. With supporting literature and quoting the participant teachers, I give explanations showing that the BDP design and features have improved the nature of the mental interactions with the map content, as well as the interactions among peers and with teachers. I also explain that concept mapping-related skills were exercised in these activities and show that children can make concept maps as stated by Novak: they could easily learn new strategies and with appropriate tools they could use needed skills.

In the future work section, this chapter outlines related work and other avenues of investigation of this research.

The conclusions section comments on the overall research in relation to Novak's theoretical accounts (see section 'background'), and the research problem and research claim that were presented earlier in this chapter. I support my commentaries with the theoretical perspectives presented in chapters 2 and 4, case study results reported in chapters 7 and 8, and the discussion of the studies' results in the discussion section of chapter 9. Finally, I state the research claims have been supported to an extent, highlight breakthroughs, refine the research's contribution to the areas of preschool education and interaction design, and finally, present limitations for the research.

Conceptualisation Phase

This phase includes chapter 2.

Chapter 2 – Concept Mapping in Preschool

Overview

This chapter draws on five examples where educators (teacher trainers, teachers, and researchers) used concept maps with 3-, 4- and 5-year olds to describe and analyse some current practices of preschool concept mapping. These examples are called experiences. The teachers in these examples modified Novak's concept maps into symbol-based concept maps. Central to the analysis of these experiences is whether the method of concept mapping employed created the conditions for meaningful learning.

I argue that symbol-based maps are inadequate for the purposes of meaningful learning, as they do not make children's conceptual and propositional knowledge explicit. This inability to disclose symbolic meanings makes children's interactions with the map limited and teacher mediation heavy and difficult. Knowledge organisation, active inquiry, and meaning negotiation are limited to simple symbol-based maps and the representation of idiosyncratic knowledge. Teacher mediation is heavily present during every aspect of the mapping process: generation, development, and interpretation, unless the teachers develop a technique that enables children to build concept maps autonomously.

These examples include a description of each experience profile, which includes theoretical reasons, applications, building process, benefits, and future work. The analysis that follows is grounded in Novak's concept maps and its underlying theories, and identifies the gaps in the use of symbolic approaches. The analysis concludes that if children's understanding in, and control over, the process was to be enhanced, a different kind of tool is required. Such a tool must enable children to build every aspect of the concept map. These changes may increase children's intrinsic motivation and facilitate teacher instruction.

Five teacher experiences in preschool concept mapping

For more than a decade, growing communities of experts within early childhood education have been exploring strategies and adaptations for children to concept map with symbols. Novak's claims and the underlying constructivist theories of this knowledge representation tool are the driving forces behind their interest (Gomez 2006).

Five teacher experiences, strategies, and adaptations of Novak's concept maps were analysed. This analysis was undertaken to see how the primary factors that were key to concept maps (chapter 1) were understood and interpreted. These experiences took place in Costa Rica, Italy, Spain, and Portugal. Some report on case studies adapting concept maps for preschool use, others report on case studies conducted as part of doctoral research, and one experience is the history of two online forums on the use of concepts maps in preschool. This chapter presents how these experts are practicing the area of preschool concept mapping. I dedicated sections to theoretical reasons, applications, building process, benefits, and future work. In the benefits and analysis sections, I only cite findings of the work of Mancinelli *et al.* (2004), Mérida (2001-2002; 2002), Figueiredo *et al.* (2004), and Peréz Cabani *et al.* (1992)*,* as these experts provided findings that were appropriate to this study. Ali Arroyo's (2004) and Badilla's (2004) reports also present conclusions of their respective studies. However, these were not appropriate for this thesis because their reports did not provide a findings section that validated their argument. In the analysis section, I cite the online forums (FOD 2004a, b) because the teacher comments are useful in understanding gaps between theory and practice.

The profile of the teacher experiences

These profiles were not only relevant for identifying gaps in the teachers' practice of concept mapping (this chapter) and during prototyping (chapters 4 and 5) but were also relevant in the analysis of the case studies (chapters 8 and 9). The way a concept mapping experience is carried out (e.g. the age of the participant children, the intensity and quality of the instruction, among other factors) impacts the success of the technique in the classroom. Badilla-Saxe, a Costa Rican educational expert, shared in an online forum that children's understanding of concept maps depends on teacher mediation and in the strategies employed. Teachers should select learning strategies based on the prior knowledge (e.g. abilities, stage of development, interests) of the group of students with whom mapping will be undertaken. According to this knowledge, the mapping activities should be adjusted and modified in order to attract their attention and interest (FOD 2004a).

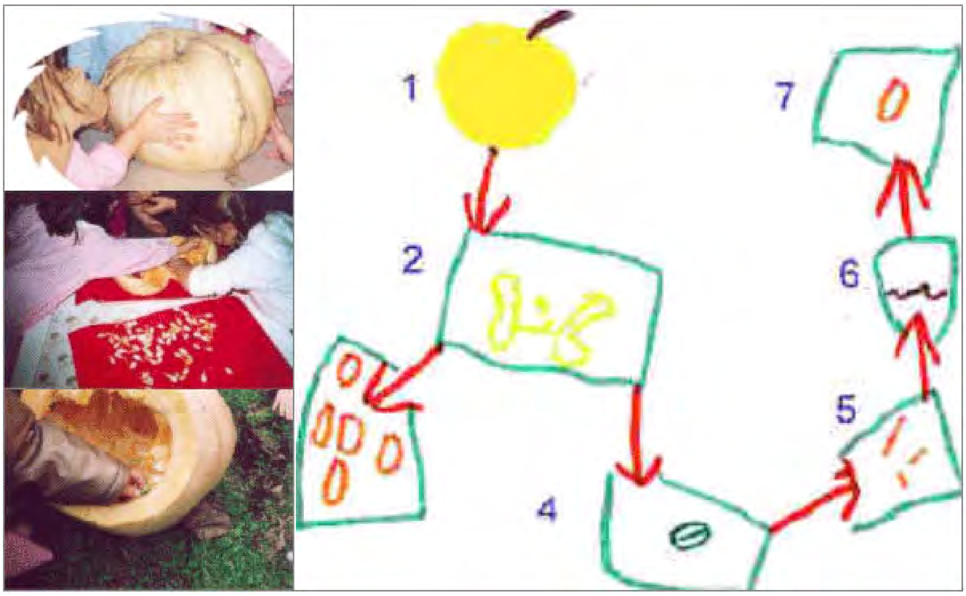


Figure 2.1 – making a symbol-based map of the pumpkin, Italian experience

In this section each experience profile is briefly described. The profile includes: a) the country in which it took place, b) the objective of the experience, c) the literature that supports the experience, d) the experience type, (e.g. whether it was; a pilot, part of the curriculum, a teacher single project, part of a doctoral study, etc), e) the age of the preschool children involved, and f) the length of time given to the experience.

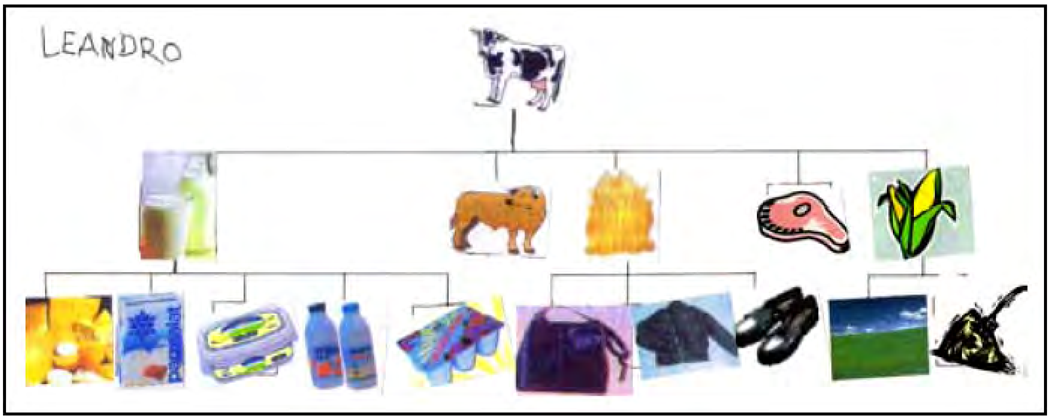


Figure 2.2 – a symbol-based map about 'the cow', Portuguese experience

The *Italian experience* is represented by Mancinelli *et al.* (2004) and Mancinelli and Guaglione (2004). These teachers' school participated in a project called *La Parolle della Scienza* (The Words of Science) that used concept maps as a strategy to achieve the project's learning goals: support science language teaching. Within the year the project was carried out, 56 children of two classrooms built approximately 180 concept maps about scientific concepts. The participating children were 4 to 5 years old. Hands-on explorations, guided conversations, and concept maps were used to carry out the science experiences. The children created symbol-based maps with tangibles (called space-maps) in teams and individually drew maps with colouring pencils in their notebooks. Figure 2.1 shows the concept map of a 5-year old.

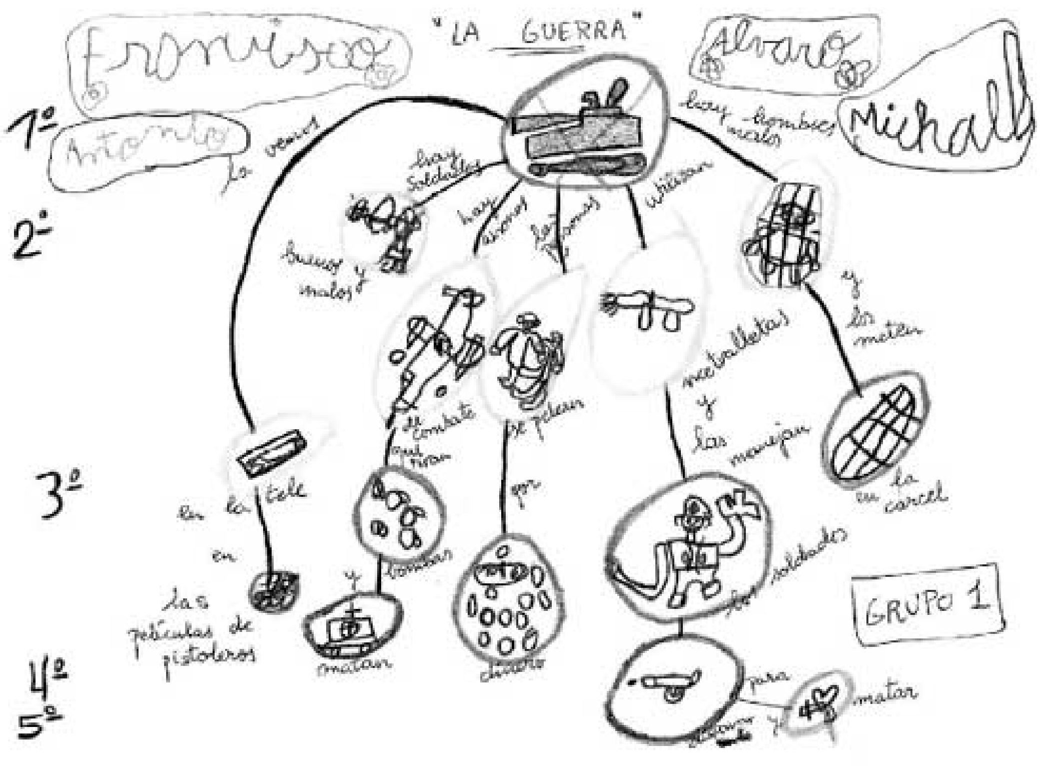


Figure 2.3 – a symbol-based map about 'the war', Spanish experience

The *Portuguese experience* is represented by Figueiredo *et al.* (2004). In this experience, preschool teacher education students (or pre-service teachers) investigated the use of concept maps with a group of children from a rural school. They worked with these children, age 3 to 5, once a week for 4 weeks. Concept mapping was used to evaluate children's progressive knowledge about the cow. Books, visits to dairy farms, among other strategies were used together with concept maps. Two types of symbol-based maps where represented: fill-in-the-blank maps and graph-from-scratch maps. See Coffey *et al*. (2003) for definitions of this kind of maps. The group maps and individual maps were created with picture cards, butcher paper and pencils. Teachers heavily mediated the building of group maps and also prepared the picture cards used in the mapping sessions based on the concepts and propositions the children expressed to know about the cow. By using the term 'heavily', I mean intense and constant intervention in every aspect of the map building. Figure 2.2 presents the map of one of the students, whose age was not disclosed.

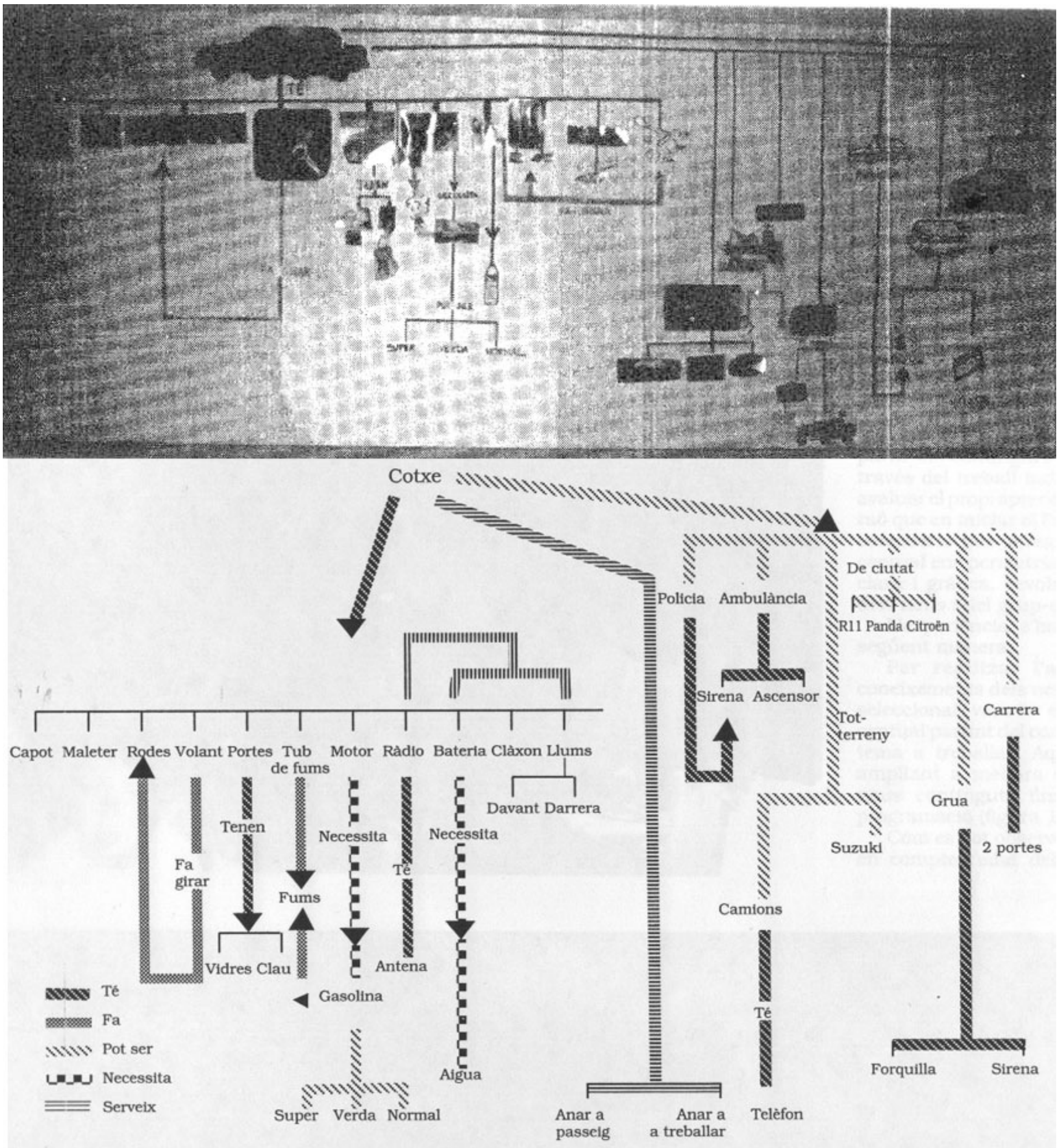


Figure 2.4 – a symbol-based map about ‘the car’, second Spanish experience

The *first Spanish experience* is represented by the reported outcomes of Mérida’s (2001-2002; 2002) doctoral dissertation. Similar to my research, Mérida investigated and developed an approach or set of tools for enabling 5-year olds of a preschool classroom to make concept maps by themselves and in small groups. Mérida taught these groups of children to represent concepts with conventional symbols, represent hierarchies with colour-coded circles and ordinal numbers (red circle for 1st level concept, yellow circles – 2nd level concepts, orange circles – 3rd level concepts and so on), represent linking phrases verbally, and finally reading the map aloud for the teacher to annotate the maps and analyse the content. The children learnt to use the technique in 17 weeks working 4 hours each time (68 hours of training in total). The annotated symbol-based maps were created with drawing and colouring materials on butcher paper. Mérida has also reported on the use of concept maps since the second half of the '90s. Figure 2.3 shows a group map built by four 5-year olds.

The *second Spanish experience* is represented by Peréz-Cabani *et al.* (1992). Peréz is a teacher trainer and psychologist. Since the early '90s she has reported on the work of practicing teachers using concept mapping in the classroom (Pérez-Cabaní 1994, 1995, 1999; Pérez-Cabani et al. 1992; Pérez-Cabaní & Tarradellas-Pifarrer 1996). In the experience that was analysed in this research, teachers and a group of 3-year old children worked together on the representation of concept maps. The symbol-based maps, see Figure 2.4, were created with pre-selected pictures and coded lines were not only used for connecting symbols but also for representing linking phrases. Teachers mediated the construction of maps on big paper formats and under their children's instruction who said where to place symbols and connections. This approach to concept mapping is similar to those of Webbing (Helm & Katz 2001) and Fleer (1996).

The *Costa Rican experiences* are represented by the online discussions undertaken in two forums (FOD 2004a, b), the experience reports of Badilla (2004), and Alí Arroyo (2004). The teachers who participated in the forum and authored the experience reports work for 'El Programa Nacional de Informatica Educativa MEP-FOD (Preescolar, Ciclo I y II)' of the Costa Rican government. This project uses the Project Approach philosophy, which aims at developing the technology skills of preschool age children and includes concept maps as a teaching strategy. Every school participating in *'el programa'* has a teacher (called tutor) who is trained to introduce the children to information technologies and to concept mapping from a constructivist perspective. The participant children worked on this activity two days a week for a period of 40 minutes. Alí Arroyo gives us an overview of how the project and the teacher training are undertaken, outlines how the technique should be used with preschoolers, and presents the theoretical framework that guides the teaching. Badilla reports on her experience, which is an example of how a teacher uses the knowledge learnt in *'el programa'* in her practice. The history of the online forums is a window to the benefits and concerns teachers see in using concept mapping with preschool age children. We do not have visual reports of the maps the children produced in any of these experiences.

In the forums teachers asked questions to an educational expert, Badilla-Saxe, and shared experiences of how they used the technique with their students. Reading the archived discussions from the forums, we see that teachers use different materials in the construction of symbol-based maps. The children were taught to construct symbol-based maps with concrete materials (e.g. toys, Play-Doh), drawings or pictures. Since the maps were created as part of a program focused on the development of technology skills, at the end of every mapping process, the children re-created their concept maps with Micromundos software.

My research and reporting interests lay in the gaps and limitations of using concept maps in preschool and the future work that can be performed to address them. Together with the previously published articles of Gomez (2005b) and Birbili (2006), the experience profiles outlined above provide an understanding of current practice. Based on Novak's theory we can see that current approaches all have limitations.

Theoretical reasons (learning philosophies and approaches)

Designing activities that include the use of graphic representations in the classroom is not a foreign practice in preschool education. 'The benefits from using visual aids are long known to the preschool teacher: visual links and relationships between ideas promote better understandings' (Campbel, Campbel & Dickinson, 1996 in Figueiredo et al. 2004, p. 1). Birbili (2006) explained '…most visual teaching methods are well suited to the learning needs of preschool children'. Venn diagrams, event chains, time lines, and cycle diagrams are commonly used. In early childhood education, the most widely used visual method is webbing. 'An important element of the Project Approach, webs are graphic maps that are used by teachers to generate and sort what children know or would like to learn about a topic, concept, or theme and to stimulate questions and ideas for activities' (Chard, 1998; Katz & Chard, 2000). In relation to concept maps, Birbili (2006) says that they are not commonly used, however, the current emphasis on teaching for understanding and the importance of conceptual knowledge, means that teachers need techniques that help children see patterns and connections, rather than memorise facts.

The teachers in the five experiences, outlined above, have drawn on aspects of Novak and Gowin's (1984) book on concept mapping and consequently have become familiar with its underlying theory and instruction methods. They have built on these principles and adapted the technique for use with preschoolers. It is important to acknowledge that to date, Novak has theorised, but not yet published specific examples, on the use of symbols when labelling concept maps (Gomez 2005b).

In addition some experts believe concept maps can help young children develop learning-how-to-learn skills: reflective thinking, autonomous thinking, and cognitive skills (Figueiredo et al. 2004; Mancinelli 2004; Mérida 2001-2002; Pérez-Cabani et al. 1992). This is based on the fact that Novak's concept mapping theory is grounded in a constructivist learning theory that promotes the development of these skills. The development of such skills are also core principle to other early childhood (EC) philosophical approaches to learning such as the Project Approach (Helm & Katz 2001) and Reggio Emilia (Giudici, Rinaldi & Krechevsky 2001).

Mancinelli *et al.* (2006) tell us that some arguments of Novak about concept maps persuaded them to use the technique. These arguments are that concept maps aim to help children to build mental models (or as Ausubel calls them cognitive structures), and that through constructing them, concept acquisition could be achieved. The underlying ideas of concept maps (e.g. mental management) relate to other philosophies applied in their educational programmes. The idea of improving children's mental functioning is part of their science teaching programme. Thus, concept mapping was seen as a good technique for enabling children to represent key science concepts acquired through other strategies such as object manipulation and conversation. On the same topic, Figueiredo *et al.* (2004) say they promote better understanding of conceptual relationships and assist the discussion of the concepts that are under study. A report following the work of Figueiredo *et al*. (2004) shows how concept maps assist in the discussion and representation of science concepts (Cassata & French 2006).

Applications

The teachers in the five learning experiences used concept mapping to: stimulate thinking processes, organise learning experiences, evaluate conceptions and misconceptions and meaning negotiation, and/or promote topic discussions (Gomez 2005b). It should be noted that concept maps are not used in isolation. Usually, they are part of a learning program where other learning strategies and teaching approaches are applied; such as observation, clinical interviews, guided conversations, site visits, and manipulation of tangibles (toys, play-doh, and clay among others). Teachers organise the experience accordingly to knowledge requirements and insert concept mapping at different stages of the activity development. Figure 2.1 shows Mancinelli and Guaglione's students exploring a pumpkin and the symbolic map created by a 4-to-5 year old that represents the lifecycle of a pumpkin: '1) entire pumpkin, 2) broken pumpkin, 3) seeds, 4) leaf, 5) pumpkin threads, 6) soil, 7) seed to plant' (Mancinelli & Guaglione 2004).

Some teachers used concept maps at the beginning, middle, and end of the activity to evaluate ongoing knowledge acquisition (Figueiredo et al. 2004). Other teachers used maps at the end of the learning experience to evaluate knowledge acquisition (Mancinelli 2004; Mancinelli & Guaglione 2004). Finally, the teachers, who investigated the application of maps in the classroom (Mérida 2002) and ways to implement them in their technology classrooms (Alí-Arroyo 2004; Badilla 2004; FOD 2004a, b), made the instruction of concept mapping the main concern of the experience. Their children made concept maps of topics that were familiar to them.

Scaffolding techniques

In the cases presented in the previous section the teachers used scaffolding techniques to introduce their children to concept mapping. Foley (n. d.) says that the concept of scaffolding has its origins in the work of Vygotsky as well as in the studies of learning languages. Schaffer (1996) expands Foley's comment in his chapter of *An Introduction to Vygotsky*:

> To do justice to the many supportive efforts made by mothers in JIEs, the concept of scaffolding has been advanced by Bruner and by Wood (e.g. Wood, Bruner and Ross, 1976). As Bruner (1975) put it, mothers often help the 'child in achieving and intended outcome, entering only to assist or reciprocate or 'scaffold' the action'. Thus the term designates all those strategies that an adult uses in order to help children's learning efforts through supportive interventions, the form of which may vary but which all aimed at ensuring that children achieve goals that would be beyond them without such support (p. 270).

Supported by a publication of Bruner (1978), Foley further explains that Bruner believed that for learning to take place, appropriate social interaction frameworks must be provided. The instructional component consists of the caregiver (normally the teacher in the case of preschool) providing a framework allowing the child to learn. To do this, the caregiver should always be one step ahead of the child (Vygotsky's zone of proximal development – see definition in chapter 4, guideline 1 subheading 'support the use of prior knowledge, play and social interactions'), and facilitate the child's learning by using contexts that are extremely familiar and routinised. These highly predictable routines, such as reading books together, offer the caregiver and child a structure within which the caregiver can continually raise her expectations of the child's performance.

> Passing on knowledge and skill, like any human exchange, involves subcommunity in interaction. At the minimum, it involves a 'teacher' and a 'learner' - or if not a teacher in flesh in blood, then a vicarious one like a book, or film, or display, or a 'responsive computer'.
>
> It is principally through interacting with others that children find out what the culture is about and how it conceives the world. Unlike any other species, human beings deliberately teach each other in settings outside the ones in which the knowledge being taught will be used. Nowhere else in the animal kingdom is such deliberate 'teaching' found - save scrappily among higher primates.[38] To be sure, many indigenous cultures do not practice as deliberate or decontextualized a form of teaching as we do. But 'telling' and 'showing' are as humanly universal as speaking (Bruner 1997, p. 20).

The scaffolding techniques used in the reported experiences involved either playful metaphors or analogies to assist children in overcoming barriers presented by limited cognitive skills (Gomez 2005b, 2006). For instance, to scaffold the teaching of connecting two or more concepts with lines, Figueiredo *et al.* (2004) built on children's previous knowledge about schematic structures and the use of arrows to connect those.

Modifications to Novak's template

In the experiences reported in the previous section, Novak's approach to concept maps was modified. There were valid reasons for these modifications. For example, the materials for the new template approaches were chosen to fit with the developmental stage of the children and also the learning philosophy (theories, methodologies and methods) of each of these preschools. To overcome the limitations imposed on concept labelling due to the children's emergent literacy, the teachers designed representation approaches or tools to allow their young students to represent meanings. These tools I called simple symbol-based concept maps (see Figure 2.1 to Figure 2.4). In my view, the goal was to incorporate familiar languages for making the map building process hands-on and meaningful to them (Badilla 2004; Figueiredo et al. 2004; Mancinelli 2004; Mérida 2002; Pérez-Cabani et al. 1992).

The children used pictures, tangibles (toys or big size objects), conventional and/or realistic symbolic drawings for representing concepts and conceptual relationships. To represent the connecting lines between concepts, woollen threads, colouring pencils or markers were employed. Some teachers concentrated on training children's drawing skills so they could use them as a way to express and explore the meanings of concepts more independently than could be done with pictures or tangibles (Mancinelli 2004; Mancinelli & Guaglione 2004; Mérida 2002).

A specific graphic representation for linking phrases was not introduced. Instead, teachers assigned meanings to each row (Figueiredo et al. 2004) or to the connecting line (Pérez-Cabani et al. 1992) or used mental metaphors to help children to differentiate them from concepts (Badilla 2004) or annotated the children's map with them once they were disclosed during guided conversations (Mérida 2002) or clinical interviews (Mancinelli 2004).

Figueiredo *et al.* (2004) trained children to use visual aids. These visual aids were templates representing hierarchical organisations (see Figure 2.2). The children used them as a guide to see where, in the symbol-based maps, they should place the symbol. Mérida developed a scaffolding strategy to teach her children the concept of hierarchy that is introduced in concept mapping. Based on the same principles, the characteristics for meaningful learning developed by Ausubel (see chapter 1), this strategy involved the use of colour-coded threads, ordinal numbers and changes in size of circles (see Figure 2.3). The most inclusive concept was drawn in the bigger circle and the more specific ones followed in order of relevance in the smaller size circles, and right below, the most relevant one (2001-2002; 2002). This is the strategy that Mérida's students were instructed to use to represent hierarchical relations between concepts represented with symbols.

Benefits

Figueiredo *et al.* (2004), Mancinelli and Guaglione (2004), Alí Arroyo (2004), Mérida (2002), and Badilla (2004) said that concept maps were valuable for the development of conceptual and knowledge organisation skills. Also, these educators claimed that maps facilitated reflection, experience organisation, meaning making, and knowledge emergence (or manifestation). In a publication, I argued that when using concept mapping with the children, '[the teachers'] objective appears to be the stimulation of children's critical thinking skills as well as the social interactions among peers' (Gomez 2006, p. 33): through language and guided conversations with the teacher(s), the children established relations between objects or between words and drawings. See the work of Figueiredo *et al.* (2004)*,* Mancinelli *et al* (2006), and Mérida (2002) for evidence of how this was achieved.

Peréz-Cabani *et al*. (1992) claim that some cognitive skills were developed during the process of using maps: to classify, to make relations, to memorise, to evaluate. Also, they argue, the children learn meaningfully through the process of hierarchically organising knowledge that is constructed through the interactions that occur in the classroom. Other authors have made similar claims, arguing that the comparison and sharing of the maps favoured the development of socialisation, verbal and iconic language: ‘Active inquiry and creative participation, attentive observation of experience stimulate the child to ask questions to himself/herself and formulate the first hypotheses’ (Mancinelli et al. 2004, p. 2).

Developed by the experts reported in this section, these adaptations or approaches to preschool concept mapping, grounded on Ausubel’s and Novak’s respective theories, have some educational value. They enabled children to learn to organise and represent knowledge with abstract symbols and high cognitive strategies (e.g. hierarchy, manipulation of abstract symbols) in a manner that is usually reserved to the learning experiences of older children and adults.

The representational, organisation and labelling skills of the children who interacted with those approaches were improved, as those children had to assign conceptual meanings to symbols (individually drawn or picture cards), organise them in a pattern or sequence, and verbally explain to the teachers why these have been done. Mancinelli *et al.* and Mérida claim that each drawing represents a child’s thoughts and acquired concepts (2004; 2002).

Children age 3 to 5 could make symbol-based maps. Depending on the intensity of the instructions, these maps were limited either to universal themes or complex concepts. 4- and 5-year olds made group maps with teacher mediation. However, after intensive instruction, 5-year olds could make symbol-based maps individually or in small groups, of not only universal themes but also of personal themes such as, ‘What did you do over the holidays?’

On their students’ mapping activities, Mancinelli and colleagues concluded that:

> Concept maps proved useful because they stimulated and facilitated children’s reflections on experience and experience organization, making meanings and knowledge emerge in the children. The comparison and sharing of learning favored the development of verbal learning and iconic language as well as socialization (Mancinelli 2004, p. 1).
>
> … Concept maps facilitate reflection, experience organization, [make] meanings and knowledge emerge in children. They favor the development of language and socialization (Mancinelli 2004, p. 3).

Figueiredo *et al*. (2004) say that children's reflective thinking was evident during the concept mapping sessions and evaluative interviews. Also, when the students were interviewed about what they think concept maps are for, five out of ten students 'identified the map as a scheme, a whole, [an] organised structure of concepts that helps us to '…know what we know about the cow'. The first group makes a metacognitive statement: the map helps to know and to monitor what we know…' (p. 3).

In the same way Mérida asserts that the symbolic representations of the concept maps drawn by the students are expressions of the evolution of their abstract knowledge. For achieving this and as a way to speed up the mapping process, Mérida's instruction included a method to move children from drawing iconically to drawing abstractly. In her article, she concludes that despite individual difference, all her students' symbolic representation skills increased and evolved as a result of a systematic and structured interaction with concept maps. Figure 2.3 is a concept map about 'La Guerra', in English 'The War', and Mérida says that it explicitly shows these four children could produce and organise abstract knowledge of topics that she considered beyond their age range, 5 years of age (Mérida 2002). Translated into English, some of the concepts and propositions of this map are:

- The war → there are soldiers → good and bad
- The war → use weapons and they are handled by → the soldiers → to kill
- The war → people → fight for money the war → there are bad men → and they are put → in jail

Future work: new claims, debates, and feature directions

Based on their experience, these experts have raised some claims regarding children's ability to make concept maps. Mérida (2002) for instance has claimed that children under five years of age cannot make maps individually and that five year olds can only represent certain type of concept maps, which she calls *'mapas preconceptuales'*. The drawings and connections the children create to build these kinds of maps, in her view, represent a process of concept formation, not a process of concept assimilation. With her existing approach, children structured knowledge by rearranging and modifying existent conceptions, not by making hypothetical combinations with abstract ideas. Merida's viewpoint is fueled by Ausubel's definition of concept formation (Ausubel, Novak & Hanesian 1978) and ignores Novak's explanations and anecdotal examples on the basis that by the age of 3, children can assimilate concepts either via concept formation or concept assimilation (see chapters 1 and 4). On the other hand, Mancinelli *et al.* (2004, p. 1) implied that '[a] study, for instance, showed that the concept grid disclosed by the map basically reflects the same structure of children's interviews and drawings'. These authors did not explain their respective claims further. These claims are discussed in chapter 9.

Debates about whether pictures, drawings, or concrete materials are more appropriate to represent concepts occurred in one of the FOD forums (FOD 2004a). On this topic Figueiredo *et al.* (2004) provide a viewpoint and discarded the idea of using concrete materials '[r]eplacing concepts with pictures seemed more suitable than using real objects. It was important for the group to understand that the map was a representation of ideas' (p. 1). However, on the use of drawings they reported that future work would involve designing mapping activities where the children are instructed to draw the symbols for the maps. They would also plan for a method to enable children to represent hierarchy without teachers' assistance or preset visual aids when working on individual maps.

Three FOD forum teachers expressed a view that maybe concept mapping should not be used with preschool age children, as it may not be appropriate for their level of development and understanding. One of these teachers commented that even if we identified more suitable concept mapping tools to work with, the preschool curriculum and expectations are focused in socialisation, play, development of motor and perceptual skills, as well as primary concepts related to numeracy and vocabulary (FOD 2004a).

Other groups of FOD forum teachers raised several questions concerning: how to organise instruction to keep children's attention for longer intervals than 15 minutes? What kinds of strategies should be developed to help children understand the mapping process so they are able to represent mental images about a subject matter with it? How can a collaborative environment for concept mapping be developed where everyone can interact? And what kinds of strategies can be used to assist children in the process to understand the technique in a shorter period of time? Despite the growth in reports on other experiences in this area, these questions remain unanswered.

The claims, debates and questions of these teachers are discussed further in chapter 9 together with the results of the case studies (chapters 7 and 8). In that chapter I also discuss the key aspects of Novak's concept maps (see chapter 1) that the teachers did not consider in their practice and investigations.

Analysis of the gaps from a design perspective

So far this chapter has looked at five learning experiences where teachers have used concept maps (or a variation of concept maps) to enhance preschool children's learning. The educators, whose work was presented in the first part of this chapter, have drawn on an educational perspective to develop their alternative preschool concept mapping approaches. They have not looked at the development of concept maps from a design perspective. In this section I use a user-centred design perspective to describe the concept map and its functions. I then analyse the five experiences as interaction design problems. This analysis opens an opportunity to design a tool for concept mapping that does not have the inherent problems of the five experiences discussed in the previous section.

Explaining the concept map template from a user-centred design perspective

The anatomical structure of a concept map template can be analysed using user-centred design concepts. The template has perceived affordances and cultural constraints. Affordances can signal how a thing operates, (e.g. a chair affords ('is for') support and, therefore, supports sitting). Affordances suggest the range of possibilities while constraints limit the number of alternatives to interact with a thing. When we use this term in relation to software or visual representations of any kind, the terms perceived affordances and cultural constraints are used. The thoughtful use of affordances and constraints together in design lets a user determine readily the proper course of action, even in a novel situation (Norman 1990).

The concept map template affords ‘downloading’ concepts or ideas that humans hold in their head about something into a graphical pattern. According to Wandersee (1990), this graphical pattern was designed to parallel human cognitive structure. The constraints or building laws of this pattern enable the author of the map to organise his or her conceptual ideas about a particular topic. In Novak’s terms, the concept map helps to organise knowledge and structure it, piece by piece with small units of interacting concept and propositional frameworks (Novak n.d.).

When we are instructed in the making of concept maps, besides being taught to read the map in pairs of the pattern concept → linking phrase → concept, we are also taught to organise concepts in a hierarchical order, differentiate more inclusive concepts from more specific ones, identify cross-links, etc. These rules for constructing the map together with the constitutive elements of a graphical pattern enable the author(s) and reader(s) of the map to make the actions (ask questions about the content, suggest more concepts, suggest re-organisation, etc) that promote knowledge organisation, active inquiry and meaning negotiation (Coffey et al. 2003).

I see the components of Novak’s concept map template as interdependent. If one piece is taken away, we cannot see the complete picture of the representation of someone’s cognitive structures. All its constitutive elements are important and play an active role. The template gives us concepts enclosed in boxes and linking phrases on the lines that connect two or more concepts. The linking phrases qualify the relationship among those concepts. The concepts are labelled with words. The words are represented with written language. The rules to arrange the template constrain the way the concept map elements are arranged. Such organisation gives us a better idea of how the concepts in a particular domain of subject matter are connected. The rules are: focus question, the most general concept goes at the top and then more inclusive concepts follow down below in a hierarchical order. The most specific concepts are arranged at the bottom of the map. There are other rules but they are not relevant to this particular issue.

In chapter 1, I explained that without a template and all its components, the building rules are inapplicable. I do not wish to repeat that argument, suffice to say here that the template affords the representation of knowledge held in the brain in an organised manner. The rules constrain the way that this knowledge is represented to facilitate understanding, knowledge retention, preservation and sharing. Knowledge retention is possible because the concepts have a spatial positioning in the map, which aids memory recall. Knowledge sharing is possible, because the template is a type of code system that can be interpreted by people who posses the skills to read the map and understand the concept of hierarchy. Knowledge preservation is possible because the map can be kept as it is for a long time, can be put away, and developed.

The interaction design problem: mapping of concepts (thoughts or ideas) is not occurring

Wandersee (1990, p. 923) says ‘a map is a bounded graphic representation that corresponds to a perceived reality’ and uses symbolic representations (or symbolic conventions) that can be interpreted by a group of people. Hoffmann (2007) explains ‘a sign’s meaning depends on interpretation. This intrinsic relativism of Pierce’s semiotics is constrained both by the community of sign users and an evolutionary development of sign meanings that is integrated in the process of science’(p. 7). Wandersee also argues that for a map, any kind of map, to be accessible to an audience, the map has to use codes that the audience can read and interpret. Depending the contextual application, a map is a way of knowing, of knowing where we are, what we need to do next.

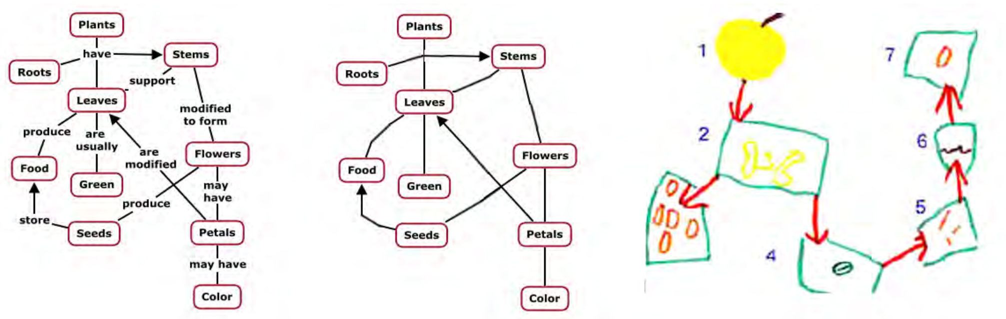


Figure 2.5 — a) left: Novak’s concept map, b) centre: a map with concepts only, c) right: a symbol-based map

Figure 2.5 shows three types of knowledge representation tools:

- Figure 2.5a, left, is a Novak’s concept map on plants. The concept and linking phrases are clearly labelled with written language. We know that concepts are the words enclosed in boxes and that linking phrases are the words located on the connecting lines. A concept map is a window to someone's understanding of a piece of knowledge. As a knowledge representation tool the constitutive elements of a concept map are pivotal to its effectiveness in helping people work with an external representation of their thoughts or their ideas collaboratively or individually (Novak & Gowin 1984).

- Figure 2.5b, centre, is a concept map on plants. For the purpose of my argument I have adapted Novak's map on plants by removing the linking phrases. Maps of this kind, that is, maps without linking phrases, are not concept maps under Novak's definition (Novak & Gowin 1984). Literate people can read the concepts, however, the relationships between the concepts are not explicit. Every person reading the map can make a different interpretation of how the concepts relate to each other, which defeats the purpose of Novak's concept mapping. Webs of knowledge (Birbili 2006; Helm & Katz 2001) are called by some experts concept maps (Fleer 1996). Webbing was defined earlier in this chapter. Again these do not comply with Novak's concept maps because the concepts comprising the web are not organised hierarchically and the relationships among them are not explicitly defined with linking phrases.

- Figure 2.5c, right, is a symbol-based map on the pumpkin (Mancinelli 2004; Mancinelli & Guaglione 2004). A 5-year old drew this symbol-based map after an exploration of the insides of a pumpkin. Each symbol represents a concept and the connecting lines with arrowheads pointing down show the reading direction. However, without the teacher annotation it is impossible to explicitly see the meaning behind each symbol and how they relate to the concept 'pumpkin'. Under Novak's definition of a concept map, this symbol-based map is not a concept map because we cannot explicitly see how the symbol concepts are related to each other. Symbol-based maps generate problems that affect the nature of the mental interactions that children have with the knowledge being mapped and also affect the manipulation of external representations of thoughts.

From these comparisons, I argue that when a map is not properly designed or uses code systems that are not familiar to an audience, the map fails to meet the purpose for which it has been created. As a result of the map failing to reach out to its audience, an interaction problem of an interpretative kind arises. The reader of the map does not have enough elements to interpret the meaning of the map and make the necessary mental interactions involved in concept mapping. If the interpretation process is broken, the communication process is broken.

> An interaction problem arises in preschool cmapping when teachers modify Novak's cmap [concept map] to make it child-friendly. They remove written words and linking phrases, and instead teach illiterate children to cmap with unlabelled symbols. The brain, literate or illiterate, cannot interpret a symbol --> symbol pattern, as symbol can stand for either a single concept or a conceptual relationship. These symbolic maps prevent children's autonomous cmapping and do not make concepts and conceptual relationships explicit (Gomez 2007, p. 1748).

From the majority of the reports presented earlier in this chapter it is not possible to infer whether or not the children are mapping. Only one of the reports and the accompanying teacher's comment gives us the information that children were unable to map a symbol-based map. Figueiredo *et al*. reported on a situation regarding students' inability to represent hierarchical relationships without a visual aid:

> We were also interested in knowing what maps the children would build on their own – with no boxes or lines and without reference to the wall map. A blank sheet with the image of the cow and 25 pictures of the concepts learnt were given to the eight children present that day. All the students placed relevant images. A total of six children missed some concept about the cow: two missed two concepts and four missed only one. Only two children forgot to mention that people use cow's skin to make jackets and shoes and that the ox is the cow's 'husband'. Even with the visit to the dairy, two children didn't place the correspondent picture in their maps. Half the group (four children) didn't choose the meat image for the construction of the map. The whole group represented what the cow eats and the fact that it gives us milk. The group draw lines that linked different concepts (Figure 4) but no map represented correct hierarchical relationships between concepts. From the previous assessments we can conclude that the group had some understanding of those relationships. Still, there was difficulty in representing the hierarchy between concepts without any visual aid (Figueiredo et al. 2004, p. 4).

Maybe the children of Figueiredo and colleagues' study did not organise the symbols (picture cards) hierarchically because they did not understand the meaning of the concept 'hierarchy' in the context of making symbol-based maps. The instruction, more specifically, the examples or guidance given did not help children to understand the meaning of the concept 'hierarchy'.

If the children were concept mapping with the teachers' approaches they would be performing the following activities (or actions): making conceptual relationships among concepts, making hierarchical organisations, editing, revisiting, and sharing the conceptual meanings represented with the symbol-based maps with or without teacher mediation. These activities did not occur in many of the instructional programmes introduced here. Badilla provides a comment that may explain why many teachers of the FOD forums cannot effectively use concept mapping. She says that in the information technologies laboratory she finds it more difficult to make use of concept maps because of their structure. Among other aspects, there is a need to take into account the building of its vertical and horizontal elements, the hierarchical order, concepts, linking phrases, etc. These are all abstract concepts for children at this stage and between 5 and 6 years of age (Badilla 2004).

When it comes to preschool concept mapping, the symbol-based map fails, as the core elements (concepts and linking phrases) that made the template work for literate people, are not present. The replacement of written symbols with visual symbols removed or destroyed the ability to map the content. Thus, while the teachers' approaches are designed using materials and symbols that are familiar to the children, the code system has not been properly designed. We know that preschool children make conceptual links because they speak with concepts and propositions (see Figure 1.2), but they cannot make concept maps like older children because they cannot read and write (see Figure 1.1). This research was undertaken to find an alternative way for children to represent concepts and propositions, which they expressed verbally within a knowledge representation structure they can map.

Symbol maps do not make knowledge explicit

Concept maps were designed to help us explicitly see how a particular piece of knowledge is held in the cognitive structure. For instance Mancinelli *et al.* (2004) claim that the drawings used in the symbol-based maps represent children's thoughts. Considering that young children communicate some knowledge with symbols, her claim could be valid. However, symbol-based maps do not make children's cognitive structure explicit and do not conform to Novak's definition of concept maps. Such situations raise new problems: Unlabelled symbols: 1) allow for map misinterpretations, 2) prevent the introduction of abstract concepts, and 3) do not accommodate the insertion of linking phrases (Gomez 2006). These problems generate the interaction problem: children's inability to map concepts.

While the theory says that concepts within a concept map can either be labelled with written words or symbols, it is important to highlight that Novak was referring to mathematical symbols. Concept maps labelled with written language make explicit the learner's understanding of a particular piece of knowledge, compared to the ones labelled with symbolic language. Young children can describe the meaning of the symbols verbally, but sadly this knowledge is not explicit when it is represented with a symbol-based map. The symbols comprising a map structure are charged with knowledge that is not explicitly stated. Neither conceptual relationships nor concepts can be accurately interpreted, as every person (literate or preliterate) interprets the meaning of symbols differently.

The symbol map, with or without annotations, may not offer preliterate children the option of keeping track of and being critical of his/her own knowledge organisation, retention, sharing and preservation process. My research has assumed that the chances of forgetting the image meaning may increase with time and level of abstraction and the more abstract the image, the more likely it is that the child will forget its meaning. While these assumptions have not been tested empirically they do draw on conclusions put forward by experts who tell us that human memory performance is poor (Norman 1990; Novak & Gowin 1984) and that young children's memories are even more limited (Cowan 1997a). Symbol maps may not facilitate: 1) long-term knowledge retention because we are likely to forget the meaning of symbols, 2) knowledge sharing of the symbols employed, and 3) effective knowledge preservation because children, owner(s) of the map and peers, cannot revisit the meaning behind them.

Teacher instruction and teacher mediation

> Despite their uncomplicated appearance, concept maps are initially, difficult to construct. It may take as long as 8-10 weeks for students to become fully accustomed to the technique and to realize the potential for improving their understanding of science (Wandersee 1990, p. 928).

Intensive instruction is necessary for people to learn to represent organised knowledge with knowledge representation tools such as Novak's concept maps. This is supported by Figueiredo *et al.* (2004) who considered that the limited instruction time (in their case one day a week for four weeks) and the children's irregular class assistance affected their instruction outcomes.

Novak, however, referenced work with a 6-year old, called Denny, who learnt to make a basic concept map within 30 minutes of instruction. See the map in (Novak 1998, pp. 53-54). In that work, instruction was coupled with particular materials. From that research it is possible to conclude that for instruction to succeed, instruction length should be coupled with suitable materials and learning strategies. Most of the teachers referred to in the experiences in this chapter were not using appropriate materials. This resulted in the children being dependant on teacher assistance during every step of the building process. I argue that, if children do not have full ownership or authorship of the mapping process, or an understanding of the process being performed, or why they are using concept maps, the symbol-based maps can transform a meaningful learning process into a rote-learning (boring) task.

On the issue of difficulty, Badilla (2004) says concept maps are seen as an excellent choice to work through topics with children, as they constitute an educational resource to represent acquired knowledge or knowledge that is in construction. However, she adds, many educators do not use this technique because they find its instruction difficult, and many times, find it too complicated to apply with very young children. On the issue of rote-learning, some FOD teachers (2004a) and Alí Arroyo (2004) expressed that children find the activity boring and that sometimes they find themselves doing the maps for the children or imposing or influencing their responses.

On the issue of representation, one forum teacher explained that it is not easy to help children understand the difference between schemas and concept maps. The issue is that the children cannot tell them apart and the explanations about their differences seem not to suffice (FOD 2004a). This is another reason why it is important to design features that differentiate concept mapping from other tools.

The majority of these teachers have attempted to overcome the problem of making meanings explicit by instructing children to construct simple symbol-based maps about universal themes (e.g. the family, means of transportation, etc) and predetermined concepts, where the range of concept production is limited to one general concept and many specific concepts. With symbol-based maps of this kind, the active inquiry and meaning negotiation happens around very simple concepts whose meaning are quite specific, and can be easily represented with symbols (e.g. dogs, cats, etc).

Teachers' mediation is provided in every step of the building process. Children required assistance for manipulating, labelling, and hierarchically positioning symbols (representing concepts, linking phrases, and propositions) on the blackboard or butcher paper. Making maps with heavy teacher mediation is a strategy that Mérida (2002) used in the introductory sessions of her case study (e.g. the whole class and the teacher make a concept map about the human body. The teacher employs guided conversations to 'extract' the children's knowledge about the topic).

In these sessions the children were instructed on the steps involved in building a concept map with her technique. Makings maps this way, Mérida explained, kept children's personal contributions to the map building limited, and all the maps looked very similar (homogeneous) because the children restrained themselves, and only reproduced the template (*esquema*) of reference that was drawn on the blackboard.

To address this issue and get away from mechanisation and repetition, Mérida instructed the children to make symbol-based maps individually. See more details on this in Mérida (2001-2002). Another way to address the process is maybe to teach the children to work with one type of symbol-based map and for one purpose. Mancinelli *et al.* (2004) taught the students to make maps for representing lifecycles or processes. In these two cases the children were able to build the maps individually, because they understood the instructions and the materials employed to represent the symbol-based maps. This is opposite to the majority of experiences shared in the forums (FOD 2004a, b) and in Figueiredo *et al.* (2004).

Forums' participants expressed their frustration and worries about support and instruction. They found instruction difficult despite the dedicated time they had for it (40 minutes two times per week in the academic year). Figueiredo *et al.* also commented on their lack of success when the children were invited to work without pre-set visual aids. In my view this reveals that the children did not understand the concept of hierarchy, therefore they were not able to organise the symbols hierarchically without teacher mediation and visual aids.

Good scaffolding strategies and educational materials facilitate instruction. The combination of both enhances teachers' mediation and makes students autonomous learners. In most occasions, it appears to be that the materials given to the children to make symbol-based maps did not assist them in the process of representing the knowledge held in the head and in understanding how to build the maps.

Some participants in the FOD forums and Badilla (2004) did not explain concept mapping to the children. They considered that it was not necessary, as concept mapping would be a complex topic to explain. Their considerations are contrary to expert recommendations: the student should be aware and understand what is involved in the process of building the concept map (Novak & Gowin 1984, pp. 24-

49). Explaining to children the process for understanding what they are doing with the mapping tools is pivotal for increasing their understanding and improving instruction. Mérida's work is an example of how this can work. After many hours of training, her students developed an understanding of what they were doing. Such understanding prompted children to suggest a more effective way to represent the symbols to represent hierarchy when building each branch of the symbol-based maps. This was done to avoid confusion (Mérida 2002). See Figure 2.3.

Lack of autonomy

A direct effect of teacher mediation in every step of the process is that children are not in control of the map building. They are not manipulating the representation and the manipulation of thoughts or ideas represented with symbols in schematic forms.

It is important that children are able to label the concept maps themselves, for the mapping strategy to disclose their thoughts or ideas about a particular topic. Novak says that it is the process of selecting and organising knowledge that makes concept maps so powerful for the development of learning. When concept mapping, the learner have to identify and select the knowledge to be learned in order to construct new knowledge by the observation of events or objects, using the concepts they already possess (Novak 1998; Novak & Gowin 1984).

The materials used to make symbol-based maps do not facilitate autonomous manipulation of symbols (representing concepts and propositions). These materials are close to static. Once the children draw the map with symbols on a piece of paper, it is hard or impossible to re-arrange them. This is contrary to the materials or tools used in literate people's concept mapping: they can easily move concepts and linking phrases around, because post-its on a whiteboard or a software application are employed.

Annotated symbolic maps disclose children's knowledge about a particular domain. However, it is equally important the children annotate their concept maps by themselves, to enjoy all the learning benefits this knowledge representation tool can offer. Annotating the map with the children's verbalisations is a solution that appears to benefit teachers only, but not necessarily the children-owners of the map. The teachers have transformed the symbolic maps into instruments for analysing and evaluating knowledge acquisition. By doing this, Mancinelli and Guaglione (2004), Mancinelli *et al.* (2004) and Mérida (2002), have tacitly acknowledged the importance of making knowledge explicit by labelling concepts and including linking phrases in the concept map.

Knowledge organisation, active inquiry and meaning negotiation is close to passive

The analysis of the mapping activities undertaken by the teachers of the five reported experiences suggested that the children's mental interactions with the symbol-based maps might be close to passive during instruction. The symbol-based maps created with the teacher approaches do not allow for mapping as stated by Novak. The majority of reports do not show evidence that the interactions with the symbol-based maps promote knowledge organisation, active inquiry and meaning negotiation in the form that Coffey *et al.* describe it:

> A major lesson learned regarding the use of Concept Maps in educational settings is that the nature of the learner's mental interaction with the subject matter to be learned during the building of the concept map is key to the learner's achievement. The interaction cannot be passive if learning is to occur. Concept Mapping is greatly enhanced when a teacher (or other 'facilitator' working with a learner), the learner him of *[sic]* herself, a device (e.g., *[sic]* computer generated prompts), or the nature of the interaction in a learning group promotes active inquiry and organization by asking questions, prompting for explanation and justification, requesting clarification, requesting embellishment, encouraging connection among elements, encouraging the learner to formulate questions about the material, and so forth (Coffey et al. 2003, pp. 9-10).

These teachers' reports did not include information about active inquiry and meaning negotiation resulting from interacting with the content of the symbol-based map, once the map has been finalised and in the manner described by Coffey *et al.* in the quote above. The reports do not describe situations of children asking questions prompting for explanations and justification, requesting clarification about the relationships among concepts, encouraging connections among the elements or formulating questions about the symbols comprising the symbol-based map.

Active inquiry and organisation is also affected by the limited ability of children and teachers to negotiate meaning when employing symbol-based maps. This is important, as Novak considers meaning negotiation the major advantage of using concept maps:

> …the same word can have significantly different meaning for each person. This is why we emphasize the constant need to negotiate meanings between teacher and learner… One reason we are enthusiastic about concept mapping as an instructional and evaluation tool is that concept maps can be enormously useful to teachers, administrators, and learners to move toward sharing the same concept meanings for the words or symbols presented. They can also be helpful to move the learner from mere representational meaning to richer conceptual meaning (Novak 1998, p. 38).

Thus, we can understand that the symbol-based maps are not enabling children to interact in the way that Novak's concept maps are designed to work. Peréz Cabani *et al.* (1992), Mancinelli *et al.* (2004), and Mérida (2001-2002) do not see this as a problem, as what they regard as important is the mapping process, not the quality of the built map. During mapping, they say, children are developing skills in the areas of critical thinking (e.g. clustering and hierarchy), meaning negotiation (e.g. symbol appearance), collaboration (e.g. turn-taking), socialisation, representation (e.g. moving from iconic to abstract language), among other skills. The educational value to preschool education of these approaches is not denied, as they fit perfectly within the goals of many early childhood programmes, and address an area of learning that is not usually addressed in early childhood education (Mérida 2001-2002). While their reasoning is not rejected, I argue that such experiences can be made much richer and more effective if the mapping tools employed provide components that facilitate autonomous behaviour and knowledge 'explicitation' or in other words make the representation process explicit. I would argue that as children become autonomous map-creators, abstract content can be introduced, and as a consequence of this, a broadening of the content of areas under study becomes possible.

Children's knowledge is in the symbol-based maps, as the symbolic drawings represent their thoughts according to the claims of Mérida (2002) and Mancinelli *et al.* (2004). But this knowledge is not explicit, cannot be revisited, and also, represents less meaning than verbal language. See the transcripts of the clinical interviews of the reports of Figueiredo *et al.* (2004), Mancinelli *et al.* (2004) and Mérida (2002) to corroborate this.

Summary

In this chapter I argued that the concept map template makes conceptual knowledge explicit when compared to symbol-based maps. To support my arguments I analysed five teacher experiences in preschool concept mapping by evaluating the adaptations made to the template for use with their students. The evaluations were grounded in Novak's template and its underlying theories and included an explanation of the problems from an interaction design perspective.

I debated teacher-mapping approaches by arguing a claim that the barrier for preschool children to concept mapping has to do with the materials used to develop symbol-based maps. Novak's template facilitates knowledge retention, preservation and sharing. Literate map creators can represent all the components of this graphical hierarchical structure (concept → linking phrase → concept) and also have a good understanding of the concept of hierarchy. Symbol-based maps do not enable literate or preliterate people to disclose knowledge. Symbols do not make knowledge explicit.

The interaction design analysis showed that children are not really mapping with the teacher approaches: these maps use materials familiar to the children, but the children do not understand the code system related to abstract conventions (e.g. hierarchy). Children's knowledge organisation, active inquiry and meaning negotiation is limited with any kind of symbol-based map because its constitutive elements do not enable them to interpret conceptual meanings.

The teacher mapping approaches described have some educational value. They have enabled children to represent some types of organised knowledge with symbol-based maps (Gomez 2005b, 2006). Despite this, I argue that these approaches require heavy teacher mediation during the building process and many hours of instruction in order to succeed. This is contrary to Novak's theories and lessens their value and impact as effective knowledge representation tools.

My claim (investigated in this research) is that to reach the three Ausubelian conditions of autonomous meaningful learning, the current teacher tools for concept mapping need re-designing to give full ownership of the authoring to the child (Gomez 2006). Introduced in chapter 1, these conditions are language relatable to the learner, ability to access prior knowledge, and wanting to learn (Ausubel, 1968 in Novak 1998).

Children need to be given control of every aspect of the map building to overcome the gaps presented in this chapter. The limited autonomy over the building process '… may be resolved by designing interaction tools that facilitate this age group to represent cmapping [concept mapping] patterns with their already mastered communication skills: spoken and visual language [1]' (Gomez 2007, p. 1748).

The research claims and issues that were presented in this chapter were examined from an interaction design perspective. In the design phase (chapters 3, 4, and 5), I present the reasoning behind the design of a functional prototype tool for preschool concept mapping. This prototype was used in the case studies, which are presented in the case study phase (chapters 6, 7, and 8). The next chapter describes the Bridging Design Prototype Method, or BDP method, and its theoretical underpinnings.

Design Phase

This phase is reported in chapters 3, 4 and 5

Chapter 3 – The Bridging Design Prototype Method

Overview

Chapter 2 was dedicated to explaining the issues in preschool concept mapping, and the research problem from an interaction design perspective, and presenting the activities a suitable concept mapping tool for young children should promote. In this chapter I draw from those activities and introduce the Bridging Design Prototype method and its underpinning methodologies. This method was used to develop a functional prototype that could be incorporated into a preschool classroom.

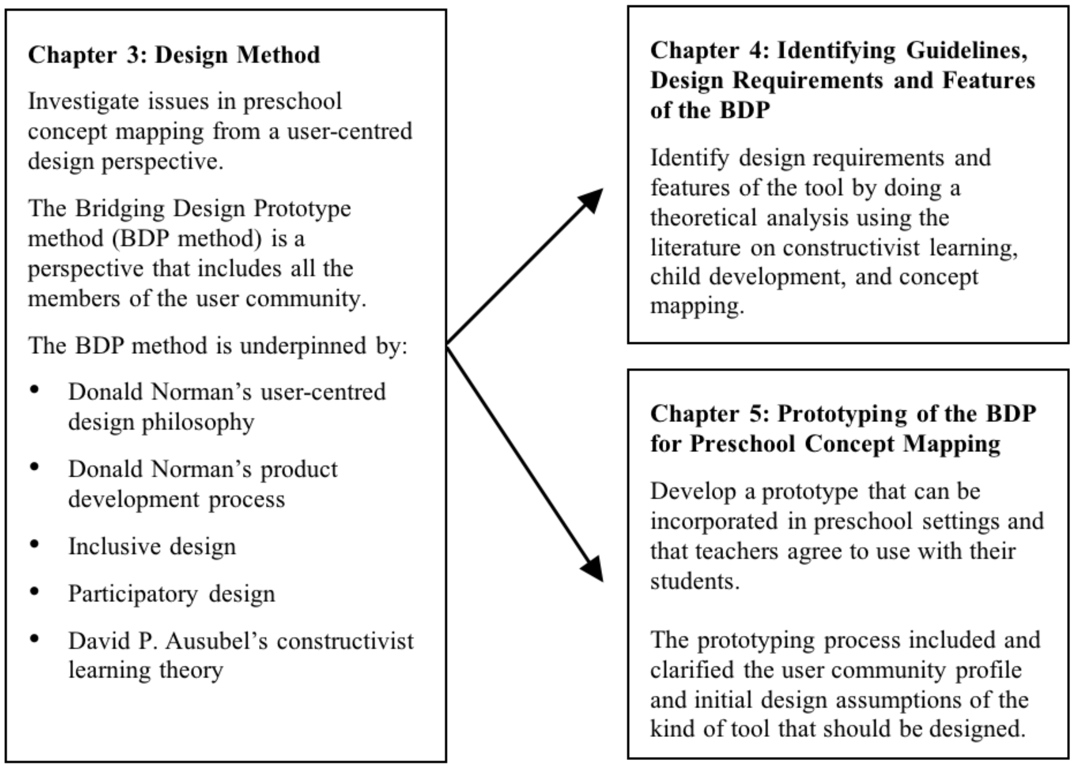


Figure 3.1 – the design method and its application

The diagram of Figure 3.1 places this chapter within the context of chapters 4 and 5. Chapter 3 deals with the design method as it relates to the development of a tool that can be used to investigate the research claims. Chapter 4 is devoted to the identification of the design requirements for the practical outcome, the prototype tool that was used in the case studies. Chapter 5 explains the prototyping process of that tool.

The philosophy behind the Bridging Design Prototype method

The Bridging Design Prototype method (BDP method) emerged from the way I applied aspects of different user-centred design methods and a learning theory to achieve the research goals. A multiple design method approach was needed to:

- Implement a tool that could be successfully incorporated into natural preschool settings.

- Investigate the research claim set out in chapter 1 and solve the interaction issues analysed in chapter 2. Columns 1 and 2 of Table 4.2 summarise claim and issues respectively.

The issue of applying user-centred design methods to the development of tools for enhancing instruction and learning has been reported. It is recommended to adjust the user-centred methods by incorporating notions from literature explaining how people learn (Quintana et al. 2002).

Using constructivist learning theories in the design of technologies for children is not new. Several constructivist technology-based projects for early childhood environments have been successfully developed following user-centred processes. See for example the following projects: PenPal (Piernot et al. 1995), 'Construction Kits made of Atoms and Bits' (*Construction kits made of atoms and bits - CAB project* n.d.; *Interim report of the developmentally appropriate technology in early childhood (DATEC) project* 2000; Penner 2000), Young Children as Technology Design Partners (Guha et al. 2004) and Ely the explorer (Africano et al. 2004).

The observation of the users doing tasks relevant to the product in their work setting is a requirement of Norman's (1999) user-centred product development process that allows for learning about the user's context and assessing their needs. His process, however, does not address what needs to be done when we cannot observe the users doing the tasks related to the product to be designed. This was the case in my research. My specific user community, or at least the members I contacted, did not use Novak's concept maps as an educational resource in their practice, which in consequence, indicated to me that the proposed product was novel to this user community.

The BDP method is grounded in Donald Norman's user-centred design philosophy, inclusive design, participatory design, and Ausubel's theory of learning. This method informed the conceptualisation, development and implementation of the functional prototype or BDP that was used in the case studies (chapters 7 and 8). The combined application and adaptation of different aspects of these design methods and learning theory resulted in the emergence of a prototyping method that can be used to investigate difficult-to-access and technologically disinclined user communities. The BDP method provides principles of how to introduce a new product into a community while taking into account their needs and context realities. The user-centredness of my research depended on how well I represented the interests of the users in my designs within the heavy constraints around my research.

The BDP method I define in the following manner:

> A BDP is a functional prototype including features familiar to users, together with novel features the researcher chooses to incorporate after careful analysis of relevant data. It capitalizes on users' prior knowledge (embodied in techniques, theories, instruments) and recognizes their context realities. These characteristics bring them into the development process early: users incorporate the prototype into their work while the researcher employs it for observation (Gomez 2007, pp. 1747–48).

My specific user community was difficult to access because preschool concept mapping, the research topic I was investigating, was unfamiliar to them. Concept mapping is a learning tool that is not used in the Australian and New Zealand preschools, the communities I first established contact with. Teachers considered this tool irrelevant to their classroom practices. Also, they were technologically disinclined – specifically they did not use computers with their children. Therefore, alternative ways to digital rapid prototyping tools were required to find out about their needs in relation to concept mapping.

An important characteristic of BDPs is that they are functional prototypes that continue evolving even during the evaluation period (chapters 7 and 8). The users can change aspects of the prototype by adding different elements or replacing the ones that do not fit with their needs. This is where the relationship between inclusive and participatory design characteristics comes into place. The relationships can also be seen in the way teachers incorporate educational resources to be used with their students: that is, the materials that teachers assign to children after observations could be considered functional prototypes. See more on this in the chapters of the case studies (chapters 7 and 8) or consult the work of Curtis and Carter to learn about the methods used to design ongoing educational learning environments for the preschool classroom (Curtis & Carter 2000; Curtis & Carter 2003).

What is relevant to this thesis is that a functional prototype developed under the BDP method allowed me to: 1) initiate a relationship with several members of my specific user community, 2) identify members that were willing to incorporate a BDP for preschool concept mapping into their classroom, 3) observe the user community using the BDP in their natural setting while I performed observations, and finally 4) develop BDPs or functional prototypes that fitted their environment, but also fitted my research interests.

Concept mapping is not part of the curriculum of my specific user community, the Australian and New Zealand preschool communities. I developed a product that they could understand (shared conceptual models), that did not challenge the classroom rules, or their educational processes, and did not require training. This product meant that I was able to engage members of these communities with my research. The user-centred design methods and learning theories presented in the next section provided concepts that were applied to achieve such BDP for preschool concept mapping. In chapter 5, I present the prototyping process that I employed to achieve this product.

The main application of the BDPs was to investigate my research goals. However, an unexpected outcome which I observed in that process was; that by interacting with the BDP the community changed perceptions about issues regarding concept mapping and the use of technology in the preschool classroom. By enabling people to take control of the process through the design of the authoring features, I developed an understanding of the developmental, cultural and representational issues that generated the concern in preschools about using concept mapping.

BDPs fall under the category of prototypes that are user-centred, inclusive, participatory, and improve learning. Explained in the upcoming section, its foundational concepts are grounded in principles of Norman's user-centred product development, inclusive design, participatory design, and social constructivist theories of learning. Drawn from the same concepts, the characteristics of BDPs are listed:

- BDPs have familiar features that were designed based on an understanding of the prior knowledge of the user community. This prior knowledge is represented in their theories, techniques, and instruments.

- BDPs only present novel features that are designed according to relevant data gathered with a diverse array of methods and according to the research constraints. The novel features have to present aspects familiar to the community or that required little training to become part of the BDP.

- The process of designing a BDP includes the development of low-fidelity prototypes. These are used to understand the context realities and the user profile via interviews with key expert informants.

- The objective of a BDP process is to get the community on board early and test concepts even before having a final product.

The design methodologies of the BDP method

The objective of the design process, explained in chapters 4 and 5, was to identify a tool that enabled the interactions presented in chapter 2 and that could also be incorporated into preschool settings. I used aspects of the learning theory of Ausubel (1978) and aspects of Norman's design philosophy (1990; 1999) to investigate the characteristics of such a concept mapping tool.

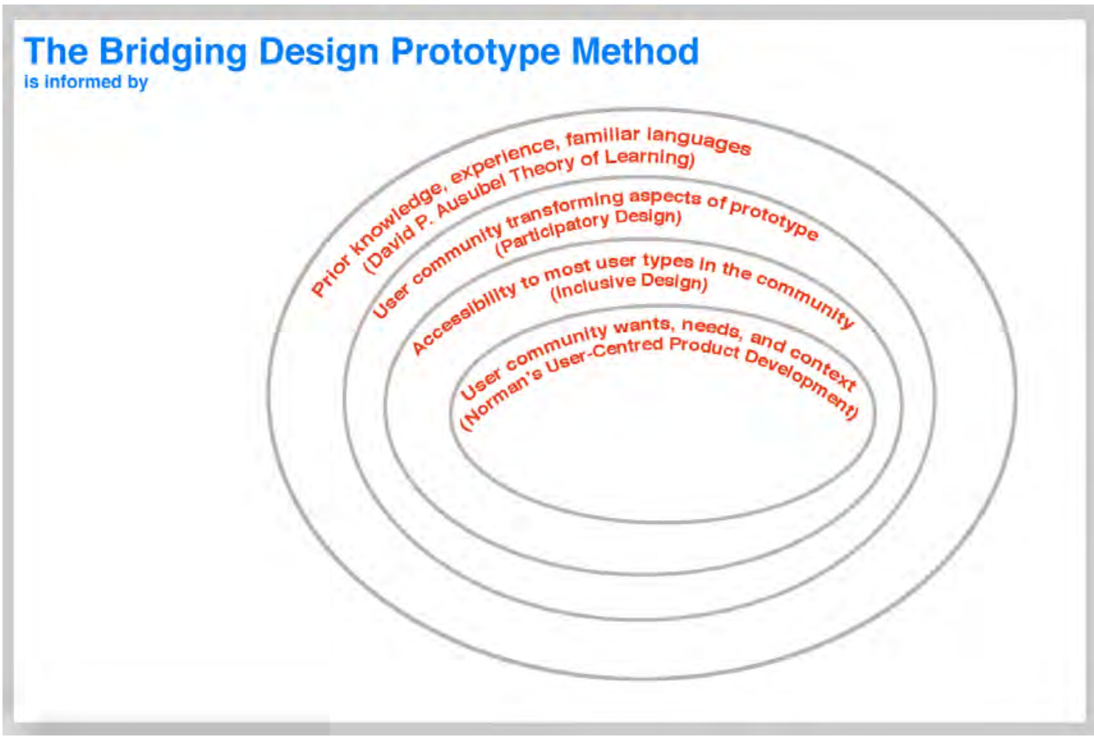


Figure 3.2 – the BDP method, a graphical interpretation

Educational resources for the preschool classroom are often designed with a developmental and educational perspective, which requires an understanding of the theories and approaches of learning and child development. Designers also ground the development of children's educational technologies on child development (Africano et al. 2004; Hakansson 1990; Piernot et al. 1995; Wyeth & Purchase 2002). If I was to design an educational technology, I needed it to be informed by theories and approaches of learning and child development.

Together with Norman's user-centred product development process (1999), participatory design and inclusive design concepts, I employed learning concepts derived from Ausubel's theory of learning (1978) as explained by Novak (1998). I used all these concepts to analyse the users' (children and teachers) needs and their interactions with tasks relevant to the concept mapping activity.

These design methodologies and learning theory appear to have elements in common, as they all seem to draw knowledge from the area of developmental psychology theory, specifically from information processing. For instance, Ausubel's conditions for meaningful learning (see chapter 1 section 'the conditions for meaningful learning) share similarities with Norman's characteristics of a meaningful experience when using a tool. Both processes recommend prior knowledge, experience, and familiarity as important elements to achieve some kind of learning.

In my view, Ausubel's concepts of meaningful learning provided conditions and guidelines for designing tools that enhance or improve learning processes. Norman's user-centred design philosophy as well as the methods of inclusive and participatory design provide principles enabling designers to develop tools that can be easy to use and integrate into people's natural settings. The aspects of the theories of learning and the design methods chosen to apply, helped me to develop a BDP that: 1) was easy to learn to use, 2) enabled children to autonomously make concept maps as stated by Novak, and 3) facilitated teacher instruction.

Participatory design and inclusive design are also approaches to user-centred design. They share similarities with Norman's philosophy, but there are a few differences. Norman's (1999) process suggests the user participation in the design process, while participatory design considers the user as designer in the process (Schuler & Namioka 1993). Norman's seven-steps approach and Keates and Clarkson's seven step approach to designing user-centred products are very similar. These approaches are considered in greater detail later in this chapter, suffice to say here that the difference between the approaches is that inclusive design makes countering exclusion and accessibility an important element of the design process (Keates & Clarkson 2003). Thus, I needed to find an appropriate way to include my users in the development of my prototype. Next I present the concepts excerpted of each design methodology and learning theories that underpin the Bridging Design Prototype method.

Donald Norman's user-centred design method

Norman's user-centred design philosophy is based on the needs and interests of the user, with an emphasis on making products that are usable and understandable. His user-centred design method provides principles and guidelines which can be followed when developing an iterative product development process that enables the designer to learn about the user's profile and 'true' needs. To establish the user profile and, simultaneously, the tool features that would enable the children to perform the actions for autonomous concept mapping and effective instruction, I had to develop a design using the following principles of Norman's approach: the design should make sure that the user can figure out what to do, and that the user can tell what is going on. I applied the following concepts of his philosophy to achieve such principles: 1) transforming difficult tasks into simple ones, 2) conceptual and mental models, 3) the seven-step principles from his Human-Centred Product Development Process, and 4) 'rapid ethnography' (Norman 1999,1990).

Transforming complex tasks into simple ones

Norman provides seven principles for transforming difficult tasks into simple ones. I used these principles during the prototyping stage to establish the user profile (wants, needs, and developmental limitations):

- **Use both knowledge in the world and knowledge in the head:** People learn better and feel more comfortable when the knowledge required for a task is available externally – either explicit in the world or readily derived through constraints. However knowledge in the world is useful only if there is a natural, easily interpreted relationship between that knowledge and the information it is intended to convey about possible actions and outcomes. Make things visible, including the conceptual model of the system, the alternative actions, and the result of actions.

  As much as possible, the device should operate without instructions and labels. Any necessary instruction or training should be given once; with each explanation the person should be able to say, 'Of course', or 'Yes, I see'. A simple explanation will suffice if there is reason to the design, if everything has its place and its function, and if the outcomes or actions are visible. If the explanations leads the person to think or say, 'How am I going to remember that?', the design has failed.

- **Simplify the structures of tasks:** Tasks should be simple in structure, minimising the amount of planning or problem solving they require. Unnecessary complex tasks can be restructured, usually by using technological innovations. This can be done through developing an understanding of the user community's cognitive, motor, and social skills.

- **Make things visible - bridge the gulfs of execution and evaluation:** Make things visible on the execution aspect of an action so people know what is possible and how actions should be done; make things visible on the evaluation aspect so that people can see the effects of their actions. The system (in my case the BDP for preschool concept mapping) should provide actions that match intentions and expectations, and should indicate the system state that are perceivable and interpretable by people (in my case children and teachers). Make the outcomes of an action obvious. Make it easy to evaluate the current state of the system.

- **Get the mappings right:** Follow natural mappings between intentions and the required actions; between actions and the resulting effect; and between the information that is visible and the interpretation of the system state.

  Exploit natural mappings, which are the basis of what has been called 'response compatibility' within the fields of human factors and ergonomics. The major requirement of response compatibility is that the spatial relationship between the positioning of controls and the system, or objects upon which they operate, should be as direct as possible, with the controls either on the object themselves or arranged to have an analogical relationship to them. The same condition applies to the movement of the controls, they should be similar or analogous to the expected operation of the system. Difficulties arise when the positioning and movements of controls deviate from strict proximity, mimicry, or analogy to the things being controlled.

  The same argument applies to the relationship between system output and expectations. A critical part of an action is the evaluation of its effects. The feedback must provide information that matches the user's intentions and must be in a form that is easy to understand.

- **Exploit the power of constraints, both natural and artificial:** Use constraints so the user feels as if there is only one possible thing to do – the right thing, of course. The design should make use of the natural properties of people and of the world: it should exploit natural relationships and natural constraints. Make it easy to determine what actions are possible at any moment (make use of constraints).

- **Design for error:** An error is simply an action that is incompletely or improperly specified. Think of the action as part of a natural, constructive dialogue between the user and system. Allow users to recover from errors, to assess what was done wrong and reverse the unwanted outcome. Make it easy to reverse operations, make it hard to do irreversible actions. Design explorable systems. Exploit forcing functions.

- **When all else fails, standardise:** Standardise functions when there is no option to design a device without arbitrary mappings and difficulties. People can learn standardised systems, no matter how arbitrary the system is. It has to be learnt once though. This is true says Norman of typewriters, keyboards, traffic lights and signals, units of measurement and calendars. It works well, when followed consistently. It is important to standardise soon enough to avoid trouble, but late enough to take into account advanced technology and procedures. Users need to be trained to use standards, sometimes extensive training.

Conceptual and mental models

> The construct, mental models, emerged from the human computer interaction field as a metaphor for describing the conceptions that humans develop for internally describing the location, function, and structure of objects and phenomena in computer systems. The facility with which users apply and exploit the functionality of computer systems depends on the internal, conceptual models that they build for describing the components and interactions of those systems. So, mental models are the conceptions of a system that develop in the mind of the user. Mental models are representations of objects or events in systems and the structural relationships between those objects and events. Most instructional designers assume that the design of instruction controls the mental model that is developed by the user, so an ideal user's mental model would be congruent with the conceptual model of the interface as developed by the designers (Jonassen & Henning 1996, pp. 433-434).

In this research, conceptual models were a key element for developing the BDP. Lessening the gap or making sure that the user community quickly learnt how to operate the system was relevant to achieve the research goals. One reason for this, explained further in chapter 5, was that the teachers did not have time to be trained in the use of the tool, and in consequence they did not have time to instruct the children either. The concept of mental models defined by Norman became the way to achieve a system or BDP for preschool concept mapping that required little instruction or none.

In relation to the development of devices, Norman (1990) says that the operation of any device (can opener, power plant, computer, etc) is learned more readily, and the problems are tracked down more accurately and easily, if the user has a good conceptual model. He identifies three different aspects of the mental models that must be distinguished:

- *The design model* is the conceptualisation that the designer has in mind.
- *The user's model* is what the user develops to explain the operation of the system. Ideally the user's model and the design model are equivalent. However, the user and the designer communicate only through the system itself: its physical appearance, its operation, the way it responds, and the manuals and instructions that accompany it.
- Thus the *system image* is critical; the designer must ensure that everything about the product is consistent with and exemplifies the operation of the proper conceptual model.

Norman continues by explaining that all three aspects are important. The user's model is essential, of course, for that determines what is understood. In turn, it is up to the designer to start with a design model that is functional, learnable, and usable. The designer must ensure that the system reveals the appropriate system image. Only then can the user acquire the proper user's model and find support for the translation of intentions into actions and system state into interpretations. Remember, the user acquires all knowledge of the system from that system image.

Developing a good conceptual model of the user in relation to the product to be used influences the ability to transform complex tasks into simple ones. I argue that the ability to create a good conceptual model relies on the knowledge that the designer has of the user community and his/her ability to incorporate this knowledge into the design of requirements and features of the tool.

Human-centred product development process and its principles

The Human-Centred Product Development Process is a process of product development that starts with the users and their needs rather than with technology. In this process, technology serves the user, technology fits the tasks and the complexity of the tasks, not the tool (Norman 1999, p. 188). This process was developed to provide technology-oriented companies with a mechanism to become user-centred. In fact, Norman explicitly says that if a company wants to become user-centred, the company has to change its operation.

To understand people and the tasks they wish to achieve, Norman's process stresses the importance of applying the following principles:

- Observing and working with users when performing tasks relevant to the device that will be developed. Observations should be performed in their natural settings;
- Using rapid prototyping techniques to visualise and analyse user's interactions with the product. This includes constructing and evaluating physical and software mock-ups of the envisioned product;
- Working in iterative, collaborative, multidisciplinary teams; and finally,
- Building a technology that fits the design specifications, mock-ups and prototypes based on the team inputs.

The process is applicable in a seven-step iterative and systematic approach. Each step represents a task with its own data collection instruments:

- Step 1: assessment of user's needs
- Step 2: study the market

- Step 3: description of the user's needs. (Put together a description with step 1 and 2)
- Step 4: create mock-ups of sample products (paper drawings, rapid prototyping tools, etc) and use costumers (or potential users of the product) as design assistants and have them play-act with the mock-ups developed
- Step 5: write the manual if one is needed
- Step 6: start the design process
- Step 7: continually test and revise

Later in this chapter I explain how the seven steps were applied and adapted to fit my research.

'Rapid ethnography'

Applied observation and testing are the preferred research methods of user-centred design methodologies. However, Norman says, applied science does not need the precision of the traditional science when it comes to the use of research methods. In industry, it is good enough to be approximately right. Speed comes before accuracy. When designing a product, designers need to know how to proceed when questions arise. They need answers rapidly. The answers can be estimates, and sometimes they can be wrong. The cost of an occasional wrong answer is small compared to the benefit of many fast answers. Human-centred development, he continues, is concerned with big, robust phenomena, effects that apply across a wide range of conditions. As a result, careful and laborious experimental methods are not required; big effects can be found with simpler methods (Norman 1999).

Human-centred development, Norman continues, uses a variant of traditional ethnography, one that I call 'rapid ethnography'. Ethnography is a branch of anthropology that deals with scientific description of human cultures. 'Rapid ethnography' is an observational technique for going to the prospective users of a product and observing the activities they perform, their interactions, and the subcultures in which they live, work, learn and play. It is critical to the invention of new product classes. New product concepts come from observation of the needs of prospective users, devising tools that will simplify and enhance their lives. The goal is to make the people who are being observed become participants in the discovery process of learning just what their real needs are – not the artificial needs proscribed by the way they do things today, but what the goals are, what they are striving for (Norman 1999).

Much progress has been made in the development of methods of estimation that fit the needs of the product development process. A series of methods called usability heuristics or cognitive walkthroughs have been developed that speed up the test process. One description of what a 'rapid ethnography' might look like is provided by a special form of rapid observations called contextual enquiry by the proponents of contextual design (Norman 1999).

Millen (2000) reported on 'rapid ethnography' and some of the methods used. He defined it as a collection of field methods intended to provide a reasonable understanding of users and their activities given significant time pressures and limited time in the field. The core elements include, limiting or constraining the research focus and scope, using key informants, and capturing rich field data by using multiple observers and interactive observation techniques, and collaborative qualitative data analysis.

Since Norman's 1999 recommendations on using 'rapid ethnography' methods, many more variations of this method of estimation have surfaced for testing products and processes that address users' wants and needs. The literature on this topic is extensive and presents varied viewpoints and approaches (Benyon, Turner & Turner 2005; Beyer & Holtzblatt c1998; Keates & Clarkson 2003; Kolko 2007b; Preece, Rogers & Sharp 2002; Raskin 2000; Saffer 2007; Sanders & Williams 2001).

The inability to spend time with the users in their natural setting prior to the case studies and the lack of control over the decisions of when and how I was to interact with the user community called for 'rapid ethnography'. Reaching out to key expert informants (via personal communication, informal meetings and at conference presentations) and studying related literature was my way to evaluate the BDPs during the prototyping cycles (chapters 4 and 5). In the preliminary case study (chapter 5) and the case studies (chapters 6, 7 and 8), I used participant, direct and passive observation. Different observation methods were use due to constraints such as teacher availability, school activity schedules, and teachers' suggestions of how I should spend my time in their school.

The data was not collected consistently or in a uniform manner during the prototyping process and the case studies. Because of this, I had different types of data and in different formats, which is completely acceptable under the concept of 'rapid ethnography'. From this different kind of data I was able to draw modest conclusions about the user profile and the kind of tool Australian and New Zealand teachers were willing to incorporate in their classrooms. The data gave me insight into a variety of issues such as the type of educational resources used in preschool, among other issues that are further explained in chapter 6.

Inclusive design

Inclusive design became relevant to this research when the profile of the Australian and New Zealand user communities was clarified and the clarification showed that computer-based prototype for preschool concept mapping was not an option for their classrooms. This was not an option because Information and Communication Technologies (ICTs) are not part of the curriculum of these communities, which meant that the proposed BDP should not require training teachers and children to use computers. See chapter 5 for more on this.

As defined by Keates and Clarkson (2003), inclusive design is about maximising the market potential of your products by making sure the maximum number of people can use them. It is an approach for designing products that should be used to appeal to the widest possible range of users (users with or without impairments, be they physical or mental). Inclusive design is aimed at users with different functional capabilities, including frequent users of the product (system or tool) or anyone who needs to interact with it for its successful operation such as installers, support and maintenance staff, and so on. Products usable for its primary purpose, can also require installation, maintenance, and decommissioning.

Inclusive design products considered for the whole population are public toilet signage, OXO kitchen tools, non-slip flooring, curb-cuts, and grab-shower bars.

Exclusive design products considered for a segment of the population are youth, functionally capable, elderly, computer literate, and Braille books.

In my view, an important contribution of Keates' and Clarkson's inclusive design to the array of user-centred design systems is the concept of design exclusion. Identifying WHY and HOW users cannot use a product makes it possible to counter such exclusion:

> The underlying principle of design exclusion is that by identifying the capability demands placed upon the user by the features of the product, it is possible to establish the users who cannot use the product irrespective of the cause of their functional impairment. Consequently by re-designing the product to lessen capability demand, users from a wider range of user groups can potentially be included and no-one is excluded unnecessarily by considering one cause to the detriment of others (Keates & Clarkson 2003, p. 68).

The preschool classroom is a community comprised of the teachers and the children. The BDP for preschool concept mapping was a tool to be used by both of them. Therefore, the tool had to be designed with features with which both types of users could interact. The tool I proposed was to enable the children to autonomously represent knowledge and for the teachers to mediate that process and instruct them on the concept mapping process. Therefore, the BDP features have to be accessible to both users.

Similarly to Norman's approach, inclusive design also has a seven-step approach (Keates & Clarkson 2003):

- First level - problem requirements: What is the aim of the system?
- Second level - functional specifications: What are the systems requirements?
- Third level - output to user: How does the user receive information from it?
- Forth level - user mental model: Does the user understand what is happening?

- Fifth level - input from users: What are the physical demands on the user for entering inputs?

- Sixth level - functional verification: Does the system meet the practical acceptability requirements?

- Seventh level - solution validation: Does the system meet the stated aim and social acceptability requirements?

The seven-level approach of inclusive design shares similarities with Norman's user-centred approach (see prior section). Therefore, I concluded that for a product, in my case the BDP, to be user-centred and inclusive, as the designer, I should aim at:

- Lessening the gap between user's model = designer's model = system image;

- Making it accessible to a broader segment of the intended user community or population; and,

- Countering exclusion in the development of its features and interactions by adding requirements that consider people common functional capabilities: physical, cognitive and social factors.

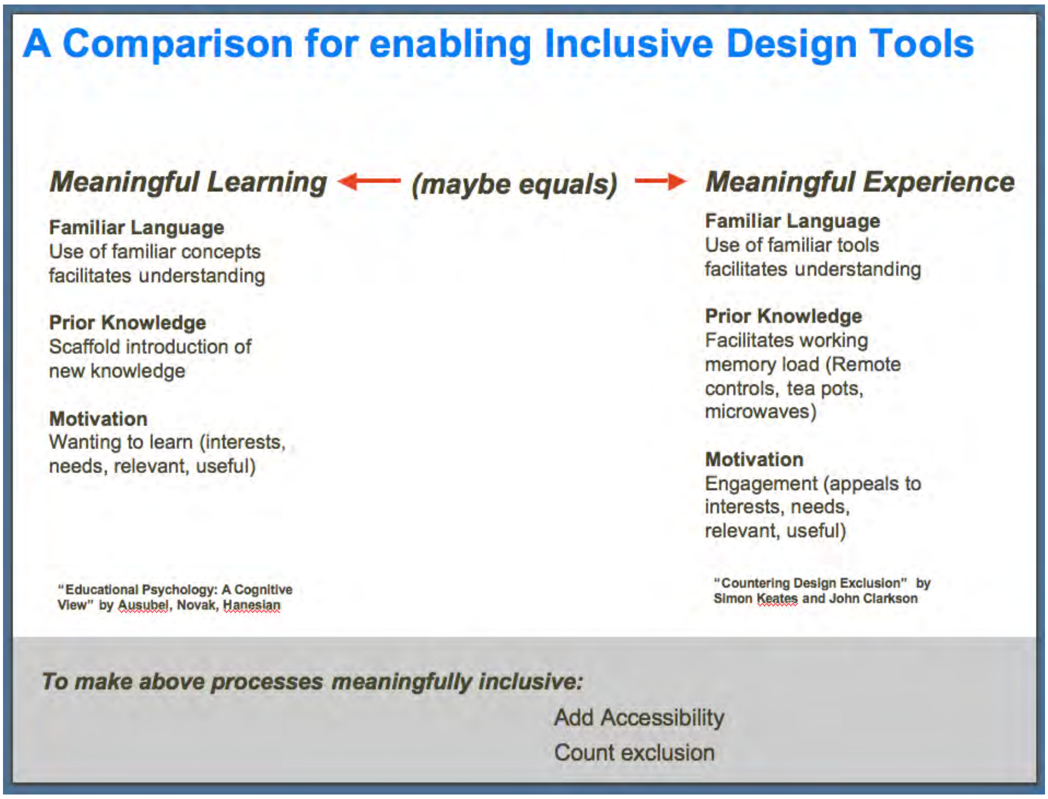


Figure 3.3 – designing meaningful and inclusive tools

The concepts just presented are the ones I considered the most powerful and practical of the inclusive design approach. The systematic application of these concepts throughout a prototyping process produces meaningful user experiences with a product:

- Familiar language: use of familiar tools facilitates understanding.
- Prior knowledge: facilitates working memory load (e.g. remote controls, tea pots, microwaves).
- Motivation: engagement (appeals to interests, needs, relevant, useful).

The meaningful experiences just described share similarities with Ausubel's conditions for meaningful learning (see chapter 1 for a definition on Ausubel's conditions of meaningful learning and chapter 4 to see how these were interpreted for the design requirements). In Figure 3.3, I present a diagram showing how I see the relationship between both sets of conditions. The similarities drawn confirmed to me that the origin of the seminal ideas of this design method and learning theory are the same. They originate in the area of information processing.

Participatory design

BDPs are functional prototypes that users incorporate into their activities while the researcher make observations. They also evolved in the hands of the users. In chapters 7 and 8, I describe how the BDPs where adapted by the designer (myself), at the teachers' request, by the teachers themselves (for improving performance of the activity), and by the children themselves. The BDP for preschool concept mapping comes with additional tools so the children use it instead of the ones provided by the researcher. The characteristics just described make the BDP a prototyping technique with participatory design qualities. Besides, Sanders and Williams (2001) say that users' participation '…early in the front-end is needed to drive truly human-centred product development' (p. 145).

Participatory design represents an approach towards computer systems design in which people destined to use the system play a critical role in designing it. The approach was pioneered in Scandinavia, and methods such as Contextual Inquiry claim to be the US version of it. Discussion on this can be found in Spinuzzi (2002).

Participatory design, as defined by Schuman is:

> …a rich and diverse set of perspectives and experiences that, despite their differences, share a distinctive spirit and direction. That spirit and direction is concerned with a more humane, creative and effective relationship between those involved in technology design and its use, and in that way between technology and human activities that provide technological systems with their reason of being (Schuman 1993, p. viii).

The BDPs for preschool concept mapping were used to develop an understanding of the user needs and their context in relation to my research claims and interaction design needs. Therefore, the user community, in this case teachers and children, had a say in the design and in how they wanted to use the tool. Because '…human-computer interaction researchers have argued that participatory design also involves the relationship among designers and the users and the manners this two interact' (Blomberd and Henderson in Spinuzzi 2002, p. 123).

Next I present the fundamentals that differentiate PD from other design methods and at the same time I explain what aspects of my BDP method relate to it.

> PD rejects the assumption that the goal of computerisation is to automate the skills of human workers, instead seeing it as an attempt to give workers better tools for doing their jobs.
>
> It assumes that workers themselves are in the best position to determine how to improve their work and their work life. This assumption turns the traditional designer – user relationship on its head, viewing the users as experts – the ones with the most knowledge about what they do and what they need- and the designers as technical consultants.
>
> It views the user's perception of technology as being at least as important to success as fact, and their feelings about technology as at least as important as what they can do with it.
>
> It views computers and computer-based applications not in isolation, but rather in context of a workplace; as processes rather than products (Schuler & Namioka 1993, p. xi).

Two compelling ideas of PD that relate to my BDP method are:

> People who are affected by a decision or event should have the opportunity to influence it….quality can improve with strong and effective participation of the people involved. User involvement and iteration are generally acknowledged to be more critical to success in software design than adherence to conventional design paradigms. Participation is essential to social interaction. It is also essential to good design (Schuler & Namioka 1993, p. xii).

Aspects of Ausubel's theory of learning

Relevant prior knowledge and meaningful material are two of the three conditions for meaningful learning that can influence the design of effective instructional materials (see chapter 5 in Novak 1998; see section 'psychological foundations of concept maps' in Novak & Cañas 2006b). In my view, these Ausubelian conditions for meaningful learning can be added to the methods for designing products, in the case of my research, of a BDP for preschool concept mapping.

Prior knowledge does not only involve the information we have in our head (or cognitive structure), but also the materials that we have in the world, in the context we live in and how we interact with tangible and intangible products. From here, I concluded that the prior knowledge of a user community lies on the theories, instruments, and techniques (methods) people use to perform their everyday activities. If we want to introduce a user community to a new product (e.g. learning material) or way to perform an activity, establishing a common ground by using known languages is pivotal to succeed. This common ground may allow the user community to see a place for the new product in their context. Their mental or conceptual models will be able to place it, to categorise it among other products that are already part of their context.

It is my view that these two conditions for meaningful learning; relevant prior knowledge and meaningful materials (see chapter 1 section 'theoretical accounts supporting Novak's claim'), are tacitly embedded in the principles of user-centred design. Norman (1990) explains, when the user finds the system image of a product functional, learnable and usable, this means the designer developed a system image for such product that supports the user's conceptual model (mental model or cognitive structure). By this, Norman means that this kind of product is one that the user community can understand. The user community can rapidly do so because they can interpret what to do with the product by observing or interacting with features of the system image. Such easy to learn system image may be more successful if the designer of the system is able to incorporate his or her understanding of the prior knowledge of the community in every feature of the system.

The reaction of the user community to the BDP used in the case studies not only supports Novak's approach for designing instructional materials following Ausubel's conditions for meaningful learning, but also corroborates Norman's premise about lessening the gap between conceptual models of the user, the designer and the system image. The participant preschool communities accepted to be part of the studies because they liked the BDP appearance and its functionality. By looking at it, the teachers were able to access the BDP features that they considered belonged to the preschool classroom. When confronted with the one novel feature (the voice-recorder), they were not intimidated by it. After explaining and demonstrating how it worked, the teachers could assess that the children would not have problems operating such a device.

To achieve an understanding and to capitalise on the prior knowledge of the user community, I analysed the process literate people follow to build a concept map and analysed the process young children follow to build a symbol map. Chapter 4 documents this analysis in which I studied existing literature in the areas of early childhood education, child development and learning, as well as Novak's concept mapping for developing explications about the issues in preschool concept mapping (see Table 4.1). Once an understanding of the issues was achieved I developed a set of design requirements and features that a suitable tool for preschool concept mapping should have (see Table 4.2). In chapter 5, I document the different prototypes of prototyping cycle 1 and prototyping cycle 2 that were developed and evaluated for implementing a Bridging Design Prototype with features that the user community could understand.

A doctoral research on intuitive interactions presents evidence that prior knowledge is an important element in the design of products. It reported on experiments performed to test the thesis that intuitive interaction involves utilising knowledge gained through other products or experience(s). The results suggested that prior exposure to products employing similar features helped participants to complete the operations more quickly and intuitively and more familiar features were intuitively used more often (Blackler, Popovic & Mahar 2004).

People can only use intuitive processing if they have previous experience to draw on. Intuition is defined as a type of cognitive processing that is often unconscious and utilises stored experiential learning. Intuition is often faster than more analytical cognitive processing. Intuitive interaction involves utilising knowledge gained through other products or experience(s). Therefore, products that people use intuitively employ features they have encountered before (Blackler, Popovic & Mahar 2003a, b).

The BDP for preschool concept mapping provides features that enable intuitive interactions and support further Blackler's argument. The children were able to use known actions such as matching two pieces together, using Velcro, placing magnetised elements on a magnetised whiteboard, using colouring pencils and markers, pushing buttons, using verbal language, among other activities (see chapters 7 and 8). What was totally new for them was that the performance of each of these activities combined produced a concept map with verbally-labelled symbols (see chapter 5). The one important issue about using a BDP for concept mapping enabling children to use familiar tools and perform familiar interactions is that dramatically reduced the training time (see chapters 7, 8, and 9). 'Require little or no training' is a design requirement that emerged during the prototyping phase (see chapter 5) due to teachers' limited time availability to learn a new educational resource. The BDP for preschool concept mapping offered features that enhanced the way teachers and children were accustomed to making concept maps (see chapter 2). However, many of the BDP materials and features were familiar to the user community and the few novel ones were easy to learn how to use.

How the BDP method was applied in this research

The first tasks in any user-centred product development process are to study prospective users, watching them as they go about their daily lives, understanding what the role of the proposed product would play, and finding activities that are close as possible to the one the product is intended to support. These tasks determine what the product should be and define it. The product of initial observations assists in determining what the product might be, what role it would play, and what actions it would perform (Norman 1999).

A multidisciplinary community of key expert informants

Important elements of user-centred design process are to involve a multidisciplinary team with backgrounds in marketing, technology, and user experience and to have access to funding for doing market research, direct observation, and iterative prototyping cycles, which are aspects of the process considered crucial to implement design technologies that fit the users needs. Norman says that User-Centered Product Development Process requires the participation of six disciplines: field studies, behavioural designers, model builders and rapid prototypes, user testers, graphical and industrial designers, and technical writers (Norman 1999).

To find a way to meet the criteria of a multidisciplinary team and more importantly to bring the multidisciplinary voice to the research project, a multidisciplinary advisory group of key expert informants was assembled. Experts (project advisors, early childhood educators, computer scientists), interface designers, young children, teachers, and software programmers were contacted to help me shape the prototype. Their input and literature suggestions were considered seriously. They commented on low-fidelity prototypes, suggested further literature review, and named people that could be interested in trying the tool.

Key informants are used as community guides or liminal group members and are part of the collection of field methods used in 'rapid ethnography'. Millen (2000) says, 'one of the major goals in applied ethnographic research is to observe and understand interesting patterns or exceptional behaviour and then to make practical use of that understanding' (p. 282).

In my research, a group of key expert informants was used as community guides. This group assisted me in the process of bringing ideas 'alive' in the form of prototypes. While some of these idea were used in testing others were used to improve design specifications or to communicate with collaborators or possible sponsors. But most importantly, the group of experts became my way to interact with and learn about the user community at different stages of the prototyping process. Every BDP was developed based on the community input, and at different stages I asked them to provide evaluating opinions of its usefulness and relevance.

The expert participation was voluntary, some members were friends and collaborators met in past projects I participated in, others were experts I contacted through my current research, conference presentations, and through visits to other universities, colleges, and care facilities. My role as an interface and interaction designer was to work directly with the children when possible, or through parents and teachers when it was not. I interpreted relevant literature and community inputs and applied these interpretations to the prototype designs. This prototyping approach continued into the case studies.

To validate design requirements, tool characteristics, the prototyping process and reduce biased decisions, I contacted key thematic informant(s) to discuss the prototype and/or, if possible, to perform a pilot study. Reaching out to the target community was a way to minimise my biases from interfering with design decisions, allow re-assessing research goals such as the foci of my PhD research and help define my role, the designer role, in the development process.

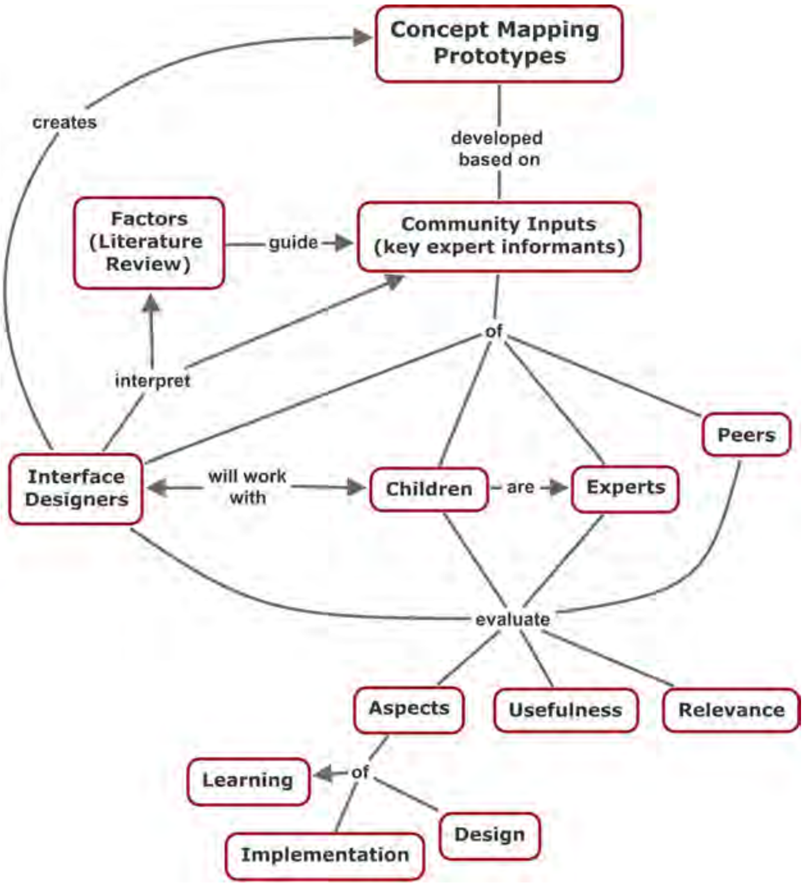


Figure 3.4 – a concept map of how the prototypes are developed according to the community input

The key expert informants have never met. The community concept is a concept that I developed in my head to bring the voice of other disciplines into the design process. The concept map of Figure 3.4 illustrates how I interacted with my expert community. Building the community concept around the research was also instrumental.

The multidisciplinary knowledge was also represented in the choices of literature to review. References were used to explicate problems and develop the design requirements and features (chapter 4). More on this is explained in the next section. During the prototyping process (chapter 5), key expert informants were consulted on the low-fidelity and functional prototypes. Their input and reading suggestions helped me refine the profile of the Australian teachers.

The resulting BDP was evaluated in a preliminary case study, presented at two conferences, and discussed with two Early Childhood trainers and a Designer. The outcomes of the preliminary study and the comments of the key thematic experts showed to me that the BDP was ready to be tested in natural settings (chapter 5). In the case studies (chapters 7 and 8), I had an opportunity to interact with the community for which the prototype was developed and obtain their feedback.

The BDP as a design product will not be analysed in this thesis, as it is not relevant to the core of my study. However, the methodologies and learning theories used to develop this functional prototype worked, as they enabled me to establish relationships with the user community. This relationship with multidisciplinary knowledge evolved from interacting with theory, to conversations with key informants, to actually working with the expert community in their natural setting. Such an approach resulted in the two case studies reported in this thesis.

Having a multidisciplinary perspective in the investigation of the issues, taking into account user community needs, and designing tools with features that they can rapidly understand, was an approach that worked for the aims of this research. By applying the BDP method steadily during the different stages of the envisioning (chapter 4), prototyping (chapter 5), and testing (chapters 7 and 8), I was able to create a community around the project and place this interaction design perspective of researching the issues in preschool concept mapping in the panorama.

Problem definition

The assessment of user needs (step 1 in Norman's approach – see earlier in this chapter) stated in the research problem and research claims (see chapter 1) was performed through the analysis of relevant literature. Chapter 2 is dedicated to defining the problem and to assessing the user needs in terms of preschool concept mapping. From this initial assessment of needs and to achieve the research goals, it was required to develop a tool enabling the following actions: add meaning to symbols with spoken language, enable the insertion of linking phrases, enable the use of multiliteracy, facilitate instruction, and promote autonomy.

Initial understanding of users' needs and their context

As explained earlier in this chapter, using traditional marketing methods and paying visits to costumers, or users as Norman also called them (1999), was not possible at the initial stage of this research. Since I was unable to access the community during the prototyping process of the BDP, to establish an initial user community profile, I gained knowledge about the product and related products through a second literature review that included analysis of visual and written material.

Presented in chapter 4, the focus of this second literature analysis was to understand the problem from different theoretical perspectives (what the gaps are in preschool concept mapping and how they can be solved). Analysis of relevant literature is a valid technique of 'rapid ethnography' (Millen 2000). Such understanding informed the development of the initial design requirements and features of the BDP (chapter 4). Including early childhood expert reports, articles and case studies on child development, children's learning habits, and preschool behaviour, the consulted literature assisted in the process of learning about the users, teacher mediation, child cognitive psychology, and concept mapping. This literature gave me insight into the children's interests, motor and developmental skills; the teachers' interests, teaching skills and viewpoints; and the classroom's overall set up including layout and materials.

Prototyping process

The prototyping cycle had two cycles (step 4 in Norman's approach, see earlier in this chapter). Prototyping cycle one was dedicated to evaluating initial design assumptions and to establish close relationships with the specific user community. Defining the aspects of the BDP for testing and refining the profile of my specific user community were the goals of this prototyping cycle. Prototyping cycle two was dedicated to developing a BDP that matched the needs of the specific user profile. Such a match was pivotal for gaining entry to the preschool settings or sites.

In each prototyping cycle I implemented a prototype that represented the information gathered via literature or key experts. I analysed the data collected to establish arguments explaining the research claim(s) and how this prototype represented the users and product aims. This process included a comparison of the findings to the key theoretical factors and the concept mapping theory. With the findings a new prototyping cycle was started. Table 5.1 provides a list of prototypes I used to refine the profile of my user community (chapter 5). The table lists the different mock-ups, paper prototypes, storyboards, and working prototype produced during the iterative prototyping cycle. The low-fidelity prototypes were used for discussions with key thematic experts. The functional prototypes were tested with the target user community (see chapter 5 – preliminary case study and chapters 7 and 8 – case study one and two).

The prototypes, low-fidelity and functional, were put for discussion to the key thematic experts, and when possible, put for testing to the user community (teachers and children in the EC classroom). The findings provided information for assessing the users' needs, validating research claims, theoretical accounts and design decisions, and identifying research strengths and limitations. Each prototype helped narrow the gap between the known and unknown research issues and became a practical representation of the theory that in turn was put forward for evaluation to the key expert informants, and when possible, to the user community. Each prototype and prototyping cycle assisted in fine-tuning the design and provided arguments to explain aspects of the research claim(s).

Each iterative prototyping cycle was used to research the aspect of a claim, a full claim or several claims, or an interface or interaction issue (step 7 - continually test and revise - of Norman's approach, see earlier in this chapter). The research claims requiring investigations were defined or were a product of the comparison between concept mapping theory and current practice of concept mapping in overseas preschool settings. The prototyping cycle helped define the user profile and the needs the product should address. It also provided the design specifications for developing mock-ups, still scenarios, physical and paper prototypes. The cycle was to enable the development of a tool that interested not only the user community, but also related experts. Manuals were not produced in this BDP process.

Data collection methods ('rapid ethnography')

Neither the user-centred design approaches nor the BDP method provide fixed instruments with which to collect data for developing the designs. On the contrary, I changed data gathering techniques according to the accessibility to the user community. The prototyping process described in chapter 5 is an example of how the BDP method was employed and evolved throughout the development of a product.

To collect data during the prototyping process I used different types of data gathering techniques. In prototyping cycle one, I conversed with key expert informants (informal meeting, phone calls, email communication, conference presentations). In prototyping cycle two, I performed a preliminary case study in which I used participant observation and collected data via note-taking and photos. Also conversations with key informants (at two conferences and informal meetings) were important to confirm that the BDP was ready to be incorporated in a real setting (chapter 5).

Ethics

In the acknowledgement section of this thesis I thank the key expert informants for their collaboration. An ethics approval was necessary to work with the children who participated in the preliminary case study. The parents of the participant children were informed of the study. One parent signed the consent form and this same parent was present during the activity performance.

Advantages in using the BDP method

In the process of using the BDPs I found several qualities to them. BDPs are not finished products, they are functional prototypes that evolved in the hands of the user community (these prototypes change as we are doing testing). They are vehicles for developing a better understanding of the needs of a user community and their context. In chapters 7 and 8, the reader will be able to see this evolution of the product while the research claims are evaluated.

Another quality of the method is that it can change user perceptions about the topic being investigated by building blocks (bridges) that enable them to envision change.

The BDP method does not force change of opinion, it persuades. This persuasion happens both ways. The researcher is persuaded by the arguments of the users, the users are persuaded by the actions they can perform with the prototype. The BDP is a flexible, open-ended tool that should be easy to transform and achieve different purposes.

I found several advantages by using this BDP. The interactions of the key expert informants and user communities with the BDP showed me who are my users and who the potential users of this product might be. It provided me with the information necessary to continue developing the product. By immersing the prototype in the real contexts (instead of control environments), I obtained real outputs enabling me to analyse aspects, such as:

- Does it make a difference?
- How it enhances, interacts with other resources?
- How different is it from other tools?
- How teachers and children relate to it? Do they like it? Do they hate it?

These observations, of different kinds in a sense, allowed me to, 1) see teachers and children using, changing, and editing the BDP, 2) compare the BDP to other learning tools used in the classroom. What makes it different from other tools?

The BDP for preschool concept mapping resulting from this prototyping process (chapter 5) was introduced to the user communities of the case studies as the Authoring Concept Mapping Kit – the Kit (chapters 7 and 8).

The relevance of the BDP method to this thesis

This dissertation will not evaluate the BDP method or the BDP for preschool concept mapping derived from it, as it is not relevant for warranting the research claims. Such analysis should wait for a different occasion. What is relevant to this thesis is that the BDP enabled me to enter two preschool classrooms to further my research.

Summary

Testing the research claims in a real preschool classroom was only possible with a functional prototype. Aspects of several user-centred design methodologies and learning theories underpinned the design of the functional prototype that was used in the case studies (chapters 7 and 8). The following is a table showing the concepts I used from each design methodology and learning theory:

Table 3.1 – design and learning principles informing the Bridging Design Prototype method

Underpinning Method or Theory	**Principles used in the development of BDP features**
Norman's user-centred product development process	• Apply the seven-step iterative approach • Use 'rapid ethnography'
Norman's user-centred design principles	• Design the system image with the concepts for transforming difficult tasks into simple ones • Design conceptual models for the system image that users can easily understand
Inclusive Design	Counter design exclusion to develop features for the system image that are inclusive and accessible to all members of the user community
Participatory Design	Design a system image that "tolerates" adaptation on the part of the user community to achieve own specific needs
Ausubel's theory of learning	Apply the concepts of 'prior knowledge' and 'familiar languages' to the design of the system image

The way I applied the concepts of such methodologies and theory gave origin to the Bridging Design Prototype method. The functional prototypes produced under this method are designed capitalising on the prior knowledge of the user community, and novel features are only introduced after careful analysis of relevant data.

BDPs are used for incorporating users early into the product development process: users incorporate it into their practice while the researcher does observation. A BDP is designed for investigating the use of a product that is novel to a user community. Also it is a prototyping option for reaching out to communities that are technologically disinclined and difficult to access. My specific user community, Australian and New Zealand preschool classrooms, embodies such characteristics.

The following two chapters report the development of the BDP. Chapter 4 explains how the constructivist theories of learning, literature on child development and learning, and Novak's concept mapping theories informed the development of the design requirements and features of a tool that could resolve the issues for preschool concept mapping. Chapter 5 explains the prototyping cycles undertaken to develop a BDP that could be incorporated in natural preschool settings. The design requirements and features of chapter 4 were used throughout the prototyping phase.

Chapter 4 – Identifying Guidelines, Design Requirements and Features: A Literature Review

Overview

The Bridging Design Prototype (BDP) Method was presented in chapter 3. It was developed to design a BDP that could be used as a tool to investigate issues related to concept mapping in preschool. One component of the BDP method, identified in that chapter, was the need for designers to familiarise themselves with the prior knowledge (embodied in theories, techniques, and instruments) of the user community by interacting with the users in their natural setting. At the design stage of the study, however, I was unable to interact with the users in their natural setting, in my case teachers and children in the preschool classroom, to learn about the theories, techniques, and instruments that constitute their educational activities. It was, therefore, necessary to develop my understandings of their setting and the attendant research problem by drawing on relevant literature. This understanding allowed for the identification of guidelines, requirements, and features for the kind of prototype that I should develop to achieve the research aims.

In this chapter, I explain my understanding of the gaps between theory and practice in preschool concept mapping, by drawing on knowledge from literature related to child learning and development as well as Novak's concept mapping. To transform theory into practice for the purpose of tool design, I organised my understanding of gaps identified in the form of four guidelines. These four guidelines informed my selection of design requirements and structuring features, which I then applied to the development of a tool, as identified in chapter 2. Applied together, these guidelines should enable children to build Novak's concept maps. The BDP for preschool concept mapping should promote the performance of the following activities; 1) make children's knowledge explicit, 2) promote autonomy and multiliteracy, 3) facilitate knowledge manipulation, and 4) facilitate teacher instruction.

In Table 4.2 I summarise the key factors described in chapter 2 as well as the guidelines, requirements, and features presented in this chapter that informed the BDP development. I employed this table as a validation tool throughout the prototyping process (chapter 5) and as an analysis instrument (chapter 6) in the case studies (chapters 7 and 8).

Background

To identify the design requirements and features for a BDP to teach preschool concept mapping, I drew on the prior knowledge of the user community by studying existing literature from the areas of early childhood education (Curtis & Carter 2003; Edwards, Gandini & Forman 1998; Fisher 2002; MacNaughton, Rolfe & Siraj-Blatchford 2001; Nicolson & Shipstead 1998), child development and learning (Anning & Edwards 1999; Ausubel, Novak & Hanesian 1978; Bransford, Brown & Cocking 1999; Bruner 1988, 1997; Cowan 1997a; Piaget 1963, 1973, 1974; Piaget & Inhelder 1977; Vygotsky 1978a; Vygotsky et al. 1962; Wood, Bruner & Ross 1976), and Novak's concept mapping (Novak 1998; Novak n.d.; Novak & Gowin 1984).

I drew on specific aspects of literature to develop an understanding of: 1) the skills older children and adults use for concept mapping, and 2) the issues behind preschool concept mapping. Understanding the reason why older children and adults can make Novak's concept maps and why preschool children cannot was the approach I used to establish the gaps in the teacher approaches to concept mapping that were reported in chapter 2. Once the gaps were established I looked in the literature for insights and recommendations to solve them and to justify modification to Novak's template.

Table 4.1 – theoretical factors and guidelines underlying the design requirements and scaffolding features of a BDP for preschool concept mapping

Relevant Literature (Prior knowledge of the user community)	**Guidelines** (Built based on theories, instruments and techniques employed in early childhood education)	
Child development literature on theories of how children learn	Guideline 1: build on how children learn (theory)	• Make the concept map experience less abstract • Support the use of prior knowledge, play and social interactions • Enable the representation of any kind of concept
Child development literature on theories of how children use memory and	Guideline 2: support the ability to retain, organise, and self-regulate	• Improve children's knowledge retention • Enable rehearsal to retain knowledge

knowledge organisation skills	conceptual knowledge	• Use clustering to organise knowledge • Facilitate self-regulation of the mapping process
Literature on instruments of how children represent knowledge	Guideline 3: support use of multiliteracy for concept labelling	• Label concepts with spoken language • Build on children's mastered representation skills
Literature on techniques of how teachers facilitate children's knowledge acquisition	Guideline 4: enable teachers to diversify instruction	• Re-establish teacher support according to theory • Provide flexible educational resources • Enable the design of 'Make Knowledge Explicit' activities

I organised the theoretical aspects identified in the literature as representative of the prior knowledge of the user community into four guidelines (Table 4.1); 1) build on how children learn, 2) support the ability to retain, organise, and self-regulate conceptual knowledge, 3) support use of multiliteracy during concept labelling, and 4) enable teachers to diversify instruction. While guidelines 1 and 2 attend to theoretical aspects that interest my user community, guidelines 2 and 3 attend respectively to their instrumental and technique aspects.

Each of these guidelines represents a way to address issues related to children's concept mapping and also develop an understanding that levels of learning will differ depending on the children's conceptual knowledge and their control over the strategies that organise that knowledge for learning.

> Strategies and knowledge are important. They show different levels of learning, depending on the children's conceptual knowledge and their control over the strategies that organize that knowledge for learning (Bransford, Brown & Cocking 1999, p. 97).

In applying the above claim to concept mapping I understood that, if children do not understand the purpose of a concept map and if they have no control over the learning strategies (cognitive skills) involved in the construction (or building) of a concept map, they would never be able to make Novak's concept maps. Taking up the argument of Bransford and colleagues that knowledge and control over relevant learning strategies are the key components for learning or acquiring knowledge, it follows that children may be able to autonomously make concept maps, with template features that; 1) preschool children understand (or know) how to operate, and which 2) enable them to gain control over the cognitive skills (or learning strategies) required in concept mapping. These cognitive skills are knowledge retention, organisation, and self-regulation.

The four guidelines explained in this chapter, see Table 4.1, describe my interpretation of how the different strategies and instruments for acquiring and communicating knowledge relate to preschool concept mapping.

Guideline 1: build on how children learn

The learning theorists, Piaget (1973; 1974), Bruner (1988; 1997), Vygotsky(1962; 1978a; 1978b), and Ausubel (1968; 1978) help us understand how people of all ages learn. Each of these theorists has published their own views of how learning occurs. However, they all agree that children, after the age of 3, acquire knowledge through active discovery-reception process, and hands-on experiences that involve play and social interactions with peers, older children and adults. They also say that children acquire knowledge using concept formation skills, and communicate such knowledge with enactive, symbolic and spoken languages.

Make the concept map experience less abstract

The concept map is a graphic hierarchical representation of knowledge, designed with symbolic representations that literate people can interpret. As a result of the ways its constitutive elements are organised (concepts enclosed in boxes, linking phrases on the line that connect those concepts), the map can be considered a tool that enables direct manipulation or hands-on experience of knowledge. The issue with this hands-on experience is that preliterate children cannot yet interpret the abstract symbols it uses: written language and hierarchy. Knowledge representation with symbols is discussed in section 'guideline 3: use multiliteracy to label conceptual knowledge' of this chapter.

In my research I accept that preschool-aged children have difficulty interpreting and manipulating concepts labelled with abstract symbols, thus, the designed template should be comprised of tangible features that can be easily manipulated. These would ensure that these children would be able to touch and directly manipulate the concept map elements. The work of Mancinelli and colleagues, which was presented in chapter 2, further supports this approach when they chose to employ tangible objects for introducing their children to concept mapping (Mancinelli 2004; Mancinelli & Guaglione 2004).

The notion that children learn through hands-on experiences is theoretically supported. Owocki (1999) cites Piaget (1973) and says that he argues education must provide children with opportunities to engage in spontaneous action that takes its direction from the learners themselves. Letting children get their hands on things to tackle new ideas and hypotheses is the way to support their natural processes of learning. The following comment of Piaget (1973) can support her interpretation:

> Supporters of the active school reply that since so little learning is retained when it is learned on command, the extent of the program is less important than the quality of the work. A student who achieves a certain knowledge through investigation and spontaneous effort will later be able to retain it; he will have acquired a methodology that can serve him for the rest of his life, which will stimulate his curiosity without the risk of exhausting it. At the very least, instead of having his memory take priority over his reasoning power, or subjugating his mind to exercises imposed from outside, he will learn to make his reason function by himself and will build his own ideas freely (p. 93).

Children come to understand about size, colour, the past, or the seasons, through a variety of first-hand experiences, which lead them to see and understand the conceptual links between one experience and another. In these ways they become able to generalise abstract principles from concrete experiences. It is almost impossible to rush this transition from concrete to abstract because if children are forced to establish connections then it is likely they will make inappropriate ones (Brierly 1994, Robinson and Beck 2000 in Fisher 2002). (The term ‘principles’ is what Novak (1998) and Ausubel (1968) refer to as concepts.)

Design guideline; the BDP features should make the concept map experience less abstract to preschool children by providing a tangible way for children to manipulate concepts, linking phrases, connecting lines, and boxes enclosing concepts.

Support the use of prior knowledge, play and social interactions

Concept mapping is a challenging activity for young children, because they have not mastered the cognitive and representational skills required for making sense of the map elements and their building rules for representing knowledge. Literate learners employ these cognitive and representational skills when interpreting and making inferences about the knowledge that has been represented with the map. For instance, a Novak's concept map will only enable the mental interactions that stimulate active inquiry, meaning negotiation, and dialogue (Coffey et al. 2003), if the learner is literate and can use the relevant cognitive skills.

Through interaction with an age appropriate set of features, that take advantage of their ways of learning, children could improve the representational and cognitive skills required for concept mapping. It is important to note that children are able to think in novel, unexpected ways if presented with tools that facilitate and support novel and unexpected thinking (Hakansson 1990) and can arrive at complex conclusions in a structured learning context (Brooks 2004). To ensure that the BDP for preschool concept mapping is appropriately designed we need to understand the conditions under which children learn: prior knowledge, play and social context. In this chapter, guidelines 2 and 3 deal with the cognitive skills and the representational skills needed for preschool concept mapping.

Prior knowledge

Introduced in chapter 1, one Ausubelian condition for meaningful learning is that the learner must posseses prior knowledge (Novak & Gowin 1984). Piaget and Vygotsky also stressed this condition to be equally important for learning. Owocki (1999) wrote:

> Vygotsky's *internalization* is comparable to Piaget's *assimilation* and *accommodation*. Both theories emphasize the notion that children restructure new experiences to make them adaptable to their existing schemas. Children build new concepts upon what makes sense to them already… (p. 49).

In relation to experiments on the development of scientific concepts in childhood, Vygotsky mentions the role of experience in the formation of concepts:

> The principal function of complexes is to establish bonds and relations. Complex thinking begins the unification of scattered impressions; by organizing discrete elements of experience [prior knowledge] into groups, it creates a basis for later generalizations.
>
> But the advanced concept presupposes more than unification. To form such a concept it is also necessary *to abstract, to single out elements,* and to view the abstracted elements apart from the totality of the concrete experience in which they are embedded. In genuine concept formation, it is equally important to unite and to separate: Synthesis and analysis presuppose each other as inhalation presupposes exhalation (Goethe) (Vygockij 1996, p. 137).

Piaget explains the role of experience in child development:

> …The role of experience [prior knowledge], far from diminishing from the third to the fourth [developmental] stage, only increases in importance. During the fifth stage, the utilization of experience spreads still more, since this period is characterized by the "tertiary circular reaction" or "experiment in order to see," and the coordination of schemata extends henceforth into "discoveries of new means through active experimentation" (Piaget 1963, p. 361).

Owocki continues '…While both theories [referring to the theories of Piaget and Vygostky] emphasize the importance of action and exploration, Vygotsky placed much more emphasis on the contributions that social experiences could make to knowledge construction' (p. 49). For Vygotsky (1978a) learning occurs within a child's Zone of Proximal Development (ZPD):

> If we naively ask what the actual level of development is, or, to put it more simply, what more independent problem solving reveals, the most common answer would be that a child's actual developmental level defines functions that have already matured, that is, the end products of development. If a child can do such-and-such independently, it means that the functions for such-and-such have matured in her. What, then, is defined by the zone of proximal development, as determined through problems that children cannot solve independently but only with assistance? The zone of proximal development defines those functions that have not yet matured but are in the process of maturation, functions that will mature tomorrow but are currently in an embryonic state (p. 38).

Owocki explains that it is within the ZPD, that children make connections between the known and the new, and internalise the problem solving tools they will require for the society in which they live. She continues to say that the ultimate task of education, in Vygotsky's view, is to support the kind of experiences that help to activate children's zone of proximal development through engagement in meaningful activities. The zone is activated through children's play and collaboration in a social context.

Play

Vygotsky (1978a) says:

> In play a child always behaves beyond his average age, above his daily behavior; in play it is as though he were a head taller than himself (p. 102).
>
> What passes unnoticed by the chid in real life becomes a rule of behavior in play (p. 95).

In relation to Vygotsky's ideas on play and development, Owocki (1999) explains that children learn while playing by themselves and with other children, and while they are interacting with older children and with adults (parents, caregivers). Through play they learn about things beyond their understanding, and when playing can do things and use concepts which otherwise are unthinkable for them to use. Play frees children to take risks and to explore roles that they are not yet fully equipped to fill in real life. They explore more sophisticated ways of thinking and acting than they explore outside of play.

Social context

Vygotsky (1978a) says:

> We propose that an essential feature of learning is that it creates the zone of proximal development; that is, learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with peo-ple *[sic]* in his environment and in cooperation with his peers. Once these processes are internalized, they become part of the child's independent developmental achievement (p. 40).

In relation to Vygotsky's ideas on the relevance of social context to development, Owocki (1999) explains knowledge is constructed through children's social involvement in talk, activity, and problem solving. When children engage in an activity of their own, they function at their actual level of development. With guidance (social problem solving), they are able to function at their potential level of development. The difference between the actual and the potential defines the ZPD. To expand Owocki's interpretation, Whitehead (1990, p. 50 in Anning & Edwards 1999) explains 'children learn to be social beings and language users in close partnership and collaboration with caring adults and other children who participate eagerly with them in the adventure of reconstructing a language for getting things done' (p. 86).

As explained in chapter 2, the teacher approaches for preschool concept mapping were designed based on the ideas of prior knowledge, play and social collaboration. Those experts developed their respective approaches based on theories and methods that foster (Piaget & Inhelder 1977), scaffold (Bransford, Brown & Cocking 1999; Wood, Bruner & Ross 1976), or bring children to their ZPD (Vygotsky 1978a). The use of toys and tangibles (Mancinelli & Guaglione 2004), the concept of schema (Figueiredo et al. 2004), ordinal numbers and coloured threads to make hierarchies (Mérida 2002), playful metaphors and games (Badilla 2004), and collaborative concept mapping (Badilla 2004; Figueiredo et al. 2004; Mérida 2002) are examples of the ways in which teachers connect the theories of child learning and the goals behind Novak's concept mapping.

Design guideline; if we accept that prior knowledge, play, and social collaboration greatly influence child learning, then it is appropriate to consider that a child-friendly alternative to Novak's template should present features that enable children to employ the cognitive and representational skills required for preschool concept mapping, but at the same time those features should be designed based on activities and materials that children relate to, understand and enjoy using and/or interacting with alone or in company of peers and/or teachers.

Enable the representation of any kind of concepts

Design guideline; if the aim is to enhance children's awareness of concept acquisition with concept maps, to explicitly see what they know about a topic, then they should not be constrained in the representation of their concepts, either with the language they use or with the misconceptions they articulate. Thus, the template should have features that make it simple for children to represent what they understood or the products of their own discoveries and explorations. It should enable the representation of conceptual knowledge, no matter if this knowledge is acquired via concept formation or concept assimilation, in Ausubel's words (1968), or if it is the result of preoperative thought, in Piaget's words (1974).

Ausubel's processes for learning

As introduced in chapter 1, concept learning (or knowledge acquisition) involves a process of concept formation and concept assimilation. Concept formation involves intensive discriminative analysis, abstraction, generalisation, and differentiation (e.g. mum, dog, growing and eating). Concept assimilation is typically characterised by an active process of relation to, differentiation from, and integration with, existing relevant concepts. All people after age 3 spontaneously use both of these processes or ways for acquiring new concepts (Novak 1998). Ausubel (1968) explains 'during the preschool and elementary-school years, concepts are acquired by a process of meaningful hypotheses-oriented concept formation' (p. 87). This process of concept acquisition goes from the many instances (or specific examples) of a concept to its generality (or the rules that the specific examples of a concept have in common).

Through concrete experiences, hands-on activities, and play, children experience many instances of that one concept, and slowly with lots of practice (or rehearsal) they are able to build a general opinion of it. Young children explain their understanding of the worlds via spoken language (see guideline 3 for literature supporting this comment). Represented with concept maps, Figure 1.2 shows verbal responses of preliterate children about the general concept 'food change'. They responded to the teacher's question with instances or examples representing the general concept: 'a fish eats a little fish', 'the penguin eats the little fish', and 'the killer whale eats the penguin'.

Piaget's preoperative thought

Piaget (1974) explains:

> …representation or representative thought consists of two different aspects which should be clearly distinguished…: the figurative aspect [or preoperative thought] and the operative aspect… The figurative aspect of thought is everything related to the configurations as such, in opposition to the transformations. Guided by perception and supported by the mental picture, the figurative aspect of representation plays an important role (abusively important and precisely at the expense of transformations) in the preoperatory thought of the child aged two to seven, before operations are constructed… (p. 75).

Operations are:

> …the interiorized, reversible, and solidary actions of whole structures such as the groupings, groups, and networks' (p. 56). Examples of operatory structures are '…the classifications, seriations, correspondence, matrices, series of numbers, spatial metrics, projective transformation, etc. A large number of logical, mathematical, and physical operations develop for the most part spontaneously in the child aged six or seven… (p. 76).

Bjorklund (2000) explains that:

> Piaget described preoperational thought, although based on symbols, as lacking the logic characteristics of concrete operations. By this Piaget meant that operations do not generate contradictions. In contrast, to concrete operational children, preoperational children are greatly influenced by the appearance of things and their thought is said to be intuitive. Thus, young children are less affected by what, according to logic, must be and are more affected by what, according to appearance, seems to be (pp. 88-89).

In her own research, Mérida (2002) identified this difficulty that Bjorklund refers to in the quote above. When using comparison to help children understand the use of a concept map, she asked them to find similarities and differences between a road map and a concept map that the children created with her approach (see chapter 2). Using the terms of Bjorklund and Piaget, the similarities between maps her children established were at the appearance or figurative level, not at the logic or abstract level. Because of this, Mérida soon stopped using comparisons with road maps, as this comparison approach was not helping her to achieve what she needed from the children: the understanding that concept maps were like a map for thoughts or ideas held in our head.

One of the keys for succeeding in concept mapping is the learner's awareness of the different tasks and the elements involved in building a concept map template. The learner always knows what to do because the elements and rules for building the concept maps enable him/her to represent and include all the words that explain a domain of knowledge. Mérida's approach to preschool concept mapping is an example of adjusting the map elements to the children's way of thinking (preoperative thought based on the appearance of symbols) for representing and organising knowledge that was also effective in enhancing awareness of the construction process. She enhanced children's ability to control the building on the symbol maps by training the children in symbol drawing (and moved away from iconic-realistic drawings), making hierarchies with ordinal numbers and colour-coded boxes, and using size-metaphors to differentiate more general concepts, the ones drawn in larger boxes, from more specific ones, the ones drawn in smaller boxes (Mérida 2002).

It should be noted that in Mérida's approach it took her children nine months to develop control over these strategies, working four hours, one day a week (see chapter 2 for a brief description of Mérida's work). The time required to implement Mérida's approach may act as a disincentive to some teachers. However, the principles underlying her approach for preschool concept mapping could be useful in the feature design of the BDP for preschool concept mapping. The principle of her approach that could be useful are: enhance children's control over map building by using metaphors and materials that are familiar to children in a preschool classroom.

In this section, guideline 1, I explained the context in which young children learn and looked at the issues around concept acquisition that should be addressed in the feature design of a BDP for preschool concept mapping. The proposed tool has to make the process of building a concept map more tangible and concrete, support the use of prior knowledge, be playful and promote social interactions among peers and with teachers, and finally, enable the representation of any kind of conceptual thinking. In the next section, guideline 2, I look at ways to support children in using concept mapping-related skills.

Guideline 2: support the ability to retain, organise, and self-regulate conceptual knowledge

In the definition of a concept map, Novak introduces us to the cognitive tasks involved in its construction. Here I have extracted some sections of the three-paragraph definition, see chapter 1 for complete version. The underlined words represent the cognitive tasks:

> Concept maps are tools for organizing and representing knowledge. They include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts or propositions, indicated by a connecting line between two concepts. Words on the line specify the relationship between the two concepts… The label for most concepts is a word…
>
> Another characteristic of concept maps is that the concepts are represented in a hierarchical fashion with the most inclusive, most general concepts at the top of the map and the more specific, less general concepts arranged hierarchically below…
>
> … There are two features of concept maps that are important in the facilitation of creative thinking: the hierarchical structure that is represented in a good map and the ability to search for and characterize cross-links… (underlined added) (Novak n.d.).

Concept mapping requires the learner to perform the following tasks: organise, include, enclose concepts (words) in boxes or circles, connect concepts (words) with lines, arrange concepts (words), identify relationships between connected concepts (words), add linking phrases (words) on the connecting line to qualify the relationship between concepts (words). Besides, it demands the ability to identify relationships among concepts (words) in different areas of the map, and differentiate hierarchical relationships.

The procedures for building a concept map (Novak & Cañas 2003) are another way to identify the tasks involved:

> Construct a good focus question
> Make a list of concepts that are somewhat related to the focus question
> Rank order of the concepts from most general to the most specific concepts
> Begin to construct concept map with 1 to 4 most general concepts
> Choose explicit linking words to relate concepts to form propositions
> Continue building concept hierarchy
> Often look at the concepts and linking phrases that have been already represented on the concept map for considering relevance and concept organization and addition of arrows
> Identify possible cross links, relationships between concepts in different sections of the map, they may lead to creative insights
> Reposition and refine map structure

Novak and Cañas' procedures require the ability to achieve the following tasks: construct, make a list, rank order, build concept hierarchy from top to bottom, choose explicit words, consider relevance, identify cross-links, reposition and refine. Older children and adults spontaneously perform these tasks, and when concept mapping, apply them to the construction of the map. However, the tasks involved in building a concept map are beyond preschool children's understanding, simply because they have not yet developed control over the cognitive skills linked to this knowledge construction activity. On the efficiency of cognitive processing, Bjorklund and Douglas (1997, pp. 215-216) say:

> By definition, strategies are effortful mental processes, consuming some portion of a person's limited mental resources for their execution. One hypothesis concerning age differences in strategy use revolves around age differences in the efficiency of cognitive processing. Young children must use most of their limited mental resources to execute a strategy than older children. Because of the difference, young children are less likely to use a strategy, or less likely to use one effectively (Bjorklund 1987; Kee 1994). That is, strategy use has a cost in terms of mental effort. Young children use so much of their limited resources executing the strategy that they do not retain sufficient mental capacity to perform other aspects of the task efficiently (Case 1985).
>
> Strategies are effortful. Developmental research has consistently found that young children process information more slowly (Kail 1993) and less efficiently (Case 1985) than older children. As a result, they are less likely to use a strategy spontaneously and less likely to benefit from the imposition of a strategy.

While young children find it difficult to spontaneously organise knowledge, they may be able to use organisational structures, like the ones required in concept mapping, if they are trained. There are a variety of well-known learning strategies that increase memory performance, which provide glimpses of the early appearance of the ability to plan, organise, and apply learning strategies. In this guideline, I introduce those strategies that increase memory performance when organising knowledge and relate these to the concept mapping tasks. Identifying the features of these learning strategies allowed me to develop the scaffolding features for the template.

Improve children's knowledge retention

Knowledge within a concept map is represented in small units of meaning of at least three objects, concept → linking phrase → concept, that can be easily assimilated by the brain's working memory. This form of representation facilitates knowledge retention. Novak (n.d.) explains that knowledge retention may be related to the way the map is constructed: step by step, and sequentially. This approach to the map construction may take advantage of how the adult brain organises knowledge in hierarchical structures and the capacity of the working memory to hold around 5 to 7 items or chunks of information at the time. Working memory and its relationships to concept maps was discussed in chapter 2.

It should be noted that young children's short-term memory (also called working memory) can only hold one item at a time (Piernot et al. 1995). Millar (1997) explains:

> The fact that the short-term memory span increases in a linear fashion with age and mental age in children is one of the best-established findings in developmental psychology (Chi, 1976, 1977) (p. 243).

Chi (1976) performed

> [An] analysis of a few short-term memory [STM] tasks where extensive developmental research has been conducted... These tasks have typically shown that children's performance is deficient when compared to adults, and these deficiencies suggest a STM capacity limitation. From an analysis of these tasks, it appears that the two major factors... differential use of mnemonic strategies and differential LTM [Long-Term Memory] knowledge base – are better predictors of performance deficits than STM capacity per se (p. 569).

Cowan (1997b) states 'in general, knowledge aids working memory because it reduces the effective memory load'(p. 175). Knowledge facilitates linking items together because stimuli do not have to be remembered as arbitrary elements. What a person does to compensate for poor memory performance is to choose known strategies to process the task. Cowan reports on research showing that if children have to perform a memory task while performing a mechanical activity, they will reduce performance of the mechanical activity because more effort is required to achieve the memory task. Tasks to be performed by younger children have to be presented to them in small sets of actions, one action at a time or two actions in the sequence of a task. The more effort needed for processing the task(s), the less effort will be available for performing other tasks.

Design guideline; the concept map for preschool age children must include features that support knowledge retention, that enable children's working memory to quickly assimilate the information mapped, but that at the same time, enables them to pace their actions and sequence the different mappings tasks that involve familiar features.

Enable rehearsal to retain knowledge

In relation to keeping information alive to be remembered, DeLoache *et al.* (1985a in Bransford, Brown & Cocking 1999) reported on research which demonstrated that young children utilise less systematic and not yet well formed rehearsal strategies such as mnemonic strategies/retrieval practice, and retrieval cueing.

Most mnemonic strategies, Cowan (1997b, see pp. 176-177) explains, would fall under the rubric of 'rehearsal' or going over the information in one's mind. Rehearsal, in turn, can be subdivided into rote rehearsal and elaborative rehearsal. Rote rehearsal means going over the information exactly, whereas elaborative rehearsal means forming new, meaningful connections between items to be remembered. When the material permits elaborative rehearsal, Cowan continues, it is by far the more effective means of remembering. The ability to carry out elaborative rehearsal is more a reflection of the knowledge structure (what Novak calls prior knowledge in the cognitive structure) and inventiveness of individuals (what Novak calls creative thinking) than of the memory's working capacity.

In Novak (1998) the adjectives rote and meaningful are used to differentiate learning styles. Rote learning results from; 1) little or no relevant knowledge and 2) no emotional commitment to relate new with existing relevant knowledge. Meaningful learning requires; 1) well organised relevant knowledge structures and 2) emotional commitment to integrate new with existing relevant knowledge.

Deducting from what has just been explained about the concepts of rote and meaningful in relation to rehearsal for remembering or retaining knowledge, it can be concluded that if the material (or information) is presented in a manner that the learner can use prior knowledge, understand the language, and want to assimilate the information, people can compensate for working memory capacity and effectively acquire knowledge, or in the words of Ausubel's psychology, learn meaningfully (see chapter 1).

Cowan (1997b, see pp. 176-177) also tells us that subsequent studies have shown that the absence of rehearsal is not just a matter of knowledge. Young children can be instructed to rehearse at the age of about 5, but it still does not improve their recall. Older children partly benefit from rehearsal because they come to rehearse in a more useful, cumulative fashion in which more items in a row are strung together. This plays an important role in the development of short-term memory. Rehearsal is used in clustering, a knowledge organisation strategy that will be introduced next which is often used in preschool settings.

Design guideline; the template for preschool concept mapping should include features that trigger meaningful connections by increasing remembering through elaborative rehearsal. They should enable children to revisit the mapped content (concepts, linking phrases and propositions) over, and over.

Using clustering to organise knowledge

Clustering organises disparate units of information into significant units of meaning and is perhaps the most pervasive learning strategy for improving memory, as adults and children use it alike. For organising knowledge, young children use clustering, can sort information by meaning, using simple categories such as animals, plants, means of transportation, and articles of clothing. However, they employ categorisation strategies less often than older children because of their inability to understand a category. Research shows that "the skill is knowledge related, not age related; the more complex the categories, the older the child is before noticing the structure" (Bransford, Brown & Cocking 1999, p. 97).

Added to this, Bjorklund and Douglas (1997) wrote that knowledge achieved through clustering is not retained for long, is not often used, and is not spontaneous because of the poor performance of the skills involved. Scaffolding is required to overcome young learners' difficulties in understanding categories. They summarised several pieces of evidence from research studies explaining that memory performance can be enhanced by grouping items according to their meaning (linking this idea to previous section - the strategy of elaborative rehearsal may allow children to make groupings).

> Preschoolers use organizational strategies and demonstrate enhanced levels of memory performance when instructions are modified to emphasize the importance of grouping items according to their meaning (Corsale & Ornstein 1980; Lange & Jackson 1974; Sodian et al. 1986), when slight changes in stimulus presentation procedures are made (Guttentag & Lange 1994), or when children are explicitly trained to use organizational strategies (Black & Rollins 1982; Carr & Schneider 1991; Lange & Pierce 1992; Moely et al. 1969)… Young children are capable of organizing information for recall, but they typically fail to do so without training. Additionally, training rarely eliminates age differences, and young children transfer organization to new situations only after extensive training (Carr & Schneider 1991; D. Cox & Waters 1986) (Bjorklund & Douglas 1997, p. 210).

Design guideline; the BDP features have to be developed around the following ideas: 1) providing instructions that are organised, emphasising the importance of grouping items according to their meaning, 2) stimulating presentation by introducing authoring, and open-ended tools that generate intrinsic motivation that invite the child to use their own skills, and 3) explicitly training them to use the organisational strategies involved in concept mapping.

Concept mapping is a type of clustering strategy that requires the conceptual meanings to be hierarchically grouped, enclosed in boxes, labelled, connected with lines, and qualified with a linking phrase. Each of these activities is a form of clustering.

Teacher approaches for preschool concept mapping include scaffolding features (game metaphors, visual, and symbolic cues) that build on the concept of clustering. With these approaches the children clustered concepts by colour, number, sequence, tree form. Figueiredo *et al.* (2004) introduced the concept of hierarchy by establishing a comparison with schemas (visual cue), as their students were familiar to schemas, another form of clustering. Mancinelli *et al.* (2004) trained her students to make concept maps about lifecycles and making processes (visual cue). Mérida (2002) trained her students to represent hierarchy (different levels) in a concept map in a tree form, with colour-coded lines (visual cue) and ordinal numbers (symbolic cue). Badilla (2004) used mind games for stimulating thinking of the difference between concepts that can be imagined (visually represented) and concepts that cannot be imagined (abstract concepts and linking phrases).

These features for facilitating clustering and hierarchy are useful in closing the gap for effective preschool concept mapping, as they enable children to use the skills for concept formation.

Design guideline; my BDP for preschool concept mapping should build on the clustering strategies developed by the teachers. However, I argue that there are other aspects still to be addressed that are more important than hierarchy and clustering. The tool should include features that explicitly address labelling of concepts and linking phrases, so the children can autonomously revisit them and map relationships among them and categorise them.

Facilitate self-regulation of the mapping process

The learner consciously choosing to integrate new knowledge with prior knowledge is a condition of meaningful learning (Novak n.d.). This condition is at the core of the concept mapping process, as the map creator chooses to relate, integrate, hierarchically arrange concepts, plus all the other tasks involved in building a concept map that were presented at the beginning of this guideline 2. Choosing to integrate knowledge involves having control of metacognition.

Brown and DeLoache (1978 in Bransford, Brown & Cocking 1999) define metacognition (also called self-regulation) in the context of young children. It is the ability to self-regulate one's learning and is essential in the organisation of any piece of knowledge. Like other forms of learning, metacognition develops gradually and is as dependent on knowledge as it is on experience. Thus, it would be difficult to engage in self-regulation and reflection in regard to topics that are not part of one's knowledge or experience. Young children find it difficult to engage in self-regulation and reflection in areas they do not understand. However, in topics children know, primitive forms of self-regulation and reflection appear early. Self-regulation – the ability to orchestrate one's learning involves planning, monitoring success, and connecting errors when appropriate. All of these strategies are necessary for effective intentional learning (Beriter, Scardamalia 1989 in Bransford, Brown & Cocking 1999).

In this research, I related the ability to orchestrate one's learning to the concept of autonomy. If effective learning involves access to prior knowledge and the ability to orchestrate (or control) one's learning strategies, then, autonomy in preschool concept mapping would only be possible when children can represent the concepts and propositions they know and have control over the relevant knowledge organisation skills.

Design guideline; children should be enabled to concept map any kind of content, but at the same time, the template should provide scaffolding features that enhance the performance of their rehearsal skills (remembering) and clustering skills (organise knowledge). These features should support the process of hierarchically integrating knowledge. The template should also have features that allow young children to see and reflect upon the products of their own thinking process, and in this manner train their self-regulation skills during concept mapping. If it is desired to see them self-regulating their activities when building a concept map, neither the template nor the teacher should take control over the mapping activity. Always, the children should autonomously interact with the template features to make their concept maps. They should always be in control of what, when, and how to represent and organise knowledge with concept maps.

Guideline 3: use multiliteracy to label conceptual knowledge

The concept map template is comprised of two types of abstract or conventional symbols: written language and geometrical symbols. Written language is used to label concepts and linking phrases. The geometrical symbols (boxes and connecting lines) and the concept of hierarchy are used to organise written language in a tree-like graphic that expands from top to bottom and sideways. The map is an interconnected web that represents a domain of knowledge, which the literate brain can interpret.

This hierarchical graphic template with written words is a way of experiencing knowledge that is beyond the cognitive ability of young children. Understanding of abstract symbols also requires learning, which occurs over time and training. Young children do not recognise or interpret ambiguous stimuli, and have difficulty interpreting abstract symbols such as written language and other conventions. In the case of writing Pinker says '[f]or although language is an instinct, written language is not… children must be taught to read and write in laborious lessons…' (1995, p. 189).

From a developmental viewpoint, Bjorklund (2000) writes 'perceptual development is not complete at the end of infancy. Although a 2-year-old's visual and auditory systems are well developed, with age children are increasingly required to make more precise discrimination among stimuli' … many things are not what they appear to be, at least on first inspection (pp. 182-183). Bjorklund cited research of Gollin (1960) to explain that, typically, 3- to 4-year olds see one thing or the other. In their research children 2.5- to 5-years of age were asked to identify pictures beginning with the least complete. The younger children needed to view the more complete picture before making a proper identification, suggesting that with age, children are able to regulate their perception. Simply put, young children perform better with completed forms, closer to reality, and iconic representations with clear meaning.

Language, in the form of speech, enactive, iconic and symbolic representations, is the means by which children communicate the products of their discoveries (Bruner 1968 in McLane & McNamee 1990) and these products represent acquired knowledge. Understanding these language forms and how they have been applied in preschool concept mapping, enables us to identify what other language forms should be implemented to enhance the interpretation of the map content.

Label knowledge with spoken language

Children's ability to communicate what they know with spoken language is the most efficient way to identify conceptions and misconceptions. Interviewing children during guided conversations or clinical conversations is the method used for disclosing the conceptual meanings hidden in children's symbol maps (Figueiredo et al. 2004; Mancinelli 2004; Mérida 2002; Pérez-Cabani et al. 1992). A Reggio Emilia teacher explains the products of listening to children's talk:

> The practice of listening to children's talk in context like these drives home with absolute clarity children's passion to uncover meaning; to make relationships between what they experience, notice, hear about, see, and feel in the middle of living in the world; to create a collective discourse; and to keep going. This means that they are constantly building and rebuilding theories. For them, there is no end; there is no one 'right' isolated answer (Cadwell 2003, n.p.).

Between 3- to 4-years old young children show a predisposition to learning about some forms of knowledge: categories, physical and biological concepts, causality, number and language. In relation to language, children begin to develop knowledge of their linguistic environments using a set of specific mechanisms that guide language development, and become fluent in language if they live in a language-using environment. Language acquisition cannot take place in the absence of shared and social situational contexts because the latter provide information about the meaning of the words and sentence structures (Bransford, Brown & Cocking 1999).

> [Vygotsky says]...Verbal intercourse with adults thus becomes a powerful factor in the development of the child's concepts. The transition from thinking in complexes to thinking in concepts passes un- noticed by the child because his pseudo-concepts already coincide in content with the adult's concepts. Thus the child begins to operate with concepts, to practice conceptual thinking, before he is clearly aware of the nature of these operations. This peculiar genetic situation is not limited to the attainment of concepts; it is the rule rather than an exception in the intellectual development of the child (Vygotsky 1962, p. 69).

> …Indeed can it be doubted that children learn speech from adults; or that, through asking questions and giving answers, children acquire a variety of information; or that through imitating adults and through being instructed about how to act, children develop an entire repository of skills? Learning and development are interrelated from the child's first day of life (Vygotsky 1978a, p. 37).

Owocki (1999) says that Vygotsky holds the position that learning involves being introduced – through language – to the symbolic world of adults. Children's new concepts and propositional learning is heavily mediated by language. Concepts are learnt by trial and error, by asking questions, interacting with others in social settings using spoken and visual language (Novak 1998). The more active this process is, the more meaningful and useful assimilated concepts are. Novak's anecdotes on the concept of 'annoying', 'underbrellas', and 'grocery shopping' illustrate how young children's talk mediates acquisition of new concepts.

Owocki (1999) discusses Vygotsky's ideas reported in *Mind in Society* (see 1978, pp. 26-27) about the role of talk in the acquisition of knowledge. According to Vygotsky, the social use of language is an important part of children's construction of knowledge, as they use language to work their way through tasks, especially when the tasks are complex. Sometimes speech becomes of such vital importance that, if not permitted to use it, young children cannot accomplish the given task. As they grow older, these external processes develop into internal mental functions. To Vygotsky, language contributes to development, and is part of the cultural toolkit that helps children to organise their thinking and work out solutions to complex problems (see complete discussion in 1999, pp. 51-52).

Design guideline; children's talk carries knowledge, therefore, a feature of the BDP for preschool concept mapping should enable children to verbally label concepts by themselves, because in their conversations they use concepts, linking phrases, and propositions. To show evidence of this claim, I quote children's comments of a conversation about birds that Cadwell and her students from a Reggio Emilia school in the United States sustained. Cadwell (2003, see pp. 26-30) was also the children's teacher and published the conversation in her book. She started the conversation re-assuring the children about what they knew about penguins (they had worked on the theme for weeks). Then she explained that she would like to have a conversation about all they knew about penguins and maybe other birds. The participant children's comments are complete sentences or propositions. Here I list a few of many more: 'Where they live, yeah, they live in Antartica', 'But some live where the bigger turtles live'… 'My dad told me that some live on smooth islands where there is sand'… 'Penguins can't even fly', 'But their ancestors could'… 'Ostriches can't fly'… 'They can't fly because they don't have hollow bones. It is more important to them to swim and catch fish. A kingfisher dives into the water. Maybe ducks also dive into the water.'…

A group-concept map of this conversation about birds could be constructed with children's comments because their sentences are complete units of meaning that contain concepts, linking phrases and propositions (Figure 1.3 presents a hypothetical map). Ausubel (Ausubel, Novak & Hanesian 1978) explains that awareness of concept acquisition and deliberate use of concepts arises earlier in relation to scientific concepts than to spontaneous concepts. He supports this claim with research of Vygotsky's (1962) , which '… chief purpose was to test experimentally our working hypothesis of the development of scientific concepts compared with everyday concepts' (p. 105) (See the complete research in pp. 105-117).

> Awareness of concept acquisition develops late, Vygotsky (1962) believes, because it requires awareness of similarity. This, in turn, presupposes 'a more advanced structure of generalization and conceptualization than awareness of difference'. Nevertheless, even though children cannot use a word like 'because' deliberately in a test situation, and does not really grasp causal relations except in a very primitive form and intuitive sense, he or she is able to use 'because' correctly in every day conversation. The rules of syntax too can generally be employed correctly by young children despite complete lack of awareness of the nature of these rules. However deliberate use of such words as 'because' is possible in relation to scientific concepts because the 'teacher, working with the pupil, has explained, supplied information, questioned, corrected, and made the pupil explain (Ausubel, Novak & Hanesian 1978, p. 112).

One big issue with preschool concept mapping is that it is difficult to explain to children the difference between concepts (e.g. penguin, ostrich, Antarctic), linking phrases (e.g. because, can't, live), and propositions (e.g. ostriches can't fly, penguins live in the Antarctic), without having a visual representation of these elements that they can grasp. Therefore, having a feature that enables verbal labelling of symbol maps is pivotal to communicate full concept meanings and propositional statements.

This enables us to see how children package meaning in their symbolic representations.

Tacitly the work of Mérida (2002) and Figueiredo *et al.* (2004) support this claim. These teachers had expressed how hard it is to explain to their students the difference between general and specific concepts, explain hierarchy without having a way to represent relationships among symbols. In their experience reports they also clearly explain how hard it is to train children in the representation of concepts.

Design guideline; an effective concept mapping template for preschool should include a verbal feature that enables the representation of the concepts. If we want to see how children connect knowledge, the template has to provide features that enable children to represent any type of concepts (general, specific, abstract, etc) and linking phrases.

Build on children's mastered representation skills

McLane and McNamee (1990) discuss that experiences, feelings, and ideas developed in real and play situations are all forms of knowledge whose meaning children represent and communicate with symbols. Between the ages of 1 to 5, children learn to use symbols to create and communicate meaning – both symbols they invent for themselves and those 'donated by the culture' (Gardner and Wolf 1979, p vii in McLane & McNamee 1990). Symbols, which may include words, gestures, marks on paper, objects modelled in clay, and so forth, make it possible to represent experiences, feelings and ideas. They also allow children to go beyond the immediate here and now to create imaginary worlds. This is what children do when they make up stories, engage in pretend play, or draw images on paper – and, later when they read books and write stories (see complete discussion in pp. 11-12).

In guideline 1 subheading 'make the concept map experience less abstract' of this chapter, I present expert comments cited in Fisher (2002) on the topic of how children learn, specifically on the importance of not rushing children's transition from concrete to abstract learning. I expand on this topic by citing Bruner (1997) in relation to the three ways he thinks humans represent the world:

> ... Some years ago, several of us at the Center for Cognitive Studies at Harvard brought out a book entitled *Studies in Cognitive Psychology and Growth.* [4] It argued, in a rather oversimplified way, that there were three ways in which humans represented the world, or better, three ways of capturing those invariances in experience and action that we call 'reality'. One was by enaction; a second through imagery; and a third through constructing symbolic systems. You represented the world in action routines, in pictures, or in symbols, and the more mature you became, the more likely you were to favor the after end of the progression than the starting end. At the time we thought that the course from enactive through iconic to symbolic representation was a progression, although I know longer think so. But I do still find it useful to make a threefold distinction in modes of representation although not on developmental grounds (p. 155).

Anning and Edwards (1999) explain that 'children experiment with different ways of representing their growing understanding of the world around them' (pp. 83-84) and use Bruner's three categories of representation to illustrate their explanation:

- **Enactive representations**: when children participate through their actions. Bruner (1988) defines them as '…a mode of representing past events through appropriate motor response. We cannot for example, give an adequate description of familiar sidewalks or floors over we habitually walk, nor do we have much of an image of what they are like. Yet we get about them without tripping or even looking much. Such segments of our environment - bicycle riding, tying knots, aspects of driving - get represented in our muscles, so to speak...' (pp. 35-36).

- **Iconic representations**: when children participate looking at or making pictures or images of things (e.g. drawing). Bruner (1988) stated '...Iconic representation summarizes events by the selective organization of precepts and of images, by the spatial, temporal, and qualitative structures of the perceptual field and their transformed images. Images "stand for" perceptual events in the close but conventionally selective way that a picture stands for the object pictured...' (p. 36).

- **Symbolic representations**: when children participate through using the abstract symbols, for example, print or mathematical symbols to represent things. Symbolic representations offer the child opportunities to move from consideration of the concrete here and now of immediate experiences to the abstraction of events that were in the past or maybe in the future. Bruner (1988) defines that '... a symbol system represents things by design features that include remoteness and arbitrariness. A word neither points directly to its referent here and now, nor does it resemble it as a picture. The lexeme "Philadelphia" looks no more like the city so designated than does a non-sense syllable. The other property of language that is crucial is its productiveness in combination, far beyond what can be done with images or acts. "Philadelphia is a lavender sachet in Grandmother's linen closet", or $(x + 2)^2 = x^2 + 4x + 4 = x(x + 4) + 4$' (p. 36).

The preschool teachers, whose experiences were presented in chapter 2, designed concept mapping activities that involve the application of Bruner's categories of knowledge representation. Before making a symbol map of the pumpkin and its parts, Mancinelli and Guaglione (2004) organised for the children to explore a pumpkin. The children cut the pumpkin open, separated the seeds from other fruit parts, etc. Similarly, before making a map of 'what we know about the cow', Figueiredo *et al.* (2004) organised for the children to visit a milk farm, and they read books about the cow. Mancinelli and Guaglione and Figueiredo *et al.* had their students experience the topic 'enactive-lly' (play with the pumpkin, visit where milk cows live), iconically (make drawings of the pumpkin and its parts and photos of the cow and its environment), and then symbolically (make symbol-maps with the drawings and the photos collected throughout the activity).

Because preschool children's capabilities enable them to use different knowledge representation styles to communicate meanings, the approaches for preschool concept mapping reported in chapter 2 include features that take advantage of these capabilities. Mancinelli and colleagues do a good job in transitioning their students from enactive concept maps to symbol concept maps. They design mapping activities where children can make maps with their bodies ('enactive' representations), toys (iconic representations), and drawings (symbolic representations) (Mancinelli 2004;

Mancinelli & Guaglione 2004). Mérida (2002) took a different approach, she developed activities that transitioned her students from iconic-realistic representations to symbolic-conventional symbols. Her method enabled the children to progressively learn to make less iconic and more symbolic representations. The strategy was used to speed up the process of representing a concept and enabling them to represent more concepts than they otherwise could.

Children's drawings are one of the ways teachers know what children know (Helm & Katz 2001) and this is the justification for some preschool programmes to dedicate part of their teaching to enhancing children's drawing skills. The Reggio Emilia approach to learning includes training children from as early as 2 years of age in the use of many representational techniques. Two teachers attend each Reggio classroom. One of them is an Arts teacher, whose role is to help children to develop what Reggio teachers refer to as 'their hundred languages to communicate meaning' (Giudici, Rinaldi & Krechevsky 2001). Brook (2004) recommends the use of drawing as a powerful meaning-making tool for young children. She reports 'drawing processes that encourage children to talk about, share, revisit, and re-conceptualise their drawings, extends children's thinking as well their awareness of different possibilities for representation' (p. 41).

Design guideline; children can only represent a limited set of concepts with the teacher approaches that were reported in chapter 2. As explained earlier in section 'label knowledge with spoken language', this limitation is not due to lack of knowledge, but to the inability to represent all the concepts that are spoken and shared during a mapping session. The representation of every concept, not only the most general and the more specific ones, is essential for seeing how all the concepts of a particular piece of knowledge are related. With the existing tools for mapping concepts and the methods used to disclose children's meaning, this 'explicitation' of knowledge is limited and is collected in formats that the children themselves cannot revisit later, and limit their awareness of mapping. The BDP for preschool concept mapping should include features that address these issues.

Guideline 4: enable teachers to diversify instruction

Effective teachers help people of all ages make connections among aspects of their knowledge (Bransford, Brown & Cocking 1999). Teachers, in general, present learning activities in an organised manner. According to the students' prior knowledge and control over the learning strategies needed to accomplish a specific task, they design programmes that help people to acquire new knowledge on a particular domain. The teacher role is to mediate and regulate this process. Such mediation is given via teacher encouragement or via appropriate educational resources, designed according to the students' needs and learning goals.

In the case of concept mapping, teachers instruct literate students in the use of the template and support construction by explaining the procedures for building a concept map. Teachers can also prepare expert, made-from-scratch, or topic maps for the students to study and analyse (see definitions of these map types in chapter 2).

Despite the kind of concept mapping activity the teachers prepared for them, the students themselves always interact with the map elements. Because the map elements are visible, accessible to the student for interpretation, the students are able to discuss them with the teachers, peers and others involved in the mapping process. '… concept maps can be enormously useful to teachers, administrators and learners to move towards sharing the same concept meanings for the words or symbols represented…' (Novak 1998, p. 38).

Re-establish teacher support according to theory

The role of the teacher in any educational task, in Piaget's view, is to foster changes in children's thinking (DeVries and Kohlberg in 1987 Owocki 1999) through engagement in activities such as the ones described in guideline 1: hands-on activities, social interactions, and play. The following comments of Piaget's (1973) support the interpretations of the authors cited by Owocki:

> There is nothing more difficult for the adult than to know how to appeal to the spontaneous and real activity of the child or adolescent. Only this activity, oriented and constantly stimulated by the teacher, but remaining free in its attempts, its tentative efforts, and even its errors, can lead to intellectual independence... The goal of intellectual education is not to know how to repeat or retain ready-made truths (a truth that is parroted is only a half-truth). It is in learning to master the truth by oneself at the risk of loosing a lot of time and of going through all the roundabout ways that are inherent in real activity (p. 105).
>
> The active school... presupposes working in common, alternating between individual work and work in groups, since collective living has been shown to be essential to the full development of the personality in all its facets - even the more intellectual. An entire technique of "work in teams" has been developed in many different countries under different names... (p. 108).

Teachers in developmentally appropriate classrooms plan for children to engage in a variety of concrete learning experience that promote their interest, engagement in learning, and conceptual development (Bredekamp and Copple 1997, p. 126 in Owocki 1999). Through these experiences, teachers help children to connect new situations to more familiar ones (Bransford, Brown & Cocking 1999). Connecting new situations to more familiar ones can be related to what Ausubel calls relating new knowledge to prior knowledge (see section 'background' in chapter 1).

Including teachers, the role of the adults or more experienced peers is to mediate these different modes of representation for the child until they are able to use them with confidence independently. As explained earlier in this chapter, this mediating role of the teacher was called 'Scaffolding' (Wood, Bruner & Ross 1976`, pp. 89-100). Bransford *et al.* (1999) presented the several activities and tasks that are involved in Bruner's scaffolding process:

- interesting the child in the task;
- reducing the number of steps required to solve a problem by simplifying the task, so that a child can manage components of the process and recognize when a fit with task requirements is achieved;

- maintaining the pursuit of the goal, through motivation of the child and direction of the activity;
- marking critical features of discrepancies between what a child has produced and the ideal solution;
- controlling frustration and risk in problem solving; and
- demonstrating an idealized version of the act to be performed (p. 92).

The concept mapping experiences reported in chapter 2 are of educational value and are examples of how teachers applied the concept of scaffolding. Teachers adapted Novak's concept map template to meet children's prior knowledge and cognitive level. The issue with some of the template designs, as some teachers have expressed, is that the children do not have complete control over the performance of the mapping activity (Figueiredo et al. 2004; FOD 2004a). The lack of control over the activities results in heavy mediation such as the teacher completing the map for them. They heavily mediate children's interactions with the concept map template because they found it quite hard to explain certain aspects of the template to the children. See chapter 2 for detailed description of teacher experiences on difficult mediation and template designs.

The conclusion of this section is that the scaffolding support that teachers provide for concept mapping, in many occasions, is preventing the children from fully participating in the construction of their own knowledge. However, it must be highlighted that this occurs more often when the teacher uses the technique only every so often. After considerable instruction and practice, and depending on the effectiveness of the scaffolding tools put in place by the teacher, children can assume total control over mapping activities. Mérida's 9-month project provides evidence of child control over a mapping activity after suitable instruction and steady practice.

Design guideline; as explained earlier in this chapter, the BDP features should enable children to take control over the building of the map. Children's autonomy during map building may facilitate teacher instruction and enhance teachers' process of scaffolding as stated by Bruner.

Provide flexible educational resources

Teachers should provide materials that are neither too simple, nor too complex, but which seem just right for their children to seek answers to their many questions about the world (Owocki 1999). Materials should include, but are not limited to, blocks and other construction materials, books, and other language arts materials, dramatic – play themes and props, art and modelling materials, sand and water with tools for measuring and tools for simple science activities (Bredekamp and Copple 1997, p. 126 in Owocki 1999). In my view, the idea 'neither too simple, nor too complex' is a practical way to talk about scaffolding, ZPD, and fostering.

The teacher approaches for preschool concept mapping use many of the materials cited by Owocki, which can be labelled under the concept of open-ended tools that can be easily adaptable to children's needs and to different educational situations. In the FOD online forum on preschool concept mapping (FOD 2004a), teachers and researchers supported the benefits of using these kinds of tools and did not challenge their stand as relevant to introducing this age group to Novak's tool.

I agree with the reasoning of the FOD forum teachers. An educationally appropriate template for concept mapping should always enable hands-on experiences. But at the same time, it should enable children to autonomously interact with the concept map elements and explore their different aspects. This is where I differ with the teacher approaches. The hands-on mapping experiences reported in chapter 2 make children's mapping process almost impossible without intensive instruction. Such difficulty results in teachers working hard in the design of a feasible tool, designing simplistic mapping activities, or dropping the idea of using the technique altogether (FOD 2004a). The materials used for designing the template components have limited representational meaning.

Design guideline; designing a template, that enables children to control and understand what has been mapped, might restore the teacher's role. The role of the teacher in Novak's concept mapping is to accompany, mediate, and scaffold the autonomous construction process of the student, which includes, demonstrating, suggesting concepts and linking phrases, and identifying propositions and cross-links. Similarly to the reports of Coffey *et al.* (2003) on diverse applications of the tool, teachers should be able to design expert maps, made-from-scratch maps, and low-directed maps that the student can revisit or edit alone or in company.

Enable the design of 'make knowledge explicit' activities

Children are the constructors of their own knowledge, as a result of their own actions (Ferreiro and Teberosky 1982, p. 15 in Owocki 1999). Action (e.g. educational activity) that is overly planned or teacher-centred cannot adequately help children to build knowledge or make discoveries (or in the words of Ausubel, acquire new knowledge) because it cannot bring about the kinds of thinking that allow them to build upon their unique schemas or mental plans (also called cognitive or knowledge structures). Children make sense of new information based on their current levels of understanding and cannot be expected to do so in any other way (Hulit and Howard 1993 in Owocki 1999).

In developmentally appropriate classrooms, children are seen playing, experimenting, acting on objects and exploring, instead of listening to a teacher talk, watching her demonstrations or filling out dittos and worksheets (Owocki 1999). In these type of stimulating and hands-on environments is where children's strategies for accommodating and assimilating knowledge are always at work (Bredekamp and Copple 1997, p. 126 in Owocki 1999).

Novak's concept mapping requires the learner to be aware of acquiring conceptual knowledge. People have to be aware of the role of the map elements in the construction process. As explained in guideline 2, young children do not control, or are not fully aware of, or do not spontaneously employ the skills required in concept mapping. However, in an earlier quote, I presented information where Ausubel (1968) cites Vygotsky (1962) to say that these children can develop early awareness of concept acquisition, within structured learning environments guided by a teacher.

Owocki (1999) explains the teachers' role is to support children by encouraging them to articulate and mentally organise their ideas. Questioning (used in clinical interviews or guided conversations) is the method most commonly used together with drawing analysis and observation to analyse knowledge acquisition (Fleer 1996; Helm & Katz 2001). Another method is Novak's concept maps. The teacher approaches for concept mapping include questioning as the strategy to disclose meaning from children's symbol-maps and to evaluate if learning has occurred. See chapter 2 for detailed explanations on this.

Meaning negotiation and collaboration are the benefits that researchers such as Mérida (2002) and Pérez-Cabani (1992) consider as the most prominent in preschool concept mapping. For Novak, as stated earlier, meaning negotiation is also the most important benefit of concept mapping. Because of this, the template for preschool concept mapping must allow for social transactions that facilitate exchange of meanings among teachers and peers. Social transactions, together with play, should bring children to their zone of proximal development, where they can make connections between the known and unknown, while engaging in meaningful conversations, peer-problem solving, and play.

Children in a supported environment gradually acquire the same learning strategies that older children and adults have, such as strategies for remembering (e.g. knowledge organisation), understanding, and problem solving. Parents and caregivers (e.g. teachers) arrange their activities and facilitate learning by; 1) regulating the difficulty of the tasks, and 2) modelling mature performance during joint participation in the activities (Bransford, Brown & Cocking 1999).

Design guideline; applying what has just been described to concept mapping, I say that the template should address the representation problems by providing structuring features for remembering, concept representation and labelling. Once these problems are addressed the teacher would be left to deal with knowledge construction problems and would be able to design activities that address them. By supporting remembering, autonomous concept representation and labelling, the teacher facilitation would then undergo a transformation, from heavily intervening in the representation of concepts, to supporting children's process of externalising and organising conceptual knowledge.

Template features that assist children in remembering, or in the words of Novak, at retaining knowledge, may enhance understanding and interpretation of template content. The teacher support here has to be in scaffolding the process of teaching the children to remember and understand by themselves. Currently, teachers interview children to disclose meaning of symbols within a symbol-map. What is preferred, is to enable children to disclose symbolic meanings and revisit them by themselves.

With Novak’s template, literate people always work on the map construction by themselves: they can label a concept with words, enclose them in boxes, and connect them with lines to make propositions. They may find it hard to make goods maps, but they do not find it hard to use the elements for constructing them. The difficulty in mapping is related to the mental processes. For the teacher to explicitly see how the student understands a piece of knowledge, how a concept is related to another in his cognitive structure, the student has to be able to represent every single aspect of it when creating it or be able to interpret every single aspect of it when studying somebody else’s map.

Design requirements

This section presents the design requirements for developing a BDP for preschool concept mapping. The conclusions of chapter 2 and the conclusions of the four guidelines of this chapter combined were used to produce the requirements that informed the prototyping cycles presented in chapter 5. Table 4.2 lists the conclusions of each chapter in a brief form.

From the theoretical factors and the aspects analysed in this chapter I concluded that preschool children are hindered in their representations and organisation of the products of their thinking (ideas, thoughts, prior and new knowledge) with Novak’s concept map template by two reasons. The first reason is that they are preliterate and emergent writers. The second reason is that they are not yet efficient at spontaneously using the cognitive skills required in concept mapping: knowledge organisation, retention and self-regulation. These representational and cognitive limitations prevent children from interacting with the template’s components. Its components are constructed with abstract symbols (written language and hierarchy) that they do not yet grasp.

Children’s inability to efficiently use the cognitive skills required in concept mapping prevents them from autonomously labelling concepts, re-organising, and interpreting single concepts or concepts related with connecting lines. With the teacher approaches to preschool concept mapping, in some cases and after exhaustive instruction, children could represent general and specific concepts with symbols and connect them to make symbolic relationships. However, these approaches, as explained in chapter 2, enabled the making of simple concept maps, but failed to include features that enabled children to autonomously perform labelling, organisational and interpretative actions. These actions, which are pivotal to concept mapping, are also essential to facilitate knowledge retention, preservation and sharing, and therefore, promote knowledge acquisition, or in Ausubel's words, meaningful learning.

The argument put forward in this chapter provides the rationale for developing a concept mapping template that provides for autonomous exploration. That is, regardless of the type of design or the materials used in the development of the feature components, the template for preschool concept mapping should enable children to autonomously explore the map elements at their own will and support them in achieving the main tasks: representing, labelling, and manipulating concepts and linking phrases. This chapter also suggests that the template should be constructed with structuring features that build on children's mastered skills and scaffold the performance of the developing skills or in other words, the skills that they do not yet have control of.

The template for preschool concept mapping should have structuring features that enable and scaffold the following (cognitive, mental, visual and physical) tasks:

- **Tangible features or concrete materials to make the process of building a map less abstract:** Tools that allow for direct manipulation, which in turn, may increase intrinsic motivation. It is widely known that open-ended tools enhance authoring and require minimal teacher assistance in the making of concepts and propositions process, but lots of facilitation in the understanding of the topics being mapped.

- **Voice recording features to enable verbal labelling:** They make the children's knowledge explicit by allowing them to verbally add meaning to symbolic representations to enable the inclusion of abstract concept and linking phrases. The concept map would not be complete without the presence of abstract concepts and linking phrases. With a voice input/output component teachers would neither require interviewing the children nor annotating the maps for the purpose of disclosing drawing meaning.

The ability to record verbal labels of concepts may allow self-idea exploration and facilitate knowledge retention, preservation and sharing. A feature of this kind may enable children to revisit, edit, replace, and share concepts created with the template. It may also increase intrinsic motivation and remove teacher direct intervention in the construction of the map.

- **Multipurpose features to facilitate teacher instruction:** These components should adapt to different mapping situations, enable the creation of low-directed concept maps, pre-constructed concept maps, and made-from-scratch maps. They should allow the teacher to diversify the range of strategies and the themes that can be concept mapped. With these features it is expected that the children and teachers add their own signature and ideas to the making process.

- **Easy shareable, removable and replaceable features to facilitate sharing and preservation of the map content:** Children should be able to discard a concept or a linking phrase or a connection without having to draw the whole map again. Whatever is produced during the session should be kept until the next session or for as long as teachers and children want to keep it.

- **Visual cues and physical constraining features that facilitate identification of concept types and hierarchical relationships:** They may speed up the mapping process and train clustering skills and visualise hierarchy among concepts. Interacting with such features may improve the performance of children's limited memory retention, short attention span, and self-regulation.

- **Augment or enhance manipulation of the concept map:** Making a map requires paying attention to many instructions that may be overwhelming to children's working memory. Group actions into manageable tasks, use strategies to sequence the making of the map. Create a mechanism, which speeds up children's concept mapping process by addressing their limited motor skills, when drawing and organising knowledge or interacting with the template components.

- **Use multiliteracy:** Enable the use of different modes of representation (with symbols, emergent writing or writing, and spoken language) to represent concepts (also called ideas, thoughts, knowledge).

Table 4.2 summarises the key concepts treated in this chapter. Columns 4 and 5 represent the aspects that should be investigated during prototyping (chapter 5).

Table 4.2 – a summary of the key factors informing the design requirements of a BDP for preschool concept mapping

<table>
<tr><th colspan="6">Table 4.2 - Claims, Requirements and Features of a BDP for Preschool Concept Mapping</th></tr>
<tr>
<th>[Chapter 1]
Research Goal</th>
<th>[Chapter 1]
Research Claims
for bringing autonomy to the children’s mapping process</th>
<th>[Chapter 2]
Activities
needed to bring autonomy to children’s concept mapping</th>
<th>[Chapter 4]
Design Requirements
to enable the design of features that bring autonomy to children’s concept mapping</th>
<th>[Chapter 4]
Structuring Features
the BDP should have for enabling autonomous interactions</th>
<th>[Chapter 2]
Expected [Inter]actions
from the ability to perform autonomous interactions with the BDP components</th>
</tr>
<tr>
<td rowspan="3">[Chapter 1]
Bring autonomy to the children’s concept mapping process.

Adding this characteristic to children’s preschool concept mapping will enable me to investigate the research claims [chapter 1]:

• Make children’s knowledge explicit
• Facilitate representation and manipulation of knowledge
• Facilitate instruction</td>
<td rowspan="2">Make conceptual knowledge explicit

and

Facilitate the representation of knowledge</td>
<td>Add meaning to symbolic representations, include abstract concepts and linking phrase with spoken language – (Related to guideline 3, chapter 4)</td>
<td>Enable verbal labelling – (Related to guideline 3, chapter 4)</td>
<td>Voice recording features to enable verbal labelling of concepts and linking phrases</td>
<td>• Allowing for self-idea exploration
• Increase intrinsic motivation
• Enhance meaning negotiation and knowledge retention
• Require minimum or non-teacher assistance in concept labelling. For e.g. teachers neither will require interviewing the children nor annotating the maps for the purpose of disclosing drawing meaning</td>
</tr>
<tr>
<td>Represent ideas or concepts with symbols, emergent writing or writing skills – (Related to guideline 3, chapter 4)</td>
<td>Enable multiliteracy– (Related to guideline 3, chapter 4)</td>
<td>Drawing tools, writing tools, or pictures or photograph library.</td>
<td>Increase children’s options to represent the template elements, according to their mastered representation skills</td>
</tr>
<tr>
<td>Facilitate or enhance teacher</td>
<td>Make maps adaptable to different concept mapping activities – (Related to</td>
<td>Enable the construction of low-directed concept maps – (Related</td>
<td>Use multipurpose features: open-ended, flexible, authoring</td>
<td>• Children may be able to create their own maps, add their own</td>
</tr>
</table>

• Promote autonomy and use of multiliteracy	instruction	guideline 4, chapter 4)	to guideline 4, chapter 4)	materials	signature, and ideas • Teacher instruction will concentrate them in explaining them how to represent their ideas or concepts with the concept map (e.g. representing and labelling the concept, connecting concepts and identifying propositions)
			Enable the development of pre-constructed concept maps for the students – (Related to guideline 4, chapter 4)	Library type-features for creating thematic maps or expert maps	• Teachers can design activities on topics that they want the children to learn, e.g. a pre-constructed map about Farm Animals • It should enable the teacher to diversify the range of strategies and the themes to explain Novak's concept maps or other mapping techniques to the children
	Enhance manipulation of the concept maps	Review, edit, and replace concept map elements	Enable efficient editing of single map elements – (Related to guideline 2, chapter 4)	Editing and feedback features	Children may be able to discard, edit or replace elements of the map without having to draw the whole map
	Facilitate sharing and preservation of concept map elements	Revisit at any time, share and preserve		• Saving features, keep map or map collection for a long time • Features for creating copies of the map, for printing	• Keep whatever is produced during the mapping session, until next session or for as long as children and teachers want to keep it • Enhance meaning negotiation,

					and encourage map sharing and map-making collaboration among the user community (peer-peer, teacher-student, and teacher-teacher)
	Scaffold children's understanding of what a concept map is	Make the template features less abstract	Enable children to experience, touch the elements of the map – (Related to guideline 1, chapter 4)	• Design tangible features, make the template features to look like a playful resource, game like metaphor… a manipulative, a hybrid between a game and a representational tool. • Features that enable direct manipulation, experience the map concretely, like a hands-on experience	• Avoid adult assistance in the making of the concept map
	Scaffold children's self-regulation skills	Keep control of every aspect of the activity. and Speed up the process of drawing in boxes and Speed up the process of drawing arrow-connections and connecting them to concepts – (Related to guideline 2, chapter 4)	Present tasks (the building steps) for making the concept map sequentially and in a few steps. Clearly delimit each task: • Drawing the concept • Labelling the concept • Connecting the concepts • Establishing conceptual relationships • (Related to guideline 2, chapter 4)	• Visual and tactile cues for delimiting the space to draw a concept … Improve the process of drawing concepts in a limited space, in a box • Visual cues or patterns to label symbols with spoken language • Visual cues for organising concepts hierarchically	It may improve cognitive performance when categorising hierarchically and motor skill performance when interactive and using the materials

	Scaffold children's limited memory retention and short attention span	Keep every activity visible to know what to do – (Related to guideline 2, chapter 4)	Enable children to use familiar tools or materials, methods, theories, in other words, enable them to access prior knowledge – (Related to guideline 2, chapter 4)	• Visual cues, use repetition, and enable rehearsal (support limited memory retention)	

The structuring features, presented in the features column of Table 4.2, may facilitate and enhance the construction of concept maps by permitting young children to explicitly see, manipulate their own mapping process, and recognise similarities and differences between concepts and propositions. Once the template addresses all these issues, autonomous representation, labelling, and manipulation of concepts and linking phrases may be possible.

As a result of being able to perform these tasks, parents, caregivers and children themselves may be able to see and understand how the children are learning to label objects (words, signs or symbols), events, and categories of events or objects. For instance a concept map may help a child to visualise that all dogs have certain characteristics, and acquire the concept dog by explicitly showing (by images or verbal-inputs) the child the similarities there are between all dogs.

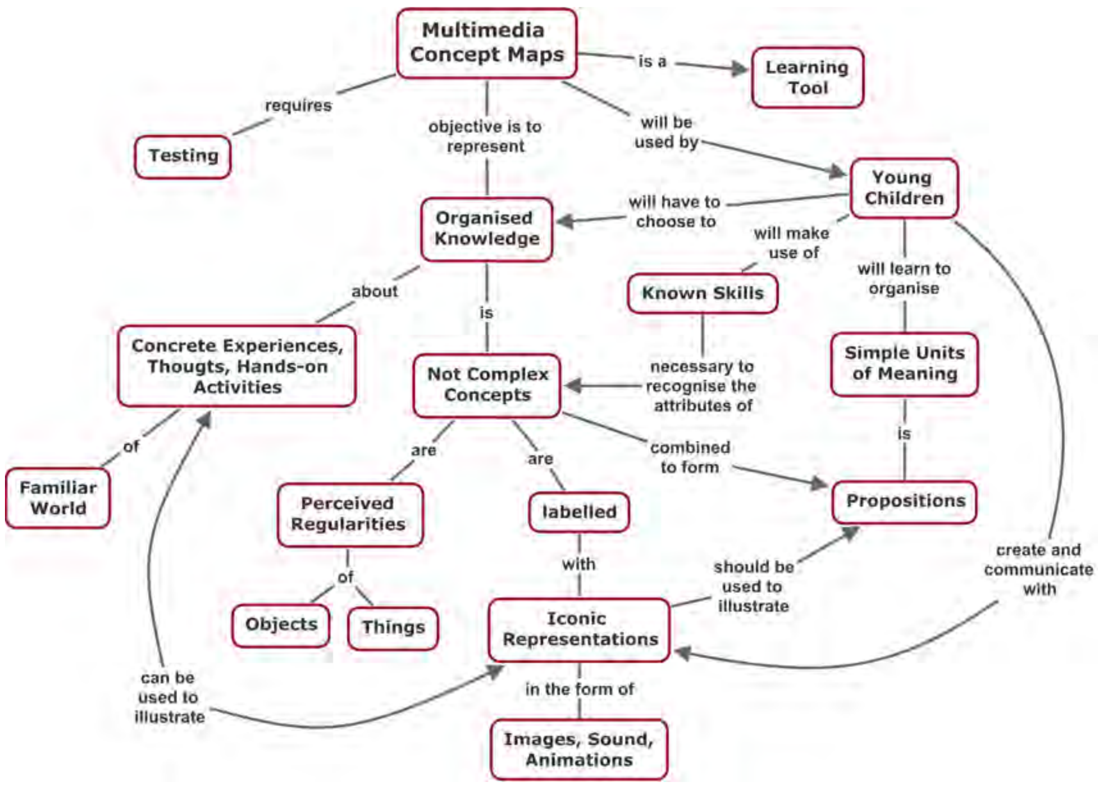


Figure 4.1 – a concept map on the type of maps the children should be able to create with the tool

Based on the theoretical factors presented, a concept map was drawn to represent the kind of concept maps the preschool children should be able to represent with a template for concept mapping with structuring features. See Figure 4.1.

As a result of interacting with this structuring educational resource, children should be able to use the skills required for autonomous knowledge representation and organisation. If the tool enabled the above interactions and the ones listed in the column 'expected [inter]actions' of Table 4.2, it would be possible to say that the re-designed Novak template for concept mapping promoted active inquiry and creative thinking. Fostering creativity, supporting the development of intentional effective learning skills, and confidence and precision in spoken language are important aspects of teaching in successful preschool systems (Fisher 2002).

Boggino (1997) suggests using the concept map to train children especially in the construction of mental images, but also in object and/or event representation. The purpose of this training should be to rehearse the acquisition of a series of concepts and language rules that play crucial roles in subsequent school learning (Novak & Gowin 1984).

Summary

In this chapter I explained how prior knowledge of the user community informed my process of identifying the BDP design requirements. By comparing theories, methods and instruments for learning to Novak's underlying theories of concept maps, I was able to identify and address issues behind preschool concept mapping.

The issues identified did not relate to children's lack of knowledge or inability to make concepts and propositions. Rather they relate to the ability to control cognitive skills required for organising knowledge hierarchically and to represent it with abstract symbols. The current representational tools for concept mapping are too abstract for children at this stage of development. At this age children show us what they know via drawings and talking, not reading and writing, and they do not have well-developed structures for remembering. For these reasons there is educational value in current teacher approaches to preschool concept mapping. They foster, scaffold, and support the development of some of the strategies that are required in concept mapping. However, when these approaches replace pivotal elements of the template (e.g. written labels that make knowledge explicit) with ones that children can understand (e.g. symbols), they cease to create Novak concept maps.

In this chapter I also stated the logic and validity of a child-friendly alternative tool to Novak's template for the preschool classroom. Such a tool must create a hands-on experience, with features that enable social interactions, play, and use of multiliteracy skills. At the same time, it should provide scaffolding features that enhance children's control over relevant cognitive skills: knowledge retention, and self-regulation. My claim is that Novak's concept mapping tool will only succeed when the elements used for representing concepts, propositions and linking phrases comply both with what literature and practice report regarding how children learn at this stage of their development.

This chapter concluded with a set of design requirements that call for the development of an authoring concept mapping tool with structuring features building on children's mastered skills and which scaffold the performance of developing cognitive skills. The features should support recording all of types of knowledge representations (verbal, visual, and written language), because children should be able to make their knowledge explicit without teacher assistance.

The goal of this chapter was to identify design requirements and features (interactions and interfaces). The reader should be able to apply this knowledge to design their own tool, whether employing tangibles or a computer. I claim that if such a tool applied the requirements and structuring features described, it should comply with Novak's theory, and with the philosophy of preschool education. In chapter 5, I describe how these requirements were incorporated into the design of BDP features, and informed the decision making process.

Chapter 5 – Prototyping a BDP for Preschool Concept Mapping

Overview

In chapter 3, I presented the Bridging Design Prototyping method I developed for investigating user communities in real settings. In chapter 4, I presented the theory and practice that led to the selection of design requirements and structuring features that the prototype should have. In this chapter, I explain how the BDP method and design requirements were applied and the structuring features were interpreted into the development of a Bridging Design Prototype (BDP) for preschool concept mapping. An important condition for the final prototype was that it could be used in any preschool classroom.

The BDP used in the case studies (reported in chapters 7 and 8) was the result of two prototyping cycles. Prototyping cycle 1 was undertaken so that I could examine my initial design assumptions (presented at the beginning of this chapter). The evaluation of that prototyping underpinned my decision as to which prototype would be used in the case studies. This decision was strongly influenced by the profile of my specific user community, Australian and New Zealand preschools. Low-fidelity prototypes were developed and presented for discussion to key experts of these communities. The results of these discussions revealed a gap between the theory and practice regarding the use of computers. This gap was addressed by modifying the design requirements according to the needs identified by the Australian and New Zealand teachers.

Prototyping cycle 2 was undertaken specifically to develop a tangible BDP that comprised materials familiar to the preschool community and one innovation, an 'off the shelf' hand-held voice-recorder for labelling symbols. This BDP was attractive to teachers for incorporation into their classroom activities, as it could be used for activities beyond concept mapping. The tangible BDP prototype was trialed through a process that used discussions with experts in Early Childhood education, Computer Scientists, and Designers. These discussions ensued from my presentation of the BDP at two conferences and also in private meetings. The results of these trials demonstrated that this BDP facilitated labelling, manipulation, preservation and sharing of the map elements. These experts agreed that the use of the hand-held voice-recorder was a significant feature and, overall, the prototype had inclusive characteristics. They did offer advice regarding possible improvements about its design and other uses it could have such as practicing phonics and with children with special needs. The preliminary findings and expert suggestions told me the BDP was ready for testing.

Initial design requirements

Technologies for making concept maps

The materials that are often used for making concept maps are: pencils or markers, Post-its or butcher paper and a whiteboard (Coffey et al. 2003; Novak & Cañas 2006b). These materials allow for some flexibility as concepts can be easily moved around, manipulated and edited. Novak and Cañas (2006b, p. 10) say this approach 'is necessary, as one begins to struggle with the process of building a good hierarchical organization' with concept maps. These materials are also part of the collection of tools currently used in preschool concept mapping (Figueiredo et al. 2004; Mancinelli 2004; Mérida 2002).

The literature suggests that computerised concept mapping can be even more effective than concrete materials for manipulation of concepts. This is because software packages, such as CmapTools, Inspiration, Kidspiration, provide features that automate tasks, enhance the manipulation, construction, and editing of the different elements of a concept map (see Coffey et al. 2003, pp. 54-62 for more examples).

When this doctoral study started, Kidspiration (www.kidspiration.com) was the only knowledge representation software available on the market that was specifically aimed at preschool age children. That software was targeted at students in Kindergarten to grade 5 (K-5), which represented an age span of 5-10 years. Kidspiration allows for building different kinds of graphic organisational charts, concept maps is one of the options. The software offers children the opportunity to create elements with text, images and spoken words. However, despite its capacity to enable mapping tasks, the software has some 'adult-like' features. It is heavily mediated by text and has organisational categories such as menu lists, drop-down menus, dialogues that are not appropriate to this age group. Fulton Suri explains it, ‘adapting interfaces originally aimed at adults is definitely not an option, as they do not take into account the developmental processes of children’ (Brouwer-Janse et al. 1997, p. 46).

Computers and young children

The literature on computer-mediated learning for young children offers extensive advice for designing and researching developmentally appropriate computer tools (Clement and Nastasi 1993 in Clements 1997; Hakansson 1990; Hill 2004; Jones & Selby 1997; Seng 1998). This includes a plethora of information regarding the positive and negative impact of computers on learning (Brouwer-Janse et al. 1997; Clements 1997; *Construction kits made of atoms and bits - CAB project* n.d.; *ECT interview: computers and young Children* 1999; Elliott & Hall 1997; Hakansson 1990; Healy 1998; Hill 2004; *Interim report of the developmentally appropriate technology in early childhood (DATEC) project* 2000; O'Rourke & Harrison 2004). See also periodicals such as the Journal of Computing in Early Childhood, Children and Computers, the proceedings of the International Conference on Interaction Design and Children conference.

In parallel, industry has developed and commercialised software applications as well as toys and learning systems with digital components. Young children have been given greater control in relation to how they can use software. Now that many technologies such as voice-activation and voice recognition have been perfected, it is possible to design portable self-contained system, cheaper scanning and printing technologies, advanced input and output devices, which enable new ways to manipulate real and virtual objects (Brouwer-Janse et al. 1997; Hakansson 1990). These technologies have been used by many researchers to develop educational products for use with children (Africano et al. 2004; Piernot et al. 1995; Wyeth & Purchase 2002).

From the literature on computers, learning, and children, I concluded that computerised concept mapping was a solution for enabling preschool children to make concept maps. Thus, the initial design requirements were gathered for developing the prototype a computer-based application. The outcomes of my research, however, suggested something very different.

… A computer-based concept mapping tool?

One of the dilemmas with a computer-based application was that some of the structuring features of an appropriate tool would only be available if technological advancements were applied to the design:

1. A voice-input/output feature
2. Sequencing features to guide the construction of the map
3. Features that address poor motor and cognitive skills
4. Plus other guiding and structuring features involving the preservation of the map elements, such as saving capabilities.

The required structuring features can be divided in two groups. Structuring features that enable the use of multiliteracy (voice input/output, drawing and emergent-writing tools, symbol and sound libraries) and the ones that enable control over the cognitive skills required for concept mapping (templates for practicing hierarchy, automated tools for enhancing retention, preservation and sharing).

I needed to investigate a different kind of computer-based application for two reasons. First, there was no evidence that Kidspiration could be used with children younger than 5. Second, my specific user community did not employ computers in the classroom (this is further explained in the coming section).

Current software technologies have features that enable verbal labelling of concepts. Thus it would be possible to programme and implement a software package that allowed for the retention of map content and enhance children's control over cognitive skills. For instance Kidspiration software and the multimedia annotation software of the Today's Stories Consortium enable voice-input. TuxPix software creates thumbnails of the drawings, which facilitate preliterate children to locate drawings stored in the system.

The objective of the prototyping stage was to develop a BDP with structuring features that bring autonomy to children's concept mapping process, facilitate teacher instruction, which make the teaching and training of concept mapping more effective and improve the type of mental interactions that children have with the tool. Such interactions have to enable children to ask questions and make decisions about the elements represented in the map. See more on this topic in chapter 2.

Prototyping cycle 1: deciding which BDP to develop

I designed the initial prototype based on relevant literature (see chapter 4) and my years of design experience. I drew on Norman's user-centred product development philosophy to develop the prototypes. Norman's user-centred product development philosophy states that low-fidelity prototypes should assist in identifying key issues that should be addressed in the development of a sophisticated technology. Low-fidelity prototypes should save money to the company and help diagnose and foresee problems. Rapid prototyping techniques are often used to define user profiles (needs and contexts), design requirements, system's features and techniques (Norman 1999). See more on this topic in chapter 3.

The low-fidelity prototypes developed in cycle 1 were used to refine the profile of my specific user community. The goal was to determine what kind of BDP should be developed, what kind of BDP may resonate with my users, and what kind of BDP they may accept to enter their setting?

The profile of my specific user community

One of the first steps in Norman's user-centered product development philosophy is to observe users working on tasks related to the system to be designed (Norman 1999). To this end I established contact with preschool communities in my countries of study and residence, Australia and New Zealand respectively. Easy and constant access to a preschool community and building a relationship with them was essential to achieve the research goals.

The initial explorations were somewhat discouraging; these preschool communities do not use concept mapping with their students and Kidspiration software is often only introduced at Primary School. To enable me to observe the users on tasks related to concept mapping, I needed to develop a BDP that would enable me to enter any of these classrooms and to engage with the user community. The prototype also gave me an insight into reasons why the Australian and New Zealand preschool teachers are not using Novak's concept mapping in their practice with the students.

Low-fidelity prototypes

Low-fidelity prototypes are tests of the designer's understanding of the issues and ability to put together a system, a user interface metaphor, that the user community feels comfortable with and that they believe will simplify their lives (Norman 1999). (See more about low-fidelity prototyping in chapter 3). As these prototypes were pieces for me to understand broader issues I, the designer, divided the investigation of an appropriate user interface metaphor into small design problems. For instance, I only developed low-fidelity prototypes of some relevant features, did not implement a prototype with all the features that represented the complete design idea. This approach was sufficient for developing understanding of the design issues.

Each of the low-fidelity prototypes (sketches, mock-ups, storyboards, and Flash-based interactive animations) portrayed an aspect or several aspects of the proposed tool. The final tool was developed through phases; the knowledge gained in one prototyping phase was used to develop the next prototype or the next ones. Sometimes two prototypes were developed simultaneously, just because they were addressing different aspects of the process. For instance one prototype was used to investigate representation of concepts and linking phrases with images and sound while another was used to investigate mouse behaviours and navigational icons.

Some of the prototypes were paper-based or digital mock-ups, others Flash-based 'experiments'. I re-created or mocked-up some of the teacher approaches to concept mapping. The purpose was to develop an understanding of their design choices while identifying relevant gaps in their designs and appropriate ways to resolve these. The Flash-based prototypes were used for investigating different interface and interaction design issues at a content and a navigational level: the representation of concepts and linking phrases, navigational icons, working space appearance, or input and output behaviours.

Applying theory to the design of structuring features

In chapter 4, I argued that children learn to operate or acquire knowledge beyond their developmental stage when such new knowledge is presented in a way that they understand (prior knowledge) and are provided with supporting tools that allow them to exercise control over the skills that are not fully developed (scaffolding).

Defined in chapter 3, the following design and learning concepts were applied to design structuring features that embodied in their characteristics the concepts of 'prior knowledge' and 'scaffolding':

- Norman's seven principles to transform complex tasks into simple ones, his definition of conceptual model (user's model = designer's model = system image), and his concept of automation (Norman 1990, 1999).
- Blackler's concept of 'intuitive interactions' (Blackler, Popovic & Mahar 2004).
- The concept of prior knowledge (Ausubel 1968 in Novak 1998).

Features that build on prior knowledge (familiar interactions and tools)

Prior knowledge allows people to make inferences about the topic to be learned (Novak 1998), or in the case of a tool or system, it allows people to make inferences about how it is used (Norman 1990). If one of the design requirements is that the BDP has structuring features that the children can rapidly interpret how to use, it is important that the system's features are recognisable to the children.

The design of a system based on prior knowledge requires that the conceptual model of the system be completely, fully understandable to the user. The designer, Norman (1990) says, must develop a conceptual model of the tool or system that is appropriate for the user, that captures the important parts of the operation of the device, and that is understandable to the user.

In chapter 3, the three aspects of Norman's conceptual model (Norman 1990) were presented: the designer's model (what the designer thinks the system should be), the user's model (the users interpretation of the system image the designer created) and the system image (the creation of the designer that is interpreted by the user). Norman explains that ideally the user's model and the designer's model should be equivalent. However, the user and the designer only communicate through the system image and its parts (physical appearance, operation, way it responds, manuals and instructions).

I used Norman's approach (Norman 1990) for developing a conceptual model for the BDP 'that is appropriate for the user, that captures the important parts of the operation of the device, and that is understandable to the user' (p. 189). For all the parts of a system to be fully understood by users, the designer has to develop a system image that is equivalent to the user's conceptual model.

I argue that one way to achieve such system image is to design the system's components with features that the user recognises. To achieve this the system has to be comprised of familiar icons and its operational aspects, navigation, tools for drawing or voice-recording features should be visible, explicit, and obvious.

The objective was to develop a system image that the children could easily learn and they could see where to start and how to go ahead. I adapted language formats that were already present in the children's familiar classrooms and imitated or emulated children's working space at school. This metaphor of the preschool working space was applied to the design of navigational icons, toolkits and virtual working space where the concept map would be placed. These topics were briefly investigated, sketched on paper, and mocked up with Power Point, and Adobe Photoshop software, see Figure 5.1.

Utilising computer actions children already know is another way to apply the concept of prior knowledge to my BDP, as incorporating interactive features familiar to a user group makes the learning of a tool more efficient (Blackler, Popovic & Mahar 2004). Therefore, I collected literature in the area of computers and young children that reported on what children can do with computers. I also explored software applications available such as TuxPix, Kidspiration, KidPiX, Finding Nemo – the Multimedia and the PBS's Teletubbies website to see what sort of interactivities, mouse behaviours, key-word programming were designed for this age group. Some of these interactivity features were programmed into the simple Flash-based activity for demonstrating a pre-constructed activity.

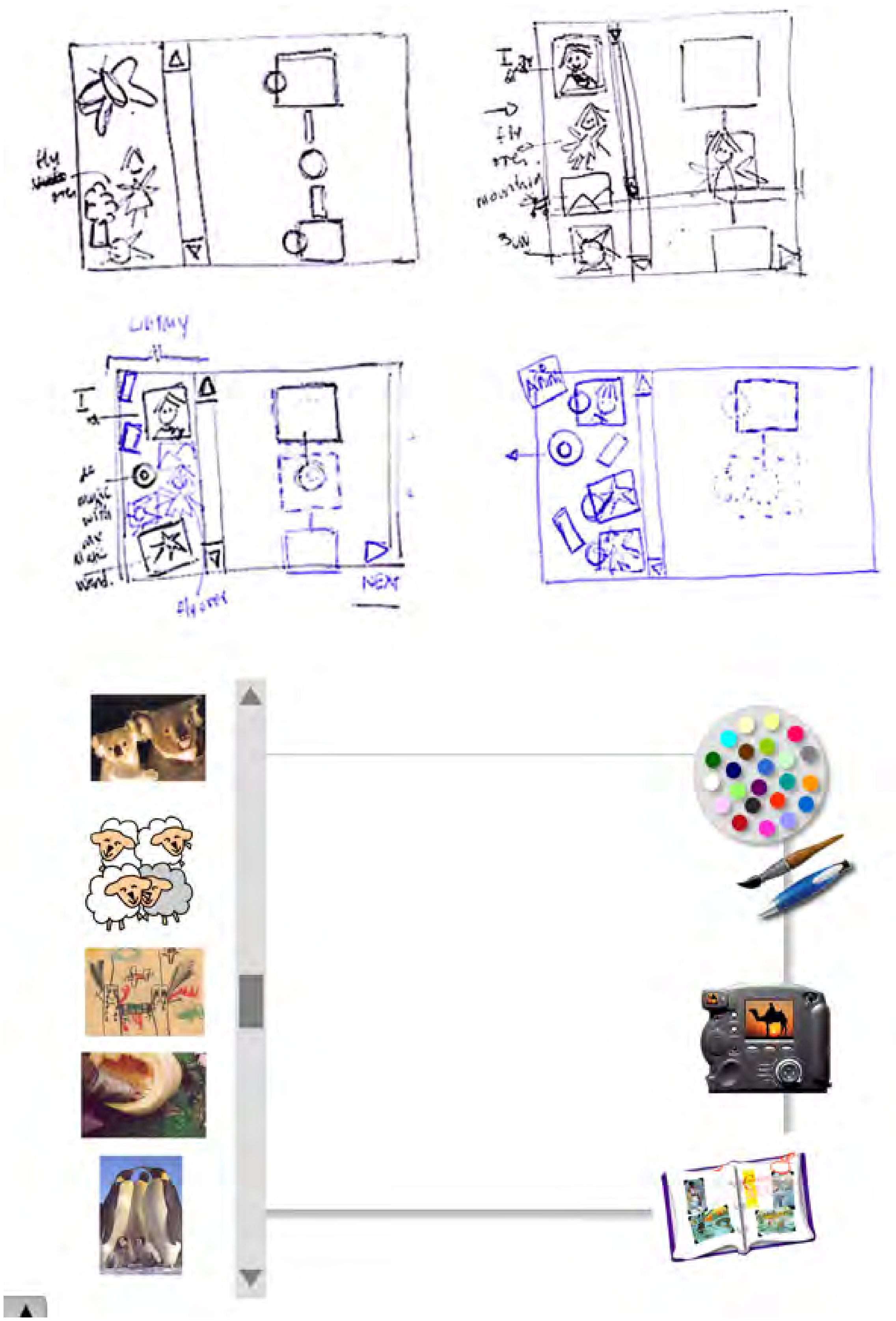


Figure 5.1 – an interface inspired in the preschool toolkit metaphor

Features for augmenting mastered skills

Drawing a symbol enclosed in a box, drawing a connecting line, editing or replacing a symbol takes young children a long time. These mapping tasks require the children to use several cognitive skills at once (see chapter 4). Mérida (2002) explained that it took steady practice for her students to draw symbols in a box and for them to master the rest of the map building activities that she designed. Computer technology can provide programming features to help children overcome these limitations and speed up the mapping process. I understood from that literature that my prototype needed to overcome these same limitations. Thus, I sketched and mocked up how the following interactions could be performed: enclosing symbols in a box or connecting concepts, and attaching pre-recorded sounds or words.

I also investigated interactions of a digital library that could give access to pre-recorded files containing concepts (verbally-labelled symbols), unlabelled symbols, and sound files of pre-recorded sounds or voice-recorded linking phrases or concepts. To find out about its feasibility with the user community, I developed a simple Flash-based prototype showing how the content of a digital library should work. It represented the making of a proposition with pre-constructed concepts and linking phrases. Children were to match the correct concepts with the correct proposition. This prototype was aimed at enhancing teacher instruction, offering more possibilities on topics and ways to represent the concept-map elements.

The stylistic approach of the images to be used in the system was also prototyped. This Flash-based prototype was designed with age-appropriate symbols inspired by the styles used in picture books. Picture books for this age group are designed with simple strokes, basic colours, are carefully planned and designed. The simplicity of children's books is deceiving, says Mem Fox, an Australian children's book author, who believes that the children's books genre is one of the hardest to write well and engagingly. Rhythm, rhyme and repetition are crucial characteristics of this kind of books.

Bjorklund and Douglas (1997) provide a developmental explanation for the use of simplistic forms and figures in the design of images to be used or employed in the design of systems for young children. In chapter 4, I also presented content regarding repetition, under the concept of rehearsal, as a way of children keeping information or knowledge present (Cowan 1997b). Simple images and repetition are two characteristics often present in the design for children's systems.

It was also desired to provide features that enable importing of own drawings, pictures, and sound files. Children and adults should be able to add new elements to the library. In terms of technology, these are features that can be successfully programmed and customised to the target users. However, these elements were not a focus of my research.

Automated features addressing poor cognitive and motor skills

I created low-fidelity prototypes to investigate simplification of tasks by automating some processes. Figure 5.2 shows a series of sketches used to investigate object manipulation with the mouse. In chapter 4 (see section about cognitive skills) I explained that the steps for building a concept map are too many for the children to handle at one time, specifically the ones related to concept assimilation, which is characterised, Novak (1998) says, by an active process of relation to, differentiation from, and integration with, existing relevant concepts. This is a skill that young children cannot yet fully control. One way to enhance children's concept map construction was to develop structuring features that enable children to organise the action and to perform a task, in a few steps: automation. Automation may enhance attention span, retention, and control of cognitive skills required for achieving the tasks.

Figure 5.2 – a storyboard for investigating mouse interactions

Automation can also take charge of tasks that are irrelevant to a mapping process. For instance, enclosing a concept in a box is a task essential to concept mapping, but drawing the box is not as essential. Many software applications for concept mapping, provide an automated way to draw boxes, because drawing a box is not an essential task. Saving maps automatically can be a good automated feature in a concept mapping tool for preschoolers. Children have short attention span and may not remember to save. Being able to save the maps is an important feature because it may allow printing and exporting to html features, which facilitates sharing and preservation.

Programming input devices such as the mouse can also enhance children's control over required skills. The computer mouse can be programmed to perform many functions that can take place at the same time such as selecting, dragging and dropping objects, and scrolling. But also, it can be programmed to perform no more than two functions at a time so it was important that the chosen functions were strictly relevant to the mapping exercise. Input device functions (e.g. mouse or keyboards) should assist navigation and interaction and enhance children's sense of control. For instance the snap-function should be added to the mouse when children click on an image to hold an object, like in the Teletubbies website (http://pbskids.org/teletubbies/teletubbyland.html). I gave preference to keyboard inputs as they are easier to learn, one can colour-code the keyboard and explain a few rules for children whose motor skills are not yet fine-tuned.

Conversations with key expert informants

I met with key expert informants to evaluate my low-fidelity prototypes. This also addresses the multidisciplinary aspect recommended by Norman (1999). Most of the key informants were experts in a discipline relevant to the research, be they Novak's Concept Mapping, Design, Early Childhood Education, Computers (Programming), while a few were parents of preschoolers. All but one of the key expert informants reside either in Australia or New Zealand.

Conversing with experts as an evaluation approach allowed me to ground my initial design requirements and to move the research from theory to practice, noting that this was not the specific user community for the final tool. It is also important to note that at this stage of the prototyping cycle children were not yet part of the group of experts. Each of these experts (or group of experts) was individually contacted by phone or in person. Their comments, insights, and recommendations on literature furthered my knowledge of different research aspects.

Working with the key expert informants, the low-fidelity prototypes became the data gathering tool from which I was able to learn about the user community's reactions to the proposed tool. The findings were analysed and grouped thematically and this analysis informed my understanding of the user community profile, their context needs and limitations. A summary of the expert comments is presented in Table 5.1.

Table 5.1 – low-fidelity prototyping cycle of the BDP

Table 5.1 THE PROTOTYPING CYCLE ONE OF THE BDP FOR PRESCHOOL CONCEPT MAPPING				
Prototype Name	**Research Goal (Theoretical Instruments)**	**Medium / Technology (Materials)**	**Evaluation Instruments**	**Conclusions**
Concept maps about universal topics The Beach, the farm, domestic animals, the colours (the fairy map), etc.	Investigate if a linking phrase can be represented with a particular type of image Investigate the representation of concepts and linking phrases and propositions	Concrete materials concept mapping activity using wire, construction paper, and preset images Digital sketches of the fairy map	Meeting: E-phone conversation with a concept mapping expert	These kinds of images are visual scripts, but not concept maps or linking phrases. Scripts of images linked together may be good educational strategies for children, but they aren't concept maps. In the scripts the knowledge is told in the form of a story. How do you know in advance what the children are going to say about the images? It is important to ask the children about the concepts and its relationships. (Ask children what they know about the beach e.g. what the beach bucket is used for). In concept mapping the knowledge has to be separated into objects (concepts and linking phrases), the beach, the sand, the bucket. Together with the children, we should make the drawings of these objects and slowly establish the relationships they know about them. The children should be able to say their own meaning, you should not pre-determine what they are going to say.

The Pig (pre-constructed concept mapping activity)	Investigate the representation of concepts, linking phrases, and propositions with sounds, spoken words, and images Test interface and interaction elements designed to support children when using the mouse and to investigate click behaviours Questions: 1) can children make concept maps with pre-constructed concepts and linking phrases? 2) can a virtual space be developed and make accessible to many teachers and preschoolers via Internet worldwide? 3) Could teachers use a web-based environment to teach concept mapping?	Flash-based simple prototypes with vision to develop a high fidelity Flash-based web concept mapping environment	A seminar presentation to design experts in New Zealand Meetings with: 1) early childhood educators who trains teachers in New Zealand, 2) a Design lecturer in New Zealand, 3) two design research students at my school in Australia, and 4) Flash developers in New Zealand and Australia to learn about the application capabilities	It would be an activity for the classroom, not to be used at home. The care facility where the child of one of the experts goes has the computer in a corner for free play use. It is not integrated into the classroom. The visual cues should be more explicit. Once the images are in place, the proposition is not yet obvious. The images used to represent sound-icons do not convey its function. The sound-icon looks like an ice-cream cone. The voice used to voice-record the spoken words of the Flash-based activity has an English accent that is hard to understand. This situation needs to be investigated. The Design lecturer and teacher trainers recommended readings on user-centred design and technology in Education respectively.
The Fairy **Interactivity for the creation of propositions with images and sounds**	Investigating interactions and interface icons	Digital storyboard created in PowerPoint	Sent to expert in concept mapping Supervisory meetings Validation Literature: Used literature on memory retention, computers for children, children and Interaction Design, and Norman's approach as references	Expert in concept mapping did not provide comments on these. In this advisory meeting it was decided that a Flash-based activity should be designed with the information on the digital storyboard. This activity should include main claims.

Findings

The findings supported some of my theoretical interpretations reported in chapter 4 and challenged others . Thus, these findings enabled me to make informed decisions about what ‘initial design requirements’ should be kept, removed, or replaced in relation to making the proposed BDP suitable for my specific preschool user community.

Two rapid prototyping tools were possible with the resources available to this research: 1) a Flash-based BDP to be used on desktop computers or 2) a concrete-materials BDP. Either or both of the prototypes could be used for testing my initial design assumptions and the research claims. However, a software prototype, or in this case a prototype developed with Flash MX (Macromedia, now Adobe), was found unsuitable. One reason was that the activities created with this prototype would not have allowed for testing authoring, which is one of the core aspects of my thesis. Table 5.2 compares the two rapid prototyping options, and shows advantages and disadvantages.

Software BDP	Tangible BDP
Flash-based activity to be used in a desktop computer	Concrete materials and portable tangible technologies
No voice input because the Flash Software (2004 version) is an enclosed programming environment	Yes to voice input by integrating a tangible voice ‘chip’ device
Only Pre-constructed maps	Made-from-scratch, pre-constructed maps
More expensive solution	Cheaper solution
Requires to be implemented for use	Provide immediate solution to teachers
Study Interface and Interaction Elements	Study Interface and Interaction Elements
Designed based on literature review	Designed based on literature review
Does not grant me access to my specific user community. Australian and New Zealand teachers do not use computers with preschoolers.	May grant me access to my specific user community. Teachers may find this tool suitable to be used with preschoolers.

Table 5.2 – comparing prototyping options for the development of the BDP

Authoring was not the major issue however. A Flash-based BDP installed in desktop computers was not an alternative if I wanted to be able to enter a preschool classroom of Australia or New Zealand. This was based on the advice from the Early

Childhood Education key informants that not all Australian and New Zealand preschool classrooms had computers for children to use. Before I describe the prototype that was used I explain the main issues that mitigated against developing a computer-based BDP.

Added a layer of complexity

Designing Flash-based mapping activities to be played on desktop computers would have added a layer of complexity to the investigation. I would have had to concentrate efforts in designing content (universal curriculum topics e.g. the beach, the farm) and at the same time train the user community on the use of computers.

Excluded mainstream Australian and New Zealand preschools

Testing of a computer-based BDP for preschool concept mapping would have limited the range of preschools that could potentially participate in the study, to only those that owned computers for children to use. The preschools that had agreed to participate would not have been able to be included. During prototyping cycle 1, I did not come across an Australian or a New Zealand preschool teacher who said that they used computers with their students. The teachers I spoke with did use computers to prepare educational activities or to write reports about the work with the children but they did not have the children performing activities on them.

Place in the curriculum

Teachers, caregivers, and parents, metaphorically speaking, hold the keys to working with children in the preschool classroom. Despite literature, which provided evidence of children’s skills with computers, the preschool classrooms of every country operate under curricula, theories and learning approaches that have been approved by their governments. The educational curriculum varied from country to country and are adjusted to their contexts and resources. The section about computers and young children earlier in this chapter provided references of research and practice of countries that have integrated computers into the official curriculum. United States and Costa Rica are among these countries.

Finding the appropriate place for ICTs in the curriculum is a recent concern to Australian and New Zealand early childhood communities. This recent research can be seen in *The Children of the New Millennium* and *KidSmart*; these are two examples of Australian researchers investigating ways to incorporate ICTs into the Early Childhood curriculum. *The Children of the New Millennium*, a two-year long project, sent teachers to their students' home to investigate what the children do with computer technology. In these technotours, as the visits were called, the children showed the teachers what they did with computers. The objective of the study was to learn from the children's home environment and find ways to transfer some of that acquired knowledge of the use of ICTs across the preschool classroom's curriculum (Hill 2004). *KidSmart* implemented a case study where teachers were trained on ICTs and thought about ways to incorporate it into classroom practices and philosophies. When the *KidSmart* Early Learning Program, an international initiative of IBM, was introduced in Australia, they partnered with the Australian National School Network (ANSN). This partnership was formed to manage the rollout of the programme, design and facilitate professional development for educators, and conduct research and evaluation. The project aimed at increasing the access to technology for children from economically disadvantaged backgrounds and subsequently to broaden their learning opportunities and support the transition to school (O'Rourke & Harrison 2004). Both of these research projects are still being tested and their effect on educational policy is yet to be determined.

Teachers' computer literacy

In the report of the Children of the New Millennium Project, one participant teacher 'commented that using ICT was the only area of the curriculum where the teacher was not the expert' (Hill 2004, p. 12). This suggests that the teacher's level of computer literacy could play a role in their views against using computer technology in the classroom.

Becoming computer literate requires the schools to allocate training-time and funding for the teachers to achieve this skill. I argued in the previous section that teacher inexperience in computer use acts as an obstacle to their utilisation of computers in the classroom. That analysis is supported by O'Rourke and Harrison (2004), who reported the KidSmart Project, and in that report explained that many of the early childhood educators who participated in the project did not have previous computer experience, and therefore experienced some anxiety in relation to their participation. Therefore, the professional learning programme for educators was designed to alleviate this anxiety while it provided a space for educators to develop understandings of ICT, that were connected with the existent early childhood philosophy and the pedagogical stance this implied. The authors also highlighted that ICT is an under researched field in Australia.

As I have argued previously, the BDP for preschool concept mapping should not be implemented with features that require extensive and expensive instruction or are difficult to implement or require long hours of training. New educational tools, specifically when they involve some component of computer technology, are difficult to insert and promote in this user community.

Parent biases

There are parents who allow their young children to play, use and interact with computers at home. The teachers of the Children of the New Millennium Project found that their students used technology in all forms and that they moved effortlessly between different Information and Communication Technology (ICT) mediums. With encouragement and supported by their parents, some 4-8 year olds can use scanners, faxes, send email from home, play video games, among other activities. Others in the first years of school were using hypertext, making imovies, creating animations and moving easily between searching for information and then creating paper versions using a range of text genres. The teachers concluded that '…technology is in their world, it is their play. Quite often children know or work things out more quickly on a computer than we as adults do. ICT[s] are very much a part of the children's lives[,] it is **their** now and **their** future' (Hill 2004, p. 9).

On the other hand, I met parents who rejected the idea of having their young children interacting with computers. Some of them relate the use of computers with video games played on PlayStation and Nintendo. During an informal conversation, a parent expressed that his child will be allowed to use computers only after learning to read and write, in age terms this would be around the child turns 6 or 7 years of age. The references provided earlier show that overall the literature favours the use of computers with young children. In practice, however, parents appear to have mixed feelings about it (Dwyer 2005; Subrahmanyam et al. 2000). Subrahmanyam and colleagues say:

> Surveys of parents suggest that they buy home computers and subscribe to Internet access to provide educational opportunities for their children and to prepare them for the 'information age.'[4] Although they are increasingly concerned about the influence of the Web on their children and are disappointed with some of the online activities their children engage in—such as games and browsing the Internet to download lyrics of popular songs and pictures of rock stars—parents generally view computers favorably, and even consider children without home computers to be at a disadvantage [5] (Subrahmanyam et al. 2000, p. 124).

Conclusions of prototyping cycle 1

My research claims did not strictly require desktop computer use, but gaining the user community cooperation and accessing the preschool classroom was pivotal to achieving the research goals. Sustaining my initial idea of prototyping a Flash-based application would have only increased the unlikelihood of accessing the children in the classroom. Instead, I needed to develop a BDP with features that teachers found beneficial to their children and useful to their practice, and whose benefits they were able to propagate amongst parents. Having the parents, also members of the user community, understanding my research was equally important, as they were the ones who signed the consent forms that allowed me to enter the classroom.

Taking into account the profile of my specific user community, I developed a tangible (concrete-materials) BDP. To reach teachers and children in their natural setting, the BDP for preschool concept mapping had to comply with the realities of Australian and New Zealand teachers and the restrictions applied to their context realities. Therefore, the initial design requirements and the characteristics of the computer-based BDP were modified to a point where the needs of both members of user community, teachers and children, were met.

Prototyping cycle 2: development of a tangible BDP

Adjusting the design requirements of chapter 4

The findings and conclusions of the prototyping cycle 1 called for adjusting the list of design requirements and structuring features presented in chapter 4. The teacher facilitation guideline, or guideline 4, needed to be expanded to include the following requirements: require little or no training, bear adaptation, not to require use of desktop computers, and have inclusive features.

Require little or no training

The BDP should require little or no training so that it can be easily integrated into classroom activities. To me, teachers appeared to be busy people. Their availability within their timetable was an issue for scheduling appointments with them. This situation made me realise that despite the teachers' willingness to meet me, and the overall teacher curiosity for learning about this new educational resource, the reality was that they had little time for extra-curricular activities. Based on this realisation, I concluded that the BDP should be easy to learn to use by both users. To avoid the risk of teacher rejection because of a busy schedule and limited time for learning how to use the system, teachers should be able to assess the benefits of the tool in the first meeting.

Bear adaptation

One approach to making the BDP attractive was to ensure flexibility so that teachers could use it in a variety of classroom activities (Gomez, 2007). It was thought that these characteristics could increase the likelihood and speed up the process of finding an Australian or New Zealand user community to work with. In general, as explained in chapter 4, educational tools that are flexible, open-ended and bear adaptation are of teacher preference. The BDP features should be made of disposable and interchangeable materials, be re-purposed to achieve other similar educational goals, adaptable to different size-groups, suitable for representing pre-constructed and low-directed concept maps, and affordable to replicate.

Any preschool classroom, teacher and child, in teams or individually, should be able to incorporate and manipulate the BDP at will. Its features should inspire teachers and children to transform it and adapt it to their own needs. It should be a low cost solution that can be easily followed by teachers. The objective is that they can rapidly incorporate it into their practice.

Teachers should be able to adapt the BDP to represent other kinds of knowledge mapping strategies. Some of these strategies are webs of knowledge, schemas, and lifecycles (Figueiredo et al. 2004; Helm & Katz 2001). Webs of knowledge are also called concept maps (Fleer 1996) or spider webs, even though they do not follow Novak's concept mapping rules because linking phrases are not present on the connecting lines and the concepts are not organised in a hierarchical manner.

Not require use of desktop computers

The Australian and New Zealand early childhood (EC) communities I approached during the low-fidelity prototyping cycle were technologically disinclined. Therefore, desktop computers were out of the question. However, I still needed to incorporate technology to enable children to label the meaning of symbols with spoken language. From here I steered my features investigation into 'off the shelf' tangible interfaces that allowed for sound and voice input/output. These exemplars inspired me to think of alternative ways to deal with technology. The digital aspects of such a sound/voice feature had to be invisible, in disguise, to avoid teacher comparisons with videogames.

In his book 'Things that Make Us Smart', Norman presents a definition of the purpose of technology in human life. His definition of technology can be used as design criteria for incorporating technology into a BDP for concept mapping that may respond to the needs of my users:

> Technology should be our friend in the creation of a better life, it should complement human abilities, aid those activities for which we are poorly suited, and enhance, and help those for which we are ideally suited. That, to me, is a humanizing appropriate use of technology (Norman 1994, p. 12).

My research outcomes suggest that the teachers may be technologically disinclined because they perceive current educational technologies to be poorly suited to their needs and the needs of the children and not humanising. I further comment on this research outcome in chapter 9 – section 'breakthroughs' and subheading 'understanding of computer technology'.

Inclusive features

Inclusive features were developed based on the prior knowledge of the user community, the things that children and teachers had in common in the classroom. An inclusive learning metaphor and inclusive interactions (see chapter 3) were developed based on the tools teachers and children used in the classroom and the tools the teachers cited in this thesis used for concept mapping (see chapter 2). The BDP that I developed in this research needed to meet the conditions or needs (biases, opinions, suggestions, prior knowledge) of the children, but also of the other member of the preschool community: the teachers.

Design metaphor for a tangible system

One of the concepts introduced in prototyping cycle 2, emulating the classroom materials and workspace in the design of navigational and activity tools, was irrelevant to this new system. Emulation was not necessary anymore, the real classroom materials could be made part of the system.

The concepts of prior knowledge, scaffolding, conceptual model, 'intuitive interactions', and automation were also re-interpreted or loosely applied to the development of this tangible (see chapter 3 for definitions and prototyping cycle 1 for first design interpretation).

With the adjusted design requirements and structuring features, a flexible, game-like, sturdy, tangible BDP was developed. Materials or tools familiar to the user community (write-and-wipe magnetic whiteboard, pencils, markers, construction paper, Velcro and magnetic strips) were re-designed or repurposed to achieve new actions, enhance or augment familiar actions (e.g. drawing, use of whiteboards, etc). The one innovative component was a hand-size 'off the shelf' voice-recorders (vrecorder or vrecorders in plural form). In the coming section I explain how these materials and components were developed into a BDP that could be used for testing my research claims about preschool concept mapping, see Figure 5.3.

Familiar features

Many features of the tangible BDP were developed with materials that every member of the user community recognised and knew how to use. Familiar features (methods and instruments) to the preschool classroom were employed to minimise time required for instructing the users about operating the tool.

Materials and concept mapping tools (paper, woollen threads, picture cards, etc) currently used in preschool inspired the BDP design (see chapter 2 for details). In the classroom, children use an endless variety of materials: use picture cards, work on the floor, use building blocks, etc, which change form and purpose according to teacher planning. See chapter 4 and Curtis and Carter (2003). Teacher plan activities that encourage children to be creative by presenting them with materials that are malleable and flexible.

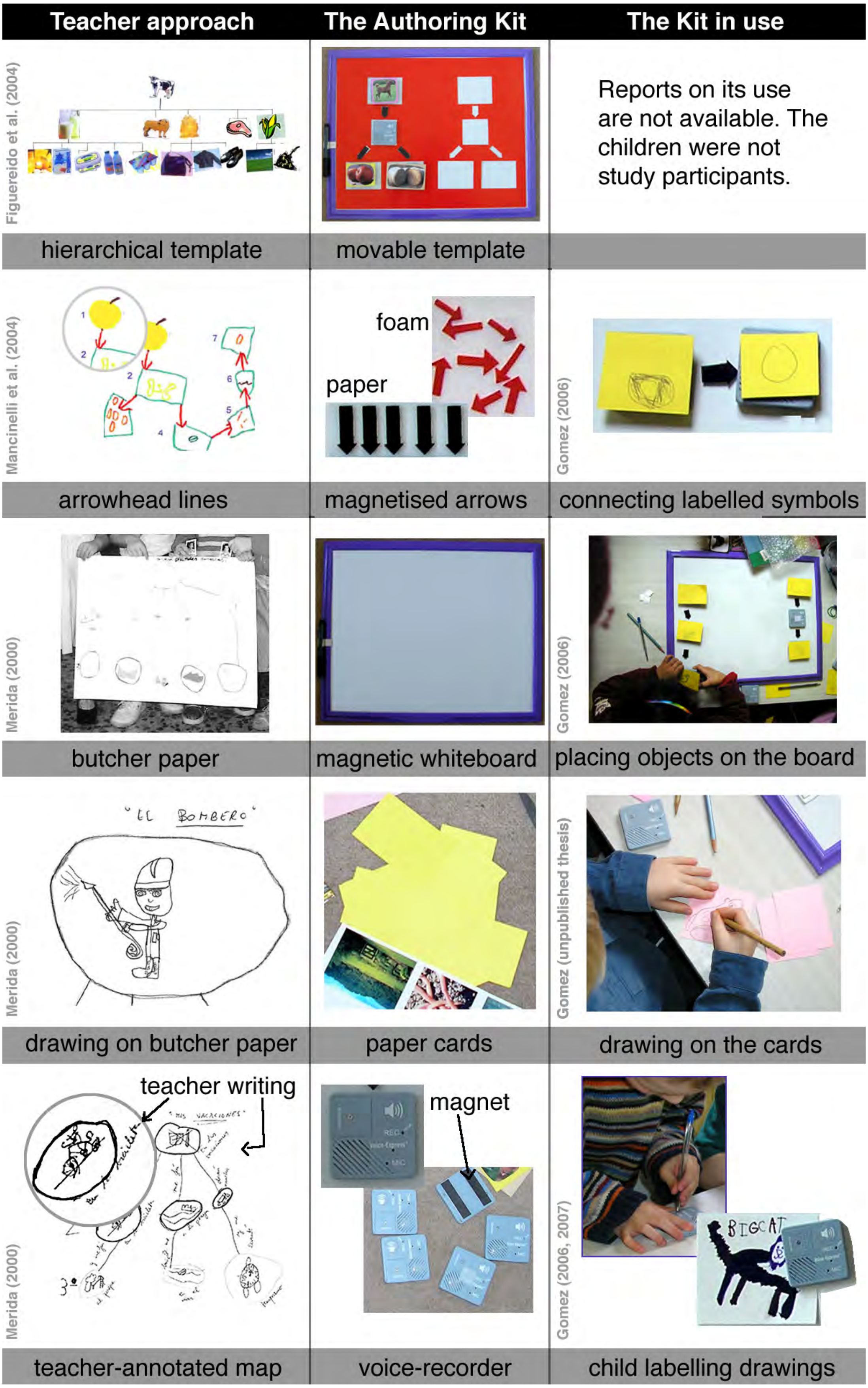


Figure 5.3 – the BDP for preschool concept mapping, also called the Authoring Concept Mapping Kit

For representing what they know, children are taught to use paper of different formats, cardboard, scissors, write-and-wipe white boards, markers, crayons, recyclable materials, among other tools. They interact with tools that are portable and fit different classroom contexts. Besides, they are attracted to interact with devices that make noise, and especially like toys that allow them to express themselves freely (Brouwer-Janse et al. 1997; Hakansson 1990).

Since I no longer had the option to use computers to augment children's skills I searched for arts and crafts materials that could serve a similar purpose: speed up and 'automate' to a degree, the children's map building process. The actions required for achieving the task were analysed and these materials were repurposed to enhance manipulation of the map features. The analysed tasks were: drawing symbols on small hand-size pieces of paper, using magnets to enhance manipulation of map elements, using removable templates for representing and practicing hierarchy, using sticky Velcro-strips to attach voice-recorders to symbols, and making representation of arrows explicit. Each of these actions is also a scaffolding strategy, as they are enabling the performance of a task pivotal in mapping:

- **Drawing symbols on small hand-size pieces of paper:** To remove children's need to learn to draw in a box or circle (see chapter 2, Mérida's mapping experience for details), which takes children's focus away from more important tasks, I developed a constraint to 'automate' this process for them (see chapter 3 for definition of constraint). Paper was cut into square or rectangular shapes. Construction paper of different colours was preferred above other paper types, as it is strong enough to support heavy handling. Besides it is not too expensive, does not bend or weaken when it is cut into small pieces and can be easily discarded and replaced.

- **Using magnets to enhance manipulation of map elements:** Whiteboards and butcher paper is often used in concept mapping together with Post-its, pencil and markers. The Post-its, small pieces of paper with a sticky frame, facilitate moving concepts around. The same applies to connecting lines: markers or pencils, depending on which surface people are working on, facilitate connecting lines to follow concepts to where they are placed on the map next, as they can be erased. Again to speed up the process and keep focus on important tasks, the need for erasing and drawing lines was removed. All map features but the pieces of paper for symbols (explained next) were magnetised with magnetic strips or magnetic squares, which were then placed onto a magnetised whiteboard. Magnets not only made the making process less messy, but also enhanced manipulation by facilitating repositioning of concept ideas and arrows on the board.

- **Using removable templates for representing and practicing hierarchy:** Removable templates were used to address representation of hierarchy; two-level and three-level concept maps. The templates were made removable to make this form of organising concepts optional, so the children could choose if they wanted to organise concepts hierarchically or not. Figueiredo *et al.* (2004) incorporated templates in one of their concept mapping activities. Their findings on template use were discouraging, therefore, I left its use optional. Colour-coding and numbering with ordinal numbers was Mérida's approach to teaching children to make differentiate hierarchy levels among symbols (Mérida 2002). In my BDP design, I did not incorporate any of Mérida's approaches to teaching hierarchy, because I realised their importance at the thesis write-up stage.

- **Using sticky Velcro-strips to attach voice-recorders to symbols:** Similarly to the small pieces of paper and magnets, sticky Velcro was used as a constraining feature. Symbols drawn in the paper pieces were not magnetised as they were only to be attached to the voice-recorders. This was to make sure that only verbally-labelled symbols were placed on the whiteboard. As a note, this activity required using matching skills, which is a skill that preschool children use often. Sticky Velcro comes in matching pieces – female and male.

- **Making arrows explicit:** It is not the same to say plants → have → leaves and leaves → have → plants. The arrowhead indicates the direction of the relationship and it was always present in the early concept maps. Recently, in many occasions the connecting lines of a concept map are drawn without an arrowhead, because we are taught to understand that when the arrowhead is not present, this is because the relationship between concepts is from top to bottom. The arrowhead is only used when the relationship between concepts goes from bottom to top. This is called an inversed conceptual relationship. Mancinelli and her colleagues (Mancinelli 2004; Mancinelli & Guaglione 2004) teach the students to use arrows to show the direction of the symbolic relationship. Because of this I designed connecting lines with arrowheads.

Novel features

Novel features or novel materials to the classroom still had to present characteristics that the user community validated and associated to their context realities. Novel materials or tools were only introduced when strictly necessary and incorporated to enable interactions that were non-existent to the setting or could not be achieved with current classroom tools (e.g. voice input/output devices).

The introduction of novel features was carefully thought out. I was aware that if there was one feature of the BDP the teachers did not understand or could not find useful or relevant to the children, such feature could jeopardise my opportunity to enter the classroom.

Computer technologies for young children, software and tangible, have the ability to simplify cognitive tasks, assist poor memory performance and enhance concentration (see beginning of this chapter). Since a software application would not have succeeded with my user community, I looked for a different type of technology, to enable children to autonomously label symbols with spoken language. The solution to labelling had to be an advanced technology, but of a kind that teachers would allow in the classroom.

> Advanced technology and automation can simplify the tasks in dramatic fashion, but the manner in which this is done is enhanced by the expert judgment that a human-centered process can provide. Automation had decreased the user's level of difficulty in many technologies. It will – and already has – with the digital computer. But the simplification is made more certain and beneficial if it is done with care and concern for the abilities of the human (Norman 1999, p. 198).

I performed a search on child-friendly tools that had voice devices embedded into them (e.g. played a sound or talked at the push of a button). I started by investigating how talking books are designed, what are the kinds of technologies that are in place in them or in other kinds of toys and educational resources with a similar make up. Talking books, complex systems such as the LeapFrog learning system, any toys with pre-recorded voice-chips (e.g. baby dolls that cry at button pressing, stuffed animals that talk at clapping hands or at sensing someone approaching) are some examples of tangible commercial toys using voice technology aimed at this age group.

These toys and tools use voice-chip technology. Jeremijenko (n.d.) performed a literature review on this kind of technology and a search in any Internet search engine for the word 'voice-chip' generates many results. My interest specifically lay with voice-chip technology that enabled voice input and output. The Internet searches took me to two companies selling products with this characteristic, one in the USA, another one in China. These companies sold two types of voice-recorders that served my needs: enabled voice-recording, playing back, and voice-recording over the previous recording. Figure 5.4 shows the voice-recorder that was adapted for the BDP.

Figure 5.4 – voice-recorders adapted for the BDP

One company selling this product is in the photo-framing industry. They have incorporated these voice-chips into their culture of scrapbooks and talking cards (visit, http://www.voice-express.com). Also Case and Bauder (2001) have incorporated voice-recording devices into the design of some of their low-tech assistive technologies. They aim to incorporate all individuals in active learning by addressing each student's uniqueness and minimising barriers. Figure 5.5 shows some of these low-tech devices including the talking pictures for communicating.

Figure 5.5 – low-tech assistive technologies (Case & Bauder 2001)

The voice-recorders I purchased enabled a voice message to be recorded that could be played back more than 500 times and one can record 10 seconds of sound every time. Also they were small enough that a child could hold it and operate it. I was somewhat concerned about children operating the device because making the voice-recording required fine motor skills and the ability to perform two actions at the same time. Despite my doubts and lack of a more suitable alternative, I decided to use this voice-chip design in my preliminary testing. The insertion of this simple technology to my BDP was an attempt to give the autonomy back to the children when adding meaning to symbols when concept mapping.

How it works, how it is intended to be used, what is expected of it

With this BDP, children draw their ideas about a particular topic on a small piece of paper, verbally record the meaning of the drawing, and place the verbally-labelled symbols on the whiteboard. To form this kind of symbol, the child attaches the drawing to the vrecorder using Velcro. The vrecorders themselves are magnetised, so they would stick to the whiteboard. To show relationships between concepts the child uses magnetised arrows or draws connections on the whiteboard with a marker (Gomez 2007).

Such interactions with the BDP features should facilitate the following concept mapping-related tasks: 1) labelling ideas with symbols and spoken language, 2) placing verbally-labelled symbols on the magnetic whiteboard, 3) connecting verbally-labelled symbols with magnetised arrows, 4) making two-level, three-level hierarchies with the templates, 5) mapping the content and moving verbally-labelled symbols around if necessary. These interactions with the BDP were evaluated in the case studies, reported in chapters 7 and 8.

This tangible BDP for preschool concept mapping required testing to determine if it enabled children to represent drawings autonomously, make knowledge explicit, and interpret conceptual relationships by mapping the resulting pattern, verbally-labelled symbol → verbally-labelled symbol. Testing of its adaptability and flexibility was also important, to see how teachers and children adapt it to their own needs. The features for this BDP are only suggestions. It is expected that the user community make it their own.

The expectation was, that by interacting with the BDP, the children might quickly learn how to make propositions, simple concept maps and most importantly they would be able to add meanings to the images that they choose/create as concepts, record linking phrases to explicitly state the conceptual relationship between concepts, make visible hierarchical structures and cross-links. Teachers would be able to effectively teach children to concept map.

Testing of a tangible BDP – a preliminary case study

Testing objectives

The BDP for making pre-constructed concept maps about farm animals served several purposes - as a mechanism to test the BDP components, as a scaffold for learning (this was the main purpose), to make simple concept maps with removable templates, and as a tool to evaluate prior knowledge. The questions that needed to be asked were; 1) can the children of the preliminary study easily make concept maps about farm animals with the BDP? 2) can people outside the immediate setting understand the concept map the children created with it? And 3) can the concept map created with it be preserved for a long period of time and be played as desired?

Figure 5.6 – building a concept map about ‘farm animals’ with the BDP

Making concept maps about farm animals

Why do a concept map about farm animals? ‘Farm animals’ is a topic familiar in early childhood. As it is part of the universal curriculum for this age group, content about it can be easily found in libraries, bookshops, games and the Internet. But farm animals are not the same in every country. Consequently, for the purpose of this study, the children were presented with New Zealand farm animals, since the subjects were from this part of the world. I created a bank of images of New Zealand farm animals and related topics. The image collection contains photos of farm animals, places where they live, what they eat and so on.

Participant children

The participants were a 5- and 9-year old who were to make concept maps about what they knew about farm animals by choosing photos from the collection and labelling them with the voice-recorders (vrecorders). If any given image was thought not to belong, they were encouraged to make new ones with the drawing tools that come with the BDP - blank cards, Post-it, scissors, markers, transparent paper, magnetic and Velcro strip tapes (see Figure 5.6).

Description of the setting

The testing environment was informal, the activity unstructured, and the adults guiding the activity were not trained teachers. We performed the activity on a Wednesday, at 6.30pm, just before dinner, sitting on the living room floor of the children's home. One parent, their mum, was present during the activity, but did not intervene in the performance of the activity. While we worked with the children, she was cooking dinner. Sometimes she came into the living room to see what the children were creating with the BDP.

The concept mapping activity

The two adults, a male friend and myself, guided the activity and explained the rules for interacting with the BDP once: selection and labelling of images to make concepts with voice-recorders; placing of concepts, linking phrases and arrows on the magnetic board for the making of propositions, and the function of the template. We did not introduce the children to the concept mapping concept and the rules were not reinforced. We observed and encouraged the children to select and label photos with the vrecorder, place them on the board and connect them with the arrows. Figure 5.7 shows the children unfolding the BDP and one of the adults showing the 5-year old how the BDP components work.

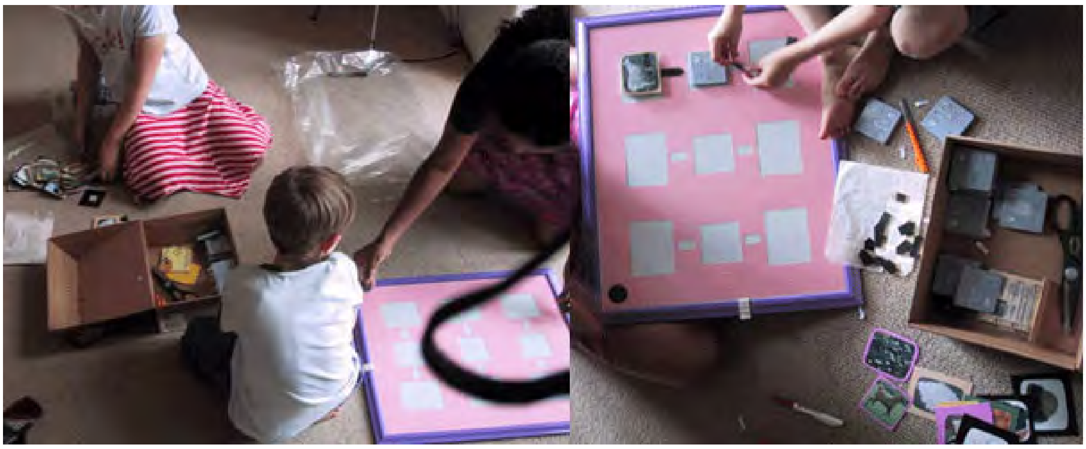


Figure 5.7 – setting up and demonstrating the materials for the activity

Images

Each image was glued to cardboard pieces and protected with transparent paper to enhance durability. Velcro was attached to the back of each image, so they could be easily Velcro-ed to the vrecorders that had the matching Velcro piece, see Figure 5.8.

Voice-recorders

Two types of vrecorders were prepared, one for using with images to represent concepts, these had Velcro on them. The other type was used for vrecording linking phrases (a white square on the vrecorder made with the Velcro). Even though children were not instructed in the elements of a concept map, this was an attempt to encourage children to explicitly distinguish concepts from linking phrases by following a visual cue.

One of the children voice-recorded concept meanings and their relationships into his/her maps. In Figure 5.9, the child is labelling an image representing the concept 'people'. In this concept mapping activity, the child was presented with a collection of images to choose from. The collection contains two images of people, one depicting adults, the other one depicting children. The child chose the former and labelled it 'people'. This concept is part of a proposition: 'The farm has people' (Gomez, 2005b).

Labelling images to make concepts

The children labelled the images with voice-recorders. First, they recorded the meaning of the image into the device, and then, attached the vrecorder and the image together using Velcro strips. The attached image and voice-recorder (containing the image meaning) stand for a concept. Figure 5.9 shows one of the children attaching the vrecorder to an image depicting a group of children. The child is vrecording the word 'people'. The child vrecorded what was his/her own interpretation of the image.

Figure 5.8 – selecting and organising the picture cards for inclusion in the map

Creation of linking phrases

Children can add linking phrases to the map via voice-recorders. For instance, in Figure 5.9, the child just created the proposition ‘the farm → has → people’. She vrecorded the linking phrase ‘has’ into the vrecorder, and placed it in-between the concepts ‘the farm’ and ‘people’, which were previously created.

Connecting lines

Black thick arrows, made out of cardboard, were used to connect concepts and linking phrases. They represented the concept reading order and guided map-reading. If the children preferred, they also had the option to draw connecting lines between concepts with a marker directly on the magnetic board.

Templates for making simple concept maps

The children were invited to start the activity using templates made of cardboard. Three types of templates were created: one for making propositions, one for making two-level concept maps, and one for making three-level concept maps. Figure 5.7 shows one of the children using the template for making propositions.

Magnetic board, Velcro and magnetic strips

The back of each voice-recorder had magnetic strips for easy placement onto the magnetic board. The magnetic and Velcro strips facilitated manipulation of the BDP components. The vrecorders firmly stayed in place after being assigned a position in the map. Only voice-recorders with magnetic strips could be placed on the board.

This constraint was to enhance the learning of the different steps involved in building a concept map. The children may also learn that only concepts, images attached to labelled vrecorders, could be placed on the whiteboard.

Figure 5.9 – building a proposition with the BDP materials: voice-recorders, picture cards, arrows, and hierarchy template

Materials to author their own images (potential concepts)

In case the children wanted to make their own drawings, we also gave them additional materials such as, Post-it notes, markers, pens, scissors, magnetic and Velcro strips, and blank coloured cards.

Findings of the preliminary study

The children were very excited about the BDP components, and started working together, but they both wanted to interact with the same images, voice-recorders and magnets at the same time. The 5-year old tried to participate, but the 9-year old did not give him an opportunity. The 9-year old took over the activity. The day before the activity, while I was explaining the objectives of the test, her mother warned me that this situation could happen.

Figure 5.10 – left: the child continued working on the map without a template, right: a completed map about farm animals

The 9-year old's concept map

The educational performance of the 9-year old is not relevant to this research, as the child is beyond the age group of study. However, the concept mapping process of the child is relevant to the study as it showed evidence of the BDP's adaptability and flexibility, characteristics needed for promoting the BDP among teachers.

The BDP components enabled the child to follow the steps for concept mapping; select concepts, organise and label them with linking phrases. In Figure 5.8, the 9-year old selected images from the collection, then, organised the images in a curvy row, created a sort of story, and read it aloud to all of us to listen to. Figure 5.9, left photo, shows that the she made a proposition with the template, created two concepts, and employed arrows to show reading direction. Figure 5.9, right photo, shows her recording the concept 'people'. At some point, early in the activity, she decided to stop using the template for building propositions and she was encouraged to do it. Afterwards, as shown in Figure 5.10, she freely continued choosing images, creating concepts and linking phrases, and using the arrows to connect them. She stopped concept mapping when the whiteboard was completely full, there was no space to add any more concepts and linking phrases on it. In Figure 5.11, the top photo shows the finished concept map while the bottom photo shows a text version of it.

The 5-year old

The 5-year old did not make concepts or linking phrases, and did not manage to focus on the activity at all. This can be put down to the time chosen to perform the activity was not conducive. The child also had problems getting the vrecorders to work, even though he had been able to perform the task in previous interactions. It is important to note that the pen we gave him to activate the vrecorded had a thin point, which did not fit into the recording hole easily. By the time we found him another pen with a thicker point he had gone to play elsewhere.

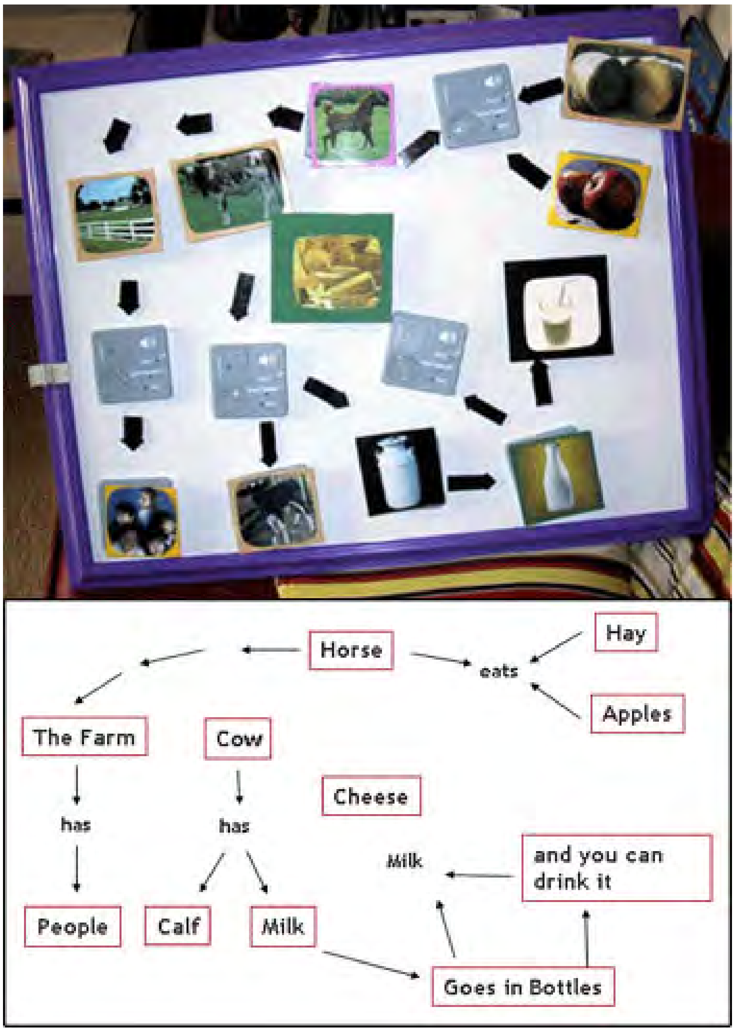


Figure 5.11 – left: completed map with BDP components, right: completed map built with written labels

We also tried to get the 5-year old involved by addressing questions directly to him, e.g. 'which images do you recognise?' On one occasion after asked, 'Do you know something about any image?' the child took the snail image and said, 'I know something about snails...' and suddenly left. This time, the child did not return to the activity (he went to have dinner).

Comments of key informants about this preliminary study

The findings of this preliminary case study were discussed with key informants of relevant areas. They were:

- Presented at the Queensland Interaction Design Postgraduate Students Conference – Quidconf 2005 and at the Our the Children the Future Conference – OCTF 2005.

- Shared with two New Zealand Early Childhood Trainers, who I first met during my low-fidelity prototyping cycle.

- Shared with two Designers, a lecturer at Otago University in New Zealand and a renowned educational and furniture designer in Australia.

- Shared with Dr Joseph Novak, the inventor of concept maps

Quidconf participants, most of them representatives from the disciplines of Computer Science, Human-Computer Interaction, and Design, suggested that the tangible BDP, which I promoted as the Authoring Concept Mapping Kit, was an appropriate and consistent approach to tackle the described problem. When I explained that I was only using this BDP for user research, and that my ultimate goal was to develop a portable and digital application, paraphrasing their answer, they asked me something like, why do you want to make a computer-based version? You can augment the capabilities of this technology with Bluetooth technology. One participant, one of the doctoral advisors of the panel, mentioned that children with special needs could benefit from using this tool.

OCTF was then considered the premier early childhood (EC) education conference in the South Pacific. 25 teachers came to my presentation and their comments about the BDP were useful and eye opening. They thought that the talk was very informative about the different teacher approaches to concept mapping, found the vrecorders fascinating and suggested other applications. While exploring and interacting with the BDP components, a few teachers shared ideas of how they would adapt it to their classroom activities. One teacher said that the vrecorders could bring to life his students personal books: they could make their own talking books. Another teacher found it useful for teaching phonics, and again, the special needs concept came into play, one teacher asked me, if the BDP could be used with older students, such as adults with disabilities.

The early childhood trainers offered to publish a note in the Newsletter they run for their teacher community. They thought that this particular BDP was possible to integrate into a real New Zealand preschool classroom. The note was an advert for inviting teachers to participate.

The Designers also thought the BDP to be relevant to the specific user community. The New Zealand Designer offered his children as subjects, but I denied the offer because the next study was to be performed in a preschool classroom. The Australian Designer recommended the BDP to two teachers who she thought might be interested in trying this BDP with their students.

As a result of this feedback I understood that the BDP was ready to be tested in a real Australian and New Zealand classroom. Regarding its application with students with special needs, the teachers' suggestions became of relevance when in my case studies two children with special needs, one with speech problems of case study one (chapter 7), and an autistic child of case study two (chapter 8), interacted with the BDP in a manner not expected by their teachers.

Conclusions of prototyping cycle 2

The test revealed that this BDP for concept mapping enables autonomous representation of concepts and linking phrases using spoken and visual language. There was no need for adults to annotate the children's images to disclose meaning, Linking phrases such as 'has', 'goes in', 'can', 'eats' and words that do not have visual representation such as 'and', 'it' were vrecorded and therefore represented in the concept map with spoken language.

Once the concept map was constructed, people inside and outside of the immediate setting could read, interact with, and discuss the created map. For instance, the key expert informants at the conferences and meetings explored the concept map the child made, see Figure 5.11. This demonstrated that the concept map can be preserved, at least until a new activity is performed, re-played as desired, shared with others for evaluation or discussion. All these characteristics solve the problems generated by the teacher approaches to preschool concept mapping.

This BDP for preschool concept mapping solved the main obstacle that prevented preschoolers from being able to author their own mapping structures, representation of written language. This meant that, with a tool with the proposed characteristics, young children would be able to create, modify and share their audiovisual mapping creations; and early childhood educators, who use the technique in the classroom, might be able to successfully teach their students to organise knowledge with concept maps.

The inability of the 5-year old to engage with the activity (working with an older child, lack of concentration, tiredness), confirms what the literature, specifically Vygotsky (1978a), who said that learning occurs within the child's Zone of Proximal Development. Young children can organise knowledge beyond their actual level of development in a structured learning environment and supervised by caregivers (see chapter 4 subheading 'support the use of prior knowledge, play, and social interactions'). Testing the BDP for preschool concept mapping with preschool age children requires a teacher who plans the activity for them, with concentrated time, and who is familiar to concept mapping. This notion was tested in the case studies (chapters 7 and 8).

I have also learnt it is important to listen to the parents'/caregivers' recommendations regarding the children's profiles. For instance, next time a caregiver tells me in advance about participant child behaviour, I should take the comment seriously and prepare for it. The parents or caregivers know the children's character and needs, it is important to draw on their knowledge about the children.

Before testing my initial design requirements, I thought that a computer-based tool would be the 'ideal solution' for children to author their own concept maps. However, the results obtained during prototyping cycles one and two, showed that non-intrusive, inexpensive simple technology such as the 'voice chip recorders' can be more effective at convincing the type of user communities that I was dealing with. The key informants and I think that this tangible BDP for preschool concept mapping can be easily incorporated into any early childhood classroom. Children may find them fun to use and teachers may be able to adapt them to different teaching situations.

Norman's user-centred design philosophy (Norman 1999) says that to identify the characteristics the envisioned product should have and to achieve the goals of the product development process, it is pivotal to observe the users in their context, working on tasks related to the product that requires designing. The results of the preliminary case study and the comments of key informants confirmed to me that I had already developed a tool that would allow me to achieve the goals Norman refers to. This BDP for preschool concept mapping not only assisted me in the process of finding teachers for the case studies, but also enabled me to develop case studies that were appropriate to my specific early childhood (or user) communities.

Summary

In this chapter I reported the two prototyping cycles undertaken to develop a BDP for preschool concept mapping which could be incorporated into my specific user community of Australian and/or New Zealand classrooms. The theories, design guidelines, and requirements reported in chapter 4 guided the development of these prototypes.

Prototyping cycle one involved the development of low-fidelity prototypes (sketches, mock-ups, and Flash-based movies) to investigate initial design ideas about the BDP features. Entering preschool classrooms at this stage of the design process was not possible, therefore discussions with key expert informants in the areas of Early Childhood Education, Design, and Computer Science were used as evaluation tools to establish a more accurate profile of the user community. The use of computers in preschool classrooms in Australia and New Zealand is not pervasive. I found that if I wished to engage with these schools I would need to modify my approach and build a tangible BDP rather than a software-based BDP.

Prototyping cycle two involved the development and preliminary testing of a tangible BDP that incorporated an extended version of the initial design requirements (chapter 4) to include teacher needs, such as that it supported adaptation and required minimal time to learn how to use. The tangible BDP was developed with familiar tools. Some of them were repurposed to scaffold children's cognitive and motor skills. The objective was to simplify the actions required to achieve the tasks for building a concept map: enclosing concepts in boxes, attaching symbols to voice-recorders, placing magnetised map elements on the magnetic whiteboard. Using familiar materials in the design of the BDP components made the design inclusive to both users. The voice-recorders, an 'off the shelf' technology and the one and only novel feature, had a context-friendly appearance. Teachers needed to find the BDP attractive and relevant to their preschool context, even if they were unfamiliar with, or did not believe in, preschool concept mapping.

Preliminary testing of the BDP elements was undertaken in a home setting with a 9- and 5-year old. They were presented with a collection of cards picturing New Zealand farm animals. The 9-year old was able to label symbols with concepts and propositions and was able to incorporate linking phrases. The 5-year old did not perform any mapping, he was distracted and the 9-year old took over the activity. Perhaps the activity was not sufficiently structured for him. Neither of the children had problems interacting with the individual BDP elements. They placed magnetised objects on the whiteboard, and 'Velcro-ed' symbols to the appropriate voice-recorder. As expected, learning to use the voice-recorder took some time, but excitement at being able to record and playback their voice kept the children interested. This prototype allowed for testing autonomy at manipulating the BDP components. However, it did not test if children could make concept maps effortlessly or whether it facilitates manipulation.

This chapter concludes that working with low-fidelity prototypes and key informants can be effective methods for finding out about a user community. While data collected is somewhat 'dirty', these methods are still useful at this stage of product development and they provide confirmation that 'rapid ethnography' (see chapter 3) can assist in perfecting a user profile to access a user community. Norman (1999) stresses the importance of the multidisciplinary aspect in user-centred processes. To apply this principle as a sole researcher and validate data in a multidisciplinary manner I consulted the literature on the relevant disciplines, organising meetings with experts, emailed reports, and used phone conversations and conference presentations. The process of exploring the literature and having informal discussions to ground my theoretical accounts opened new pathways for the research and alternative interpretations of the data and designs.

The case study phase is discussed in the following chapters 6 to 9. The next chapter, chapter 6, discusses the research method that was used to investigate the user community with the BDP during mapping activities.

Case Study Phase

This phase is reported in chapters 6, 7, 8, and 9

Chapter 6 – The Research Method

Overview

The previous chapters 3, 4 and 5 describe the design methods and prototyping of the Bridging Design Prototype (BDP) for preschool concept mapping. In this chapter I present the research method, case study, which was used for evaluating the behaviours (tasks or activities) for which the BDP was designed. Case study is a qualitative research method often used to in early childhood research and practice. I draw on scholarship from the area of early childhood research, regarding the application of this method in classrooms to design every aspect of each of my case studies. Following from that I present the study goals and the selection of the sites for this research. I argue that these sites were selected to address study limitations and present ‘a well-substantiated story’, I then present: the data collection techniques, data collection instruments as well as a discussion of the content analysis approach. Working with young children raises particular ethical issues, for this reason I present the ethics considerations and the ways that my engagement with the method needed to be adapted to work in each of the participant preschools.

A caveat to this section

My case studies were of a short length due to constraints imposed by participant teachers (see chapters 7 and 8 for details). Despite these constraints, the studies' results do contribute to new knowledge. The BDP for preschool concept mapping makes children's conceptual and propositional knowledge explicit, facilitates instruction, promotes autonomy during mapping activities and the use of multiliteracy, facilitates manipulation and sharing of knowledge. Therefore, the results presented in the following chapters should be enough to motivate early childhood experts to try the designed tool with their students.

Under the user-centred design philosophy (see section ‘rapid ethnography’, chapter 3), a designer enters the user community environment to collect as much information as s/he can within the constraints of the environment and the constraints placed on the designer's participation. Under this principle, the data gathered during the case study phase (chapters 8 and 9), I combined and used to answer the research claims that were presented in this chapter and analysed in chapter 2.

The case study method: a qualitative research method

Early childhood experts (Edwards 2001; Rolfe 2001; Siraj-Blatchford & Siraj-Blatchford 2001) tell us that case study is a method for investigating questions in depth through the observation of people in their own context and with the purpose of building an understanding about their interactions and behaviours in relation to the problem or situation being investigated. Mixed data collection methods and data collection instruments, these experts continue, increase the value and the insights obtained in case study research. Overall, they appear to be good to apply when we want to know about an issue that has not yet been systematically researched. Thus, this research method was suitable for investigating how teachers and children incorporate a BDP for preschool concept mapping into classroom activities; my research claims (chapter 1).

Through intense observation and participation in the activities of the social world that are enabled by the case study method, a researcher, Flyvbjerg (2006) says, can cast off preconceived notions and theories. Intense observation is an activity, a central element in learning and in achieving new insights.

> …the proximity to reality, which the case study entails, and the learning processes that it generates for the researcher will often constitute a prerequisite for advanced understanding… More simple forms of understanding must yield to more complex ones as one moves from beginner to expert' (pp. 236-237).

To enable me to support and/or challenge my research claims, I needed to immerse myself in the world of my user community (teachers and children in the preschool classroom) and from there, from inside their world, collect information and elaborate a meaningful (or well-substantiated) story. Entering a natural setting to undertake my research implied entering the complexities of a social world and its dilemmas. On this point Edwards (2001) says '…whatever version of qualitative design and analysis we select, we will find ourselves getting to grips with the complexities of the social world of early childhood' (p. 117). I was entering this complex environment to track and report the performance of behaviours that the BDP for preschool concept mapping was designed to support (see chapters of design phase regarding the design of the BDP).

Reasons for using this method

Early childhood researchers such as Edwards (2001) and Siraj-Blatchford and Siraj-Blatchford (2001) as well as social scientists such as Flyvberg (2006) and user-centred design experts such as Norman (1999) have written methodological debates about the merits of quantitative and qualitative research methods and their differences and contributions to different research purposes. At the time of selecting a method, I was aware of the tensions between these two ways of doing research. These discussions and debates indicated that each paradigm addressed particular research questions. Since my research was concerned with the wants and needs of a user community, it was aligned with design research that also sought to understand users' wants and needs. Thus, the use of qualitative methods in general and case study methods in particular was seen as appropriate. I had three reasons for employing an ethnographic approach, and specifically a case study approach:

1. Broad understanding of the issues around preschool concept mapping

2. Teachers use ethnographic approaches in the classroom

3. Early childhood research methods vs. 'rapid ethnography'

Broad understanding of the issues around preschool concept mapping

'Ethnographies typically aim to provide holistic accounts that include the views and perspectives, beliefs and values of all of those involved in the particular sociocultural practice or institutional context being studied' (Siraj-Blatchford & Siraj-Blatchford 2001, p. 193). In preschool, though, due to the limited resources and time constraints, ethnography broad aims are difficult to achieve. Therefore, it is preferred to refer to how the method is applied in preschool as an ethnographic approach or as providing a partial ethnographic account.

As explained in chapter 2, the issues in preschool concept mapping are developmental, curricular (cultural), and representational (technical): these same factors also affect the effective application and dissemination of Novak's concept mapping as a relevant instruction tool for early childhood. I needed to conduct studies in the preschool classroom to develop a broad understanding of how these socio-technical and developmental issues influenced concept mapping and how these issues were interconnected. Developing such understanding was a way to improve my context-based knowledge of the user community experience with concept mapping. Before the studies, my experience with the issues was via literature review (chapter 4) and conversations with key expert informants (chapter 5). Also, a broad understanding of these issues would enable me to determine appropriate features of an effective and suitable concept mapping tool for preschool. Or in Norman's words understanding these issues would help me:

> Determine what the product should be. Although this seems obvious, it is the task most often ignored and most often done too quickly, poorly and superficially. How does one define the product? Study prospective users: Watch them as they go about their daily lives. Understand what role the proposed product would play. Find activities that are close as possible to the tones the product is intended to support. The goal is to understand the users' true needs, what they care about. Then compile, refine and analyze the observations to determine what the product might be, what role it would play, what actions it should perform. Go beyond the problem that is given to develop solutions that meet the customers' needs (Norman 1999, pp. 185-186).

Teachers use this method in the classroom

Ethnographic research methods are well established in early childhood research and have been utilised for a wide variety or reasons. For example, Siraj-Blatchford and Siraj-Blatchford (2001) summarised and cited ethnographic research applied to the study of educational outcomes or the study of play, to identify the different experiences of minority groups in specific settings or in the context of school improvement and effectiveness studies. They cite many other authors suggesting that the early childhood ethnographic studies currently being applied are also important in allowing new voices to be heard. These are voices of teachers, other careers, families and the children themselves.

Ethnographic research methods are varied and include case study, biography and action research (Edwards, 2001). However, most ethnographic research is performed in the form of case studies (Siraj-Blatchford & Siraj-Blatchford 2001). The teachers of the five experiences in preschool concept mapping (chapter 2) used case studies for investigating the concept mapping issues. This method was appropriate to my research as it enabled me to establish a relationship with the teachers and learn also from them.

Is early childhood research similar to 'rapid ethnography'?

In carrying out the case studies there was an identifiable similarity between ethnographic case study method as used in education and the methods used in user-centred design: that is ethnographic case study is similar to 'rapid ethnography' (see chapter 3). These similarities can be seen in how teachers designed educational programmes for each child or a group of children, observed and collected data from the children who were using the programme. After doing this for a few days, and after evaluation of the data they had collected they applied modifications to the programme. The data collected during these few days of observation may not satisfy an empirical research agenda, but they were sufficient for the teachers to assess the students' ongoing educational progress and for planning of next educational programmes. Using similar methods to the teachers' own practices would ensure that the research method was familiar to the teachers.

A well-substantiated story

> …the major virtue of qualitative studies is their capacity to tell a well-substantiated story. These stories are strengthened, by using voices from the field, or detailed snapshots of the field, to bring to life the arguments being pursued in the research report. Organization of qualitative evidence therefore has to allow the researcher to access easily the qualitative sources of the strong themes being discussed… Systematic organization of data cannot be overemphasised (Edwards 2001, p. 133).

In this chapter I described how the methods and instruments of ethnography were applied to the design of a case study. The combined evidence resulting from using such methods enabled me to tell a ‘well-substantiated story’ about children’s ability to make concept maps if presented with suitable concept mapping tools.

Picture of interactions or behaviours of what’s going on in a setting

Qualitative research designs, included case studies, provide access to the web of interactions between the different actors of a setting and situations. Qualitative designs ‘… allow us to build up a picture of the actions and interpretations of children and adults and locates them in the shifting networks of complex interactions that make up the context providing the constraints and possibilities for action and interpretation’ (Edwards 2001, p. 117).

‘Case study… They all attempt to answer the question ‘What is going on here?’ by focusing on the particularities of lives in context…’ (Edwards 2001, p. 126). The use of case study allowed me to collect information regarding the social interactions that ensued when the children used the BDP. I was able to take that information and categorise the children’s behaviours. This enabled me to confirm or refute my different research claims (regarding Novak’s concept mapping in preschool). The design of the BDP allowed children to overcome some of the representational issues that, in previous studies, may have been misinterpreted as a curriculum issue rather than a representational issue— how children’s developmental limitations affect their performance with the tool? And, can these developmental limitations be overcome with a different tool? In other words, the use of the BDP in the preschool classroom allowed me to build up an informed picture of the web of interactions around its use and from this being able to answer the ‘what’s going on here’ question.

Example of an intervention

> Case studies are often referred to as units of analysis, the bounded systems which we explore in our study. A case study can be for example, an individual, a family, a work team, a resource, an institution or an intervention. Each case has within it a set of interrelationships that both bind it together and shape it, but also interact with the external world. Stake usefully describes a case study as ‘an integrated system’ (Stake, 1994). Case studies can be longitudinal, but more often than not they provide a detail snapshot of a system in action (Edwards 2001, p. 126).

My case study (comprised of interactions with two different preschools) was an example of ‘an intervention’ that recorded a ‘detail snapshot of a system in action’: how teachers and children incorporated the BDP for preschool concept mapping into their classroom activities.

The design of the case studies

The following summary provided by Hammersly (1999 in Siraj-Blatchford & Siraj-Blatchford 2001) presents the features of ethnographic research, case studies included:

- Peoples’ behaviour is studied in every day context (in this thesis I refer to people as participants or user community)
- Data are gathered from a range of sources, but observation and/or relatively informal conversations are usually the main sources
- The approach to data collection is unstructured
- The focus is usually a single setting or group
- The analysis of data involves interpretation

How these features are represented in the design makes one case study different to the next one. The choice of data collection methods, data collection instruments and content analysis approach heavily depends on the research questions and the constraints applied to it.

In this research, the same method of case study was used in all the participant preschools, however, some adjustments were made to fit the specifics of each setting. These adjustments were performed at many levels: study goals, data collection methods, data collection instruments and the BDP for preschool concept mapping. Participant teachers’ comments, classroom size and distribution, time constraints, children’s profile and classroom philosophies influenced decisions regarding adaptations to the study design. Most care was taken to not affect the overarching research goals.

Participants' profile: general characteristics

Before securing the two case studies reported in chapters 7, 8 and 9, a profile of the user community was developed for the purpose of prototyping. See chapter 3, 4 and 5. In this section the general characteristics of the user community are presented.

Selection of the sites and gaining entry

As explained in chapter 5 the results of my preliminary case study together with discussions with two early childhood trainers, and presentations given at two relevant conferences (Gomez 2005a, b) demonstrated that the BDP for preschool concept mapping was ready to be incorporated in any preschool classroom. At this time I initiated contacts with teachers of different preschool communities in Australia and New Zealand.

Three key expert informants and one of my doctoral advisors introduced me to the first case study site. They referred me to preschool teachers they thought would be interested in participating in my research. I contacted the teachers via mail, email, phone and an advertisement in a teacher newsletter. Information packs containing information about the research goals and photographs of the preliminary study were also sent. From this effort the Australia case study emerged. The director of the preschool and I met in June 2005.

The second case study site presented from my position as a visiting doctoral scholar at Carnegie Mellon University's (CMU) School of Design in the USA. The head of the Design School, Prof Daniel Boyarski, encouraged me to contact the director of CMU's Children's School, Dr Sharon Carver. Again I prepared an information pack together with an introduction letter and contact details. I left this pack with the administrative coordinator of the School and asked her to deliver it to Dr Carver. Dr Carver emailed me saying that she reviewed the package and it appeared to be that we had mutual interests and that she would like to meet. This initial meeting with the director was in February 2006 and from this meeting the US case study emerged.

Participants

The participants of the study are members of the preschool community. The focus of the research was concerned teachers and children using the BDP for preschool concept mapping. For the purposes of this study I was not concerned with the names, ethnicity, gender or any other particularities (e.g. special needs, health issues).These issues may be the focus of further research.

The preschools of my case studies were different at many levels such as resources, computer usage, curriculum design, teaching and learning philosophy, and children placement in the classroom. For instance in the Australian preschool classroom, 3 to 5 year olds studied together while in the US preschool 3, 4 and 5 year olds studied in separate classrooms. The difference has to do with each preschool's teaching philosophy. See more on this in the chapters 7 and 8 respectively. What these schools had in common was that they were not familiar with Novak's concept maps, the classroom layout was similar and the teachers used similar kind of educational tools.

The lack of familiarity with Novak's concept mapping was not seen as problem because the question was whether the BDP allowed children to record concepts in a meaningful and autonomous way. If children who did not have knowledge of Novak's concept mapping method were able to make meaningful concepts then I would be able to claim that the barrier to concept mapping may not be developmental as has been argued but, rather, a matter of literacy skills.

I chose a naturalistic setting, opposite to a laboratory setting, because I needed to see how the BDP worked in a real place, in an unstructured environment. The teacher participation, advice and collaboration were essential to the success of the activity since they were familiar with the children's backgrounds and personalities. In study one, the teacher played an observation role while I worked with the children. In study two, the teachers performed the activity and I interacted with them and the students at their request only.

Usually, the topics and the activity were discussed with the teacher(s) in advance. These discussions were important because teachers brought issues up that should be considered regarding the student's background or simply recommendations of how to better perform the activities. A special effort was made to avoid reference to topics that might bring up personal issues. However, if an unexpected situation occurred, teachers were present at all times during the activity.

During the sessions we used the BDP and other supporting materials that we found beneficial to the activity. We used whatever was available in the classroom that could trigger children's imagination to make concept maps. I expected the children to interact with me and talk about matters involved in the concept mapping activity.

A guest in the preschool

I was a guest in the preschools, this meant that decisions related to how and when to work with the children or the time length I would spend with them were made by my hosts. Directors and teachers set up the interaction rules, which meant that I had to adjust the way I would achieve my research goals to their context's rules and needs. To accommodate this I offered to change aspects of the tool to meet the context requirements. It was not possible to impose any of my research needs on them. The need to adapt is not unusual for this type of research method:

> Observational contexts thus vary in terms of the amount of control the observer has over the setting. In naturalistic settings, the observer may have little control over the characteristics of the setting and what happens in it. In a laboratory setting the observer may have complete control over at least some parts of the setting. For some research questions this sort of control is very important. (Rolfe 2001, p. 235)

This was not an issue in terms of the research, as I needed to see how the BDP adapted to user community activities. It was an opportunity to put in practice aspects of the user-centered design philosophies. Norman (1999) says learn, learn, learn as much as one can about the users.

The best way to learn is to listen, be open to changes, receive the participants opinions openly, so they do not feel threaten or challenged by this new tool I was bringing to their space, to their practice. I listened to the participants and let the directors, teachers, and children run the different processes involved in using the BDP. I recorded all of this information, later it helped to answer questions regarding the feasibility of my tool or concept mapping in their environment.

Adjusting case study to the particular school

The concept mapping activities were designed according to the group size, relevant content, and school make up. In case study one, I worked with the children in small groups (four, three or two children at a time) or individually. Therefore, I used a small size magnetic whiteboard. In case study two, the teachers worked on a single topic and divided the classroom in two groups. Each group had more than 8 children, therefore the BPD had to be adjusted to this size, for example bigger magnetic whiteboards were used.

The content changed for each of the sites. It was important to work with the children's interests or the current topic of study, thus, the concepts to be mapped using the BDP were discussed with the teachers in advance.

Adaptations to the BDP were applied as I was performing the case studies and based on my ongoing observations and the comments and suggestions of the user community, directors and teachers and children in the classroom. This was to be expected as one the design requirements for the BDP was to bear adaptation (chapter 5).

The BDP for preschool concept mapping was introduced to the communities as the Authoring Concept Mapping Kit -the Kit. During the case studies I found that this open-ended, flexible BDP enabled me to learn more about the user community wants, needs and context in regard to the issues I was investigating (see more on this topic in chapter 9).

Data collection methods

> Rather than offering a particular method for data collection, ethnography may be conducted using a wide range of methodologies. It should therefore properly be understood as providing us with a particular perspective on what counts as legitimate knowledge or, to put it in more academic and philosophical terms, as providing us with an epistemology for our research (Siraj-Blatchford & Siraj-Blatchford 2001, p. 193).
>
> …The question does not rule out the capacity to reveal causal relationships, but the prime purpose of the study is to get below the surface offered by one method of data collection on one element of the field in order to achieve some purchase on the complexity of the social worlds. (Edwards 2001, p. 126).

Given that most case studies examine existing systems and try to avoid much disruption, case study researchers aim at low-intrusion data collection methods so they can do justice to the story the case is telling (Edwards 2001). My case study is opposite to the goal of most case studies, in fact my case is highly disruptive because it is monitoring an intervention the introduction of a new tool into classroom practices. This meant that the participants became used to my presence (specially in case study one where I was interacting with the children, I was the teacher). Therefore, to get the 'best' and 'available' information under these disruptive circumstances, I used multiple sources of information (mixed methods of study) and multiple collection instruments.

To achieve observational data of high quality, Rolfe (2001), appeals to the concept of objectivity. Objectivity is achieved through the observer training and careful definition of target behaviour. Using different observation styles and data collection instruments reduced subjectivity biases. They were used according to classroom setting, class structure, observation styles, time availability, ethics approval, and available instruments.

Mixed method studies are becoming popular. They provide multiple sources of information involving methods, data, investigators and theory (Siraj-Blatchford & Siraj-Blatchford 2001). Different methods offered different goals. Case studies typically collect data in the form of observations and interviews, however in this research documented sources were also used. I explain it next.

Direct observation

Challenging or warranting my research claims depended on the richness of the behavioural data that I could gather by observing teachers and children using the BDP. Direct observation is more appropriate if we want to know what people are doing in a natural setting. On this Rolfe (2001) says, 'when we are interested in understanding or explaining everyday behaviours as they occur, data of these kinds will help us to understand or explain something else (for example, quality of a service, effectiveness of an intervention)' (p. 229).

Preschool teachers regularly use this method in the classroom to learn about the children, to evaluate their students learning and developmental progress. Based on the analysis of these observations, teachers arrange or re-arrange the curriculum to match the learning needs for each child. Most early childhood teachers in pre-service training learn about techniques of systematic observation because consistent, careful observation is fundamental to good teaching. The techniques learnt for classroom practice are similar to those we apply in observational research. The techniques of direct observation include both qualitative measures (running and anecdotal records) and quantitative measures (checklists, rating scales and time and event sampling) (Rolfe 2001).

Literature in early childhood qualitative research methods informed my observation process (Curtis & Carter 2000; MacNaughton, Rolfe & Siraj-Blatchford 2001; Nicolson & Shipstead 1998). I also observed teachers of my studies performing their own classroom observations. In particular the preschool directors shared their knowledge on this topic with me, which helped me to improve my own observation techniques.

Direct observation involves the researcher recording the data of interest directly from their own observations from the research participants (Rolfe 2001). However, the observation styles can change according to research goals and classroom schedules. I used passive and participant observation. Passive observation was used to learn about the children's background, to understand behaviours, or to learn about classroom teaching styles, or to familiarize with the potential subjects of my observation. Due to classroom schedules or rules, these passive observations were sometimes obtrusive, other times unobtrusive. For instance, in the CMU preschool more than three researchers cannot perform observation in the classroom at the same time, therefore, when Dr Carver's students were observing the classroom, I was to do my observations from the observation window. Participant observation was used in the performance of the activities with the BDP. In case study one, I was the researcher and the facilitator of the activity. In case study two, I participated in the activity at the teacher's request.

Interviews

Interviews, Edward says,

> …allow case study researchers to explore the meanings that lie behind observed behaviour or documentary evidence… In case study research is commonplace to use observations as a starting point for interviews. Most interview schedules start quite broadly and then focus more narrowly on the issues that have arisen as the case has been explored. Case study researchers often use interviews to explore their interpretation of data and the tentative links they have been making between elements of the case as part of the process of progressively increasing an understanding of the case. Of course here is important to avoid leading questions. The researcher can focus the topic of the interview, but should avoid constraining the response (Edwards 2001, p. 131).

I used several interview styles: guided conversations, open-ended and unstructured, informal meetings, informal conversations. While informal or guided conversations with the children helped me to have a better understanding of who they were, teacher interviews or informal conversations allowed me to gain knowledge about the teacher viewpoint on children's behaviour with the BDP.

In case study one, while interacting with the children I used guided conversations with the children. Guided conversations are also called clinical interviews or clinical conversations and used by early childhood experts in their research and practice (Cadwell 2003; Fleer 1996; Mancinelli 2004; Mérida 2002). This literature reports on experiences of the researchers in clinical interviews. I used that literature to learn about appropriate techniques to use in my interactions with the children. In case study two this was not necessary, as my interactions with the children were limited to observation time where I was only assisting the teachers.

The preschool directors, the teachers and I had many informal conversations or meetings before, during and after the sessions using the BDP. These conversations covered a variety of topics regarding the set up of the activity, the children's background regarding learning abilities and developmental stage, and their interest as teachers. At the director's recommendation and to familiarise myself with the children of case study one, informal conversations were also undertaken.

Teachers of case study two were 'formally' interviewed after the sessions with the BDP. Unstructured questions were designed according to a rapid analysis of observations made. Obtaining teachers' viewpoint during interviews assisted with the analysis, as their viewpoints were also included in the content analysis. Post-case studies I shared the outcomes with some key expert informants (including Dr Joseph Novak) and presented one conference CMC2006 – the Second International Conference in Concept Mapping), and two seminars (Psychology Department at Carnegie Mellon University and Institute for Human and Machine Cognition). In chapters 7, 8 and 9, I go over the informal conversations, meetings, 'formal' interviews and presentations in more detail.

Documentary sources

The concept mapping activities for case study one were designed based on literature of early childhood practice and research (see chapter 4 and 5). To learn more about the preschools' background (goals, mission, the staff), I studied the information booklets of the preschools.

Data collection instruments

> Direct observation can be time consuming but the richness of data achieved, and the insights that come from prolonged periods of sustained attention to the behaviours of interest as they occur in the ongoing behavioural stream, more than compensate (Rolfe 2001, p. 230).

The constraints on access meant that prolonged observations were not possible. To ‘guarantee' that a rich data was collected I used different kinds of instruments for recording the same behaviours. A characteristic of ethnographic research is collecting multiple representations of the same data. This is to show different definitions and present the research in a manner that is open to multiple interpretations (Siraj-Blatchford & Siraj-Blatchford 2001). By combining approaches a more complete picture or understanding can emerge (Rolfe 2001). I gathered data in the form of anecdotal notes, photos of children’s maps, photos, audio-recordings, and a video of the process of building and revisiting a concept map video.

- *Note-taking:* I kept a personal journal, which I took to every session and meeting with key experts. In this journal, I described and reflected on actions occurring during the sessions, informal conversations with teachers and/or children, thoughts that originated in different occasions (e.g. after the sessions, while reading some relevant literature, during a conference or seminar topic) and new ideas or concerns about how I was proceeding with my sessions. In case study one, I was also the facilitator, which meant I had to plan the educational activities, make observations ‘teacher style’, and re-arrange them accordingly to children’s interactions. Because of the role I played many of my journal reflections of case study one are concerned with teaching and learning.

- *Anecdotal records:* I used anecdotal records to gather data about 3 participant children in case study one. In these anecdotal records I collected information about children’s interest, mastered skills, and knowledge construction in the classroom. The information was classified in the following manner: Child name and age, session date and number, interests, creations, reading interests, vocabulary, reasons to change activity, revisits work, remarkable words, forms of expression, reasons to change activity and comments. The anecdotal records were used to achieve a better understanding of the children’s developmental skills and what they could do with them. Such understanding was used in the analysis of the mapping productions these children made.

- *Photos:* I took photos of the products, of the building process, and of the participants manipulating the BDP features and producing content.
- *Audiotapes:* audiorecordings of each session where the children and the teachers interacted with the BDP were made. Detail explanation of how audiorecording took place in each preschool is given in chapters 7 and 8.
- *Videotapes:* Video was used to film a complete session. The film was later analysed, and a snapshot taken of each key step in the building of a concept map. A collection of snapshots together with dialogues transcripts made it possible to analyse the process of building a concept map. This collection depicted a complete mapping session.

  This snapshot collection together with the transcribed dialogues provided the data on how the teacher and the children interacted during the building of the concept map. It enabled to analyse the data from two viewpoints: manipulation of content and manipulation of objects. See more in the analysis section of this chapter.

  Only children from case study two were video-recorded (see ethics considerations for explanations). 'The camera is highly intrusive and a focus of ongoing interest to the children' (Rolfe 2001, p. 237) are two reasons for avoiding its use for doing classroom observations. However, in my case these issues were not a problem. The CMU's children's school is a laboratory school and these children are used to having researchers around using video.

Data collection challenges

As briefly explained earlier, every preschool was not only different, but also I did not know the participants well before hand. Usually in ethnographic research is recommended having a long period of adjustment before starting with the 'official' observations. Due to the limitations of the research, the period of adjustment or familiarity with the user communities was shorter than would normally be preferred..

However, despite these limitations sufficient data was collected to show that preschool children are able to use the BDP to concept map.

Regarding observations, participant observation data was difficult to collect with the instruments in case study one. As I was the teacher and the researcher, it was difficult to collect photographic data of the children's process of building the concept map. Another difficulty was that I worked with the whole classroom, comprised of 25 children, but was able to report on only the 9 children whose parents signed the consent form for participating in the study. Such restriction meant that most times I worked with children I was not able to report on. Findings regarding use of removable templates for representing hierarchies were not possible to report because the children who participated in these activities were not in my ethics list. Not being able to report on hierarchies is one example of how this restriction strongly affected what is possible to report.

Re-scheduling of some activities reduced my time for preparing observations and time to set-up video and audio. In case study two, I performed observations while the teachers worked with the students on the mapping activity. But different problems arose, changes to the observation schedule at the last minute due to teachers' new schedules or a sudden change of plans in the classroom affected the way I collected data. Unlike case study one, in case study two I was able to video-record the sessions (the reasons for this are presented in the ethics section of this chapter), however due to a conference that one of the teachers had to attend, I had to perform my case studies a week forward than planned. This meant that I did not have time to organise video-recording and audio-taping for the first session.

Analysis

> Qualitative analysis usually involves content analysis, that is, a process of combining evidence. The comb can be quite fine, allowing detailed analysis of the transcribed interview text - for example, the type of language used to talk about the children. Or it can be broad and pick up thematic responses – for example, believes about children as learners. Analysis can involve the entire text or simply segments of it. Much depends on the purpose of the study. Whatever method is used, the case study researcher needs to explain carefully how the analysis was carried out (Edwards 2001, p. 132).

Two case studies were performed to gather data about the performance of behaviours (tasks or activities) with the BDP for preschool concept mapping in a preschool setting. However, the data of both studies was used for the same content analysis. Combined, these data gave a richer view of the issues in preschool concept mapping. For example:

- In case study one I worked with individual and small groups of children (two to three). Published literature says that concept mapping with individual children is not possible (Mérida 2002). See more in chapter 7.
- In both case studies I have evidence of concept mapping with two children with special needs. Such evidence when combined gave me information about the questions raised by the teachers of the OCTF conference that were presented in chapter 5. See more on this in chapter 9.

How the data was used

Different data provided different ways to analyse the material, which combined provided a richer view of the issues. Table 6.1shows how the data was used.

Table 6.1 – used given to data collected in the case studies

Type of Data Collected	How was the Data Used in the Research?
Analysis of the verbally-labelled symbol maps the children produced in the sessions	The maps showed what the children could represent, the type of knowledge that they were able to make explicit with the BDP features
Analysis of audiotaped dialogues that happened while building the maps	Are the children mapping knowledge? Is there evidence of knowledge retention, organisation, and preservation? Are they using metacognitive skills? Are they authoring the process of building the map? What is the kind of teacher facilitation?
Analysis of photos showing the building process	What are they doing? Are they independently using the BDP features? How are they working with the teachers or with peers?
Analysis of object manipulation	Do the BDP features enhance control over every aspect of the making of the map?
Analysis of teacher interviews	To learn the teacher viewpoint of how they see the interactions with the BDP. What do they think about the product?
Pre and Post informal conversations – a selection of	These key comments were analysed using theoretical accounts. The experts expressed comments about the

key comments	BDP features, further tool development, children's development, and further literature review.

The relevant sections of the data collected illustrate themes that warrant or challenge my research claims. The behavioural categories introduced next were used to organise the themes in a way that I was 'able to illustrate the arguments the organisation of the data collected has to allow the researcher to access the qualitative sources of the strong themes being discussed' (Edwards 2001, p. 133).

Behavioural categories

Before combining the data for a final analysis with the different theoretical perspectives relevant to the research (chapters 2 and 4), the data of each case study was categorised in behaviours.

> In fact, ethnographic study is by its very nature interpretative, that is, it is concerned to understand the subjective world of human experience. The central aim of the ethnographer is therefore to provide a holistic account that includes the views, perspective, beliefs, intentions, and values of the subject of study. To achieve this, we focus upon human actions that are always understood as 'behaviours-with-meaning' (Cohen and Manion, 1994). 'Actions' are only meaningful to us if we can identify intentions of the actors involved. This is often far from straightforward… _(Siraj-Blatchford & Siraj-Blatchford 2001, p. 194)

My research claims are behavioural statements. The different activities that children and teachers performed with the BDP for preschool concept mapping should all together enable them to perform the following type of behaviours: 1) bring autonomy to children's concept mapping process (by promoting use of multiliteracy by enabling addition of meaning to symbols with spoken language, and insertion of linking phrases) and 2) facilitate teacher instruction. The presence of these types of behaviours in one form or another in the case studies provided information to warrant my claim: preschool children's are able to make concept maps as stated by Novak, if the are presented with a tool which allows them to make knowledge explicit with spoken and visual language.

> The main point to remember in observational research is that behaviour is 'a continuous stream of movements and events' (Martin and Bateson, 1986, p. 39). To measure behaviour, these movements and events must be broken down into categories that should preferably be defined in such a way that different observers viewing the same sequence would produce the same behavioural record. How molecular or molar the behaviour categories should be is determined by the research question (Rolfe 2001, p. 234).

To measure the behaviours expressed in the research claims, the design requirements and scaffolding features represented in Table 4.1 and Table 5.1 were re-grouped in categories to show what I was looking for in the data. See Table 6.2.

Table 6.2 – categories used in the content analysis

Behavioural Categories I was Looking for in the Data
1) Actions required for concept mapping (manipulation of content)
Labeling ideas with symbols and/or voice-recorders (vrecorders)
Connecting verbally-labeled drawings with magnetised arrows
Using removable templates in proposition making and two-level map making
Mapping the content created with the BDP features
2) Actions with BDP components (manipulation of objects or system's components)
Voice-recording
Cutting pieces of Velcro to attach paper cards to voice-recorder
Handling and drawing on small pieces of paper
Handling paper arrows
Drawing materials
Sharing working space
Placing magnetised objects on the magnetic whiteboard
Using extra materials (paper, sticky magnets, markers to draw directly on the whiteboard)
3) Teacher facilitation (with content manipulation and object manipulation)
Demonstrating how the BDP features work
Guide the idea generation process (e.g. support the process of deciding what to draw and/or what to voice-record)
Assisting children with operation of BDP features
Assisting children with the performance of behaviours (assisting in voice-recording, drawing or map making)
Mediating map revisiting or reading

In chapter 4 (see guideline 2), I explained the behaviours (also called tasks) that older children and adults can perform with Novak's concept map template. Concept maps stated by Novak should promote active inquiry and meaning negotiation as well as knowledge organisation, preservation (retention) and sharing. Table 4.1

shows the desirable behaviours that a tool for preschool concept mapping should promote. Table 5.1 shows the behaviours that the BDP for preschool concept mapping should enable. What is expected from the BDP for preschool concept mapping is that this allows preliterate children to perform some of the behaviours that older children and adults are able to perform with Novak's concept maps.

The categories of Table 6.2 represent behaviours-with-meaning that provided information to answer the research claims. Here I give an example of how they were interpreted. For instance,

- If I gathered data showing that a child was able to label ideas with symbols and/or voice-recorders, such results were an indication that the child was able to perform self-idea exploration (or in words of concept mapping, concept labelling). Other sub-analysis were also performed:
    - If the child performed this behaviour (or set of actions or) by herself/himself or if they needed help of another person (e.g. such as an adult or a peer) was also analysed.
    - If the child was assisted in the labelling process, 1) was this assistance limited to showing how to operate the device, 2) was the assistance related to operating the device and drawing the symbols for them, and 3) was the assistance related to supporting children at the level of idea generation by supporting symbol creation and verbal labelling.

The results of this categorization of the data allowed me to make an evidenced-based judgment as to whether a particular feature of the BDP allowed for autonomy in the child's mapping process and whether it facilitated teacher instruction.

> For an idea to have value, or to be valid, is for it to be strong and effective. Our assessment of validity are based upon our perceptions of 'worth' and hence upon our value systems. In clarifying our rationale we are delegating this responsibility to the reader, who may accept or reject our explicit values (Siraj-Blatchford & Siraj-Blatchford 2001, p. 204).

Theory-led analysis

To understand what the behaviours meant in the context of the issues around preschool concept mapping and in relation to theory, I used theoretical perspectives to unpack their meaning.

> But when we learn about other people and about social events, the process is even more complex. Our understanding of any kind of event is conditioned by our prior knowledge, but in this case the object of our interest behaves according to their own understanding of what it is they are doing. We cannot really understand why they act in a particular way unless we first discover what their intentions are. This process of determining the intentions of the authors of either texts, actions or other cultural products is termed hermeneutics. While the lesson was most clearly learnt in anthropology it is now widely recognised that a hermeneutic process must be applied in all of the social sciences. We now recognise that if we wish to describe what someone is doing we must first understand what they think they are doing. If this wasn't complicated enough, as social scientists we must also recognise the process that Giddens (1975) referred to as the 'double hermeneutic' (p. 12), where our respondent's understanding of events changes as a direct response of our intervention. As Jamesand Prout (1997) have observed, this is nowhere less apparent than in the study of childhood itself (p. 5) (Siraj-Blatchford & Siraj-Blatchford 2001, p. 203).

The data collected (teachers' comments, audiotape and videotape transcripts, photos) was analysed using the theoretical structures introduced in chapters 2 and 4. To capture important features of the preschool classroom (the field) in relation to my research and to enhance the study's integrity, I analysed the data under a theoretical perspective (child psychology, learning, concept mapping, and knowledge representation) and established comparison with other research in preschool concept mapping: the five teacher experiences reported in chapter 2 and more recent research in preschool concept mapping (chapter 9). Such theoretical accounts informed the development of the BDP for preschool concept mapping that was used in the classrooms. The content analysis showed how close or far the proposed design reflected or complied with practice.

The findings of the user community interactions with the BDP were analysed to provide arguments to the following themes related to preschool concept mapping. Among others, these are some of the themes that were discussed in chapter 9:

- Labelling of concepts with multiliteracy
- Organisation of concepts with hierarchy
- Metacognitive or self-regulation skills
- Use of arrow connections
- Intrinsic motivation

Ethical considerations

To increase its feasibility, the case study was designed during the prototyping face and before gaining entry to the participant preschools. This meant that I had to anticipate possible ethical issues so that these were prevented and I had a way to address any ethical problems early. Such ethical considerations allowed me to clarify the teachers' profile and have a better understanding of the kind of tool that would be accepted in any preschool classroom (see chapter 5).

The study was designed to perform under tight constraints and to work in any preschool setting. These constraints were reflected in my Swinburne Application for Ethics Approval. The application was prepared based on the documentation and guidelines that the Swinburne Office of Research and Graduate Studies provides to people performing research with human subjects (http://www.swinburne.edu.au/research/ethics/human.htm).

In this application I stressed that the participants' faces would not be photographed and their names wouldn't be disclosed, the teacher would always be present in the classroom and that I would always work under the school's rules and teachers advice. In the analysis and transcripts I proposed to use aliases and initials to differentiate one child from another one and stressed that the data collected in the case studies was only to be disseminated via the doctoral dissertation, refereed journal publications, and academic conferences.

Together with the application I had to provide the following supporting materials:

- Form of Disclosure and Informed Consent that was given to the preschool director and the parents
- Written permission to use public or private premises off-campus. Case study two was performed in a different country and university. I had to comply with their ethics procedures and this documentation was added to my Swinburne ethics. (How this process was performed later in this section.)
- Written approval by other Ethics Committee(s)

The Swinburne Human Research Ethics committee approved my ethics application under the conditions presented in it. However, differences to how the ethics issues should be addressed in each participant preschool surfaced. These differences are explained next.

Case study one

<u>Level of consent</u>

The preschool director signed the consent form, however, only 9 out 25 parents did. Therefore, the director recommended working with the whole class, 25 children, and only report on the children whose parents gave consent form, 9 children. Originals of these consent documents were sent to my supervisor and added to my ethics documents. Also the preschool director kept her own copies of the documents.

<u>Consent documents</u>

Once the preschool director accepted to make their preschool part of the study, the participants' parent or guardian were informed, as their signed consent was necessary for working with the children in the classroom. The parents or guardians were informed about the project through two documents that were prepared under Swinburne ethics regulations and printed on Swinburne's letterhead. These documents were:

- *The individual form of disclosure and informed consent* included information about the researcher's background and study objectives, a description of the activities that were to be performed with the children and data gathering methods, how unexpected issues were to be addressed in case something came up and the time that I was planning to spend in the classroom. The participants, in this case teachers and parents or guardians, were also reminded that they could withdraw participation, contact the researcher for further information at anytime, and had access to the data collected. Regarding dissemination and complaints, the participants were informed of how the data would be used and who to contact if they had a complaint about how the study was conducted.
- *The consent form for persons participating in the project* was to be signed by the parents and the director of the preschool. The consent form is a legal document where the participants give consent and authorize the children to participate as well as acknowledge to be informed about the study goals, procedures, and their rights.

The study only commenced after the director and parent or guardian signed the consent form.

Data dissemination and treatment

My ethics approval limited reporting on children's interactions with the BDP and analysis of the audio-recordings. Conversations with the teacher regarding other issues were not included, even though I found them relevant or related to my research to an extent. A total of 6 audiotapes were recorded, but I could only disclose content of two and half of them. The other tapes include interactions with children who were not participating in the research.

Photographs of children's faces were not taken. The visual collection limited to the children's actions building the concept map and the final product. Also I took photos of the area of the classroom that was assigned to me for performing the activity. These photos were taken before the session and after the session.

A tape recorder was used to audio-record children's comments while performing the task and the teacher and researcher's motivating inputs. This information was important to collect in order to be able to confirm or refute the research claims.

Case study two

At the US preschool the ethics issues were handle differently. This preschool is a laboratory school. At the time of enrolment parents signed a blanket consent form authorizing their children to participate in any research activity under the school supervision. In other words, the children all have blanked consent forms for being observed /or to be subjects of research. This meant that for simple classroom experimentation with my BDP was possible without special consent, if it was purely for product development. Ethics approval was only necessary if I wanted to be able to disseminate information about actual subjects. To be able to use the findings of my observations in my thesis, publications and presentations, I had to obtain an ethics approval from the University were the preschool was located.

<u>Carnegie Mellon University Ethics Approval</u>

When a research project is performed under the supervision of two universities, the study has to be approved by both universities. Swinburne University ethics procedures demand it in their ethics application. The same rule applies to Swinburne University students who perform studies in overseas universities. To comply with this University's requirements I had to submit an ethics application. The information of this section was taken mostly from the documents that I downloaded from the website of the Associate Provost for Research & Academic Administration, section Regulatory Compliance Administration (http://www.cmu.edu/provost/spon-res/compliance/hs.htm).

The IRB or institutional review board is a diverse group of scientific and non-scientific individuals who conduct the initial and ongoing review of research studies in order to ensure the protection of the rights, safety, and well being of human subjects participating in those studies. The federal code of regulations governs the composition and conduct of the IRB. (Title 45: http://www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.htm). Carnegie Mellon

University has their own IRB, which is called the Carnegie Mellon institutional review board.

The IRB is only charged with reviewing research that involves people as research participants. My project needed to be reviewed because it complied with the following criteria:

- The research was a **systematic** investigation (including development, testing, and evaluation) designed to discover or contribute to a body of **generalizable** knowledge.

- **It involved human participants.** Human participants include those who are actively involved in the research process (being interviewed, filling out surveys, etc.). They also include those who may not be in front of us: those who provided medical samples, left records of their activities through applying for marriage licenses, etc. The IRB reviews research that involves living individuals (1) about whom 'an investigator conducting research obtains data through intervention or interaction with the individual' or (2) which contains 'identifiable private information' (Title 45 CFR, Part 46.102.f). Secondary data analysis of existing datasets where participants are individually identifiable should be reviewed by the IRB.

Research must be approved by the IRB before research can be conducted. My application was submitted (via email and fax) to the CMU's Regulatory Compliance Administration office. This application and supporting materials had to be signed by the director of the preschool (CMU's representative) and myself. My thesis supervisor was also included in the application as co-investigator, but her signature was not required.

With my IRB review form, I submitted a document with the following supporting information:

- An abstract of the proposal.

- A clear definition of how the subjects will be utilized, how the experimental treatment will be administered or the methodology.

- A copy of the 'informed' consent form(s) that the subjects or parent or guardian will be required to sign. (Since the consent form for the preschool was already on file with the IRB, so no further consent was necessary.)
- A description of how confidentiality/anonymity will be protected.
- The name(s) and address(es) of official(s) authorizing access to any subjects in cooperating institutions not affiliated with CMU.
- A description of the risks and benefits to the subjects.
- A copy of any recruitment document (include advertisement flyers/invitation letters/invitation emails) to be used.
- A copy of my online training certificate (http://cme.nci.nih.gov/).

This is an online course for gaining training in the ethical treatment of human research participants. NIH certificate is granted if one passes the online exam. The course and exam is administered by http://cme.cancer.gov/clinicaltrials/learning/humanparticipant-protections.asp

Swinburne Ethics

Two comply with the Swinburne University ethics; I prepared an *individual form of disclosure and informed consent* for the director to keep and asked her to sign a *consent form for persons participating in the project* that was to be added to my ethics approval files. I also required that the parents signed a consent form, but since this was not done at this preschool, I asked the director to provide me with a copy of the document that the parents sign at the time of their children's enrolment. This was to justify to the Swinburne committee on the change in procedure regarding parents' consent. Similarly to case study one, originals of these consent documents were sent to my supervisor and added to my ethics documents. Also the preschool director kept her own original.

Data dissemination and treatment

The blanket consent form of this laboratory preschool allowed me to take photographs, audiotape and videotape the children, the teachers, their facilities and all the products that generated during our interactions.

Similarly to study one, photographs of children's products were taken and audiotapes were made. I photographed session 1 while session 2 was photographed, audiorecorded and video-recorded.

The advantage of being able to do all of this was greatly appreciated, however, I still needed to consider my Swinburne ethics. I was still bound to my University rules. My way to deal with the restrictive Swinburne ethics and the permissive CMU IRB was to settle for a middle ground when it came to disclose information about case study two. When reporting on this case study:

- I do not disclose preschool name, teachers or children's names, which were replaced with aliases.
- I video-recorded one session, made transcripts of the dialogue, and analysed the video at the school. The analysis involved a detailed visual account by taking still photographs out of it to show the process of building a concept map. I was not permitted to keep the video. It stayed at the preschool. It belonged to them. If, in the future, I wanted to analyse it again, I will have to visit the preschool.
- Similarly to case study one, I did not disclose children and teachers' faces. I blurred their identities by using a Photoshop filter or placing a black shape on their faces.

The data was analysed for establishing what kind of actions (behaviour) related to concept mapping the children were able to perform. If these actions 1) promoted autonomy in concept mapping by enabling children to add meaning to symbols with spoken language, use multiliteracy, and insert linking phrases; 2) facilitated teacher instruction by transforming teacher mediation role from the making of the concept map to guiding children in the process to construct them themselves.

Summary

The case study method was the qualitative research method of choice for evaluating the user of BDP for preschool concept mapping in the classroom. The selection of the sites and gaining entry was a process aided by advisors and key thematic experts. Emails or packages with information about the BDP for preschool concept mapping and the research were send to several teachers. Two preschool communities showed interest in participating, one in Australia and one in the USA.

The forms of data collection were observations, interviews and documentation sources. Observing the user community interacting with the BDP was used for several reasons: 1) immersing myself in the community provided a better understanding of their context realities (at a technical, developmental and curricular level), 2) teachers use this method in the classroom, and 3) user-centred design also uses observations. Interviews and informal conversations with participants added richness to the observations, a multiple view approach that brought other voices to the discussion. Photos, tapes, video and notes were used as data collection instruments.

The data was analysed from the same shared-theoretical perspective (child development, learning, and design) that informed the development of the BDP (chapters 2, 4 and 5). The content analysis involved identifying the behaviours that the BDP was designed to produce when the children interacted with it. The children's ability or inability to perform such behaviours provided the information required to answer the research claims (chapter 1).

The ethical considerations were also explained and the differences between the two studies were also stressed.

In the design of the case studies, I dealt with issues of control, time constraints, lack of training, etc that were addressed by using mixed data collection methods, multiple data collection instruments, and performing a content analysis from a theoretical viewpoint. A well-substantiated story surfaced from the way these issues were addressed.

The following two chapters are dedicated to presenting the actual case studies, with chapters 7 and 8 describing case study one and two respectively.

Chapter 7 – Case Study One

Overview

In the previous chapter I described the research method that was used in the case studies, the site selection and gaining access to the participant preschools. This chapter presents the case study one, designed to observe teachers and children incorporating the BDP into their activities. It is divided in three main sections: preschool description, design of the case study, and results. Results from both case studies are discussed together in chapter 9.

Nine children from a preschool classroom were observed during free-play time. Due to my inexperience of teaching, the children's background, and the classroom's teaching philosophy, Novak's concept maps were not introduced. Instead, the children performed concept mapping-related activities, for which the BDP was repurposed. These activities were called knowledge representation activities or KRAs.

The work of three observed children is reported. Verbally-labelled symbols disclosed the children's acquired knowledge, and when arrows were used, their organisation. Conversely, unlabelled symbols did not disclose knowledge.

The BDP components put children in control over every aspect of the map building, but only when they mastered required representational skills: drawing and voice-recording. The mastering of those skills also promoted active inquiry and meaning negotiation. The less intrusive the teacher mediation was, the more visible were the children individualities, and vice versa. These children's level and length of engagement in the activity was an unexpected outcome.

Preschool description

Background

This brief background summary was prepared based on the School's family information handbook. The citation for this source is not disclosed in the thesis, to avoid breaching ethics.

This preschool is a children's service run by the city council. Its approach to preschool education provides 'developmentally appropriate, play based experiences in an environment sensitive to the diverse needs of all children with an emphasis on open-ended activities, the use of natural materials, fostering respect for the natural world and a love of learning' (quotes cannot be referenced, read above paragraph).

The preschool teacher manages the day to day operations of the service, reports to the programme leader at the Children's Services Resource Unit (CSRU), and must act in accordance with the:

- Statutory requirements of the Children's Services Act 1996 and the Children's Services Regulations 1998 and other relevant legislation
- Funding requirements of the Commonwealth Department of Family and Children's Services (Child Care Benefit and Quality Improvement and Accreditation System) and the State
- Department of Human Services (preschool funding)
- City of [undisclosed] policies, procedures and work practices

Initial meeting

The teacher/director and I met during and after school hours. She asked first about my doctoral research, my research aims and my professional background. She then asked in detail about the BDP and how it was used. We talked about the preschool, the profiles of the children and her teaching style and goals. Lastly we toured the school.

I was offered the opportunity to work with the children two times per week for ninety minutes during free-play time. The teacher suggested starting this way and 'play it by ear', modifications to this approach could be made as we went. Also it was suggested that I should try to have morning tea with the children, as it would be a good opportunity to meet them and to familiarise myself with their backgrounds.

After this meeting I prepared the ethics application with consent form for the parents and documents with information about the research for parents and the teacher. The research was not to commence until parents had returned the signed consent forms. Read more about the ethics process in chapter 6.

Research familiarity

This teacher/director informed me that she opened the door of her preschool to researchers on a regular basis, which meant the children were familiar with having observers in the classroom undertaking research activities with them. This made the situation easier for me, as the children did not have to go through an adjustment period.

Teacher involvement

The teacher/director decided not use the BDP herself. However, she observed my working with the children and on occasion assisted me with activities. This included the provision of advice about the children's profiles, language use, and ways to approach them or present the activities (Gomez, 2007). It also included assistance in the provision of resource materials such as paper, pencils, scissors, and classroom space to perform the study.

The teacher/director and I had informal conversations prior, during, and after each session as well as during morning tea. We had also agreed to meet at the end of every week, but because of her busy schedule, this meeting only occurred once, via phone call. Not having the weekly meetings did not affect the research in anyway, but further supported findings reported in chapter 5 in relation to teachers' busy schedules preventing them from participate in research activities.

Teacher/director's profile

With over 30 years of experience working in Early Childhood, the teacher/director was the person in charge of the preschool. Two other teachers assisted her in the classroom, one professional, and one or two pre-service teachers. Despite the presence of these other teachers, the director/researcher had sole responsibility for class preparation, activity design. The other professional teacher assisted with evaluations of children's performance.

Researcher/teacher's profile

I had no experience of teaching, did not know the students' backgrounds, and had never instructed people on concept mapping. My 10-years experience lies in the area of design of educational tools, and this was the first time that I had actually tested a prototype with the users in their natural setting.

The children's profile

This group of children came to school two times per week, the class was multicultural and ages ranged between 3 and 5 years. I did not record details about gender and ethnicity as these details were not relevant to my study. However, the teacher provided such information when it was considered relevant to my interactions with the children. The parents of nine children signed the consent form. However, because of the classroom situation where it was not possible or appropriate to isolate these nine, it was considered best to work with the whole class, comprised of 25 children, and only report on those nine children. Since the children were to 'choose to play with me', this meant that in some sessions I worked with children that I was unable to report on. The term 'choose to play with me' is explained further in the free-play time subheading of this section.

All the children worked in a big open space in which younger children worked and played together with older children. Figure 7.1 shows a diagram of the space. A programme was implemented for each child or group of children, according to their needs. These needs were assessed by the classroom teacher based on her analysis of her data, which was gathered using Early Childhood education research methods such as direct and participant observation.

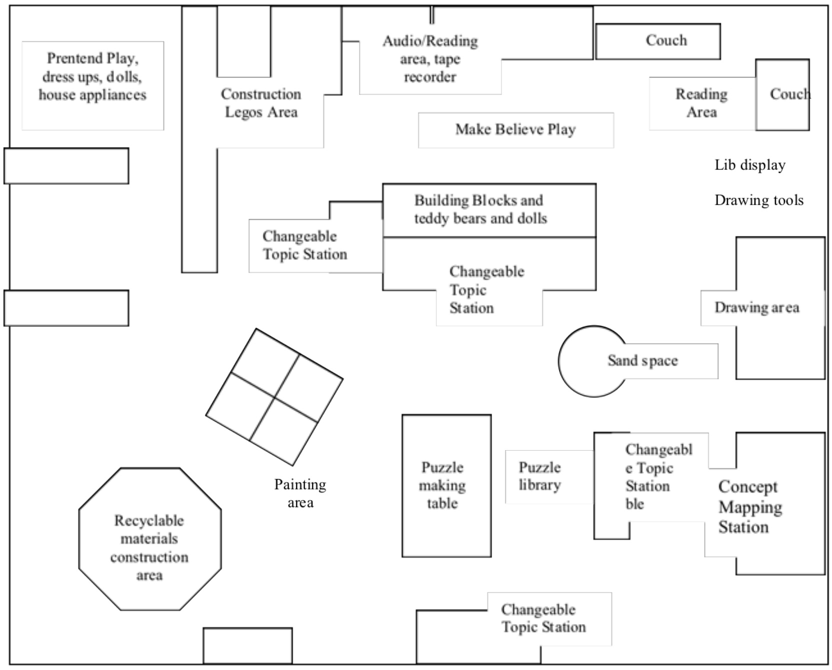


Figure 7.1 – layout of the preschool classroom at the time of the study, the space is divided into activity stations

Prior knowledge about Novak's concept maps

Despite the preschool's lack of familiarity with Novak's tool, the teacher/director was confident that the children were able to use some of the cognitive strategies required in concept mapping (retention, knowledge organisation, and self-regulation). She was also confident that the children would have high levels of attention (or concentration) during activities that were of their interest. Her one concern was related to whether the children would adapt to the structured activity associated with use of the BDP. She was not sure that her students would follow the rules for building a concept map, as they were not used to 'play under fixed rules'.

Sessions design

Goals

I sought to identify if, and to what extent, children could independently make knowledge explicit using the BDP for preschool concept mapping. The children were neither instructed on Novak's concept maps nor assessed on concept acquisition. It was not feasible to evaluate children's ability to concept map, due to the school's curriculum and researcher/facilitator inexperience as a teacher.

Planning

Activity preparations

The activities were framed as a game of concept mapping-related exercises. All sessions except for session 1 were planned based on the outcomes of the previous session. In session 1, as the teacher/director's requested, the children worked with the pre-constructed activity about 'New Zealand Farm Animals' (chapter 5). Her students are city children who rarely have the opportunity to visit the countryside. She wanted to know what the children knew about this topic. Besides she was interested to see how the children reacted to using the voice-recorders, as she found this device novel and child-friendly.

The pre-constructed mapping activity was to be replicated as performed in my preliminary case study, see chapter 5 and Gomez (2005b). But, it was to be presented to the children as 'Farm Animals'. The picture cards represented animals that could have well been Australian animals.

The activities for the other five sessions were designed based in concept mapping aspects. As defined in chapter 1, three pre-constructed and two low-directed mapping activities were designed. This kind of concept map-making strategies were defined in chapter 1. Each activity was designed weekly, based on the children's responses to the previous activity, teacher/director's recommendations, and the children's evaluated skills. This approach to the design of the sessions gave me the opportunity to develop strategies that worked with the participant children.

The preparation of each session included studying literature on methods suited to observing young children, and revisiting literature on preschool concept mapping and child development to understand the stage of development of the participant children. A picture book review was also performed on topics that were identified as interesting for the children. There was a preference to selecting picture books with few words and descriptive lively images that prompted the children to 'picture-read'.

The day of the session

Onsite preparation

I arrived at the school around 10.30am, displayed the material on the table and set up the tape-recorder, and then joined the children and the teachers for morning tea in the playground. After morning tea, we all went back inside the classroom, to free-play. The interactions in the playground are not reported and are not relevant to this study.

Teacher/director assistance during activity execution

The teacher/director observed my interactions with the children during each session, recommended word phrasing that would increase children's understanding of activity instructions. For example, she suggested using the words 'concept image' instead of the word 'concept' when explaining the children what to draw – let's draw a 'concept image'. Also to raise my awareness of the time that needs to be allowed for children's mental processing skills, she made comments such as the following: it takes the children a moment to figure out how things work. See chapter 9 for further teacher recommendations and her perceptions on the activities performed.

Setting up the activity space

A child-sized four-seat table was assigned for 'playing' with any child who approached this space. The table was placed in a corner of the room that was next door to the kitchen facilities (see Figure 7.1). The number of chairs placed around the table indicated to the children the number of people who could play with me at the same time. One chair around the table indicated I could play with one child, two chairs indicated I could play with two children, and so on. The teacher/director recommended following that rule, as a way of keeping some kind of organisation and to reinforce the learning of the turn taking concept. This rule was very useful, the teacher said, when many children, more than I could handle at the same time, wanted to play with the BDP. It was possible to sit four people around the table, three children and myself.

Free-play time

During a free-play time session each child was to choose a play activity to do. Once an activity was selected they could stay doing the same activity for the whole ninety minutes or jump from one play activity to another. The one thing they could not do was to stay unoccupied. If they did not choose a play activity by themselves, the teacher organised one for them. Play stations represented play activities. Some of them allowed cooperative play, others individual play. The children travelled from one station to the next until they found something on which they were interested to spend time. The concept mapping activity was one of those stations.

Observations

Incorporating three different roles of researcher, teacher and BDP designer, implied experiencing the case study from a participant observer viewpoint. Participant observation was used in session one to six and passive observation in week seven to ten. The reason for this change was that at the beginning of week six the teacher/director suggested stopping the observations all together. Her reason for this suggestion was that she considered that enough data has been collected for answering the study goals and she provided recommendations of what to do in weeks seven - ten. These recommendations are integrated to the discussion of results in the next chapter.

Data collection instruments

Data were collected in the form of audio-recordings, photographs, and note-taking.

Audio-recordings

For learning about the children's interactions with the BDP, the process of the mapping activities were tape-recorded. The tape recorder was placed in a corner of the worktable. Four sessions out of six were audio-recorded. In session four, I forgot to activate the record button, and accidentally overwrote the recording of session six. Nevertheless, despite these accidents, there was still quite sufficient data to analyse. The audio-recordings played an important role in this study, as they give trustworthiness to the notes taken and provide a context for the photographs.

Photographs

The making process and the children's final concept map were photographed. Photos of the children's faces are not used in this study to protect privacy. The making-process photos show the children's hands peeling off Velcro strips, or drawing on a piece of construction paper, handling arrows, or placing magnetised objects onto the whiteboard. I also took photos of the space where the activity took place and a few of the surrounding elements. I always avoided taking photographs of the classroom space and the children performing other activities

Note-taking

Note-taking occurred during session preparation, immediately after the participant observation sessions, and in the evening of the session's days. I not only recorded situations that happened in the sessions but also of conversations with teacher/director, and the plans for the following sessions. As social interaction with non-participant teachers was unavoidable, I restrained from note-taking or recording our conversations and their commentaries.

Notes taken during the passive observation sessions were organised into anecdotal records, a type of qualitative measure used in observation. The researcher's comments of the children's play activities were registered in these records. Details of the content of these records were presented in chapter 6.

Transcription

Sessions one and two were only partially transcribed because some children participating in these sessions were not part of the study. Session three was not transcribed, as the participant children were not a part of the study. As noted above session four was not recorded. Session five was transcribed in full.

In the transcripts I used aliases for identifying study participants. Each child is represented with a letter: the 5.6-year old alias is 'A', the 4.6-year old is 'N', and the under-5-year old is 'C'. The facilitator's alias is 'Glo'. [Undisclosed] appears when the dialogue involves children out of the study. [Inaudible] when the talk is not clear. The abbreviation for voice-recorder is 'Vrec' and indicates that these are the exact spoken words that had been voice-recorded. The children pressed the vrec's play button to listen to the voice-recording which was the record of their meanings.

Results

Of the nine participant children, three children participated in two sessions, four children in one session, and two children never showed interest in participaing. Of the three children who participated in two sessions, one child participated in one whole session and withdrew participation at the beginning of the second one. This happened immediately after the child was shown what to do with the components of BDP.

In each of the six sessions different strategies were tried for engaging children in concept mapping. In four out of the six sessions the children were invited to perform a concept mapping foundational activities such as proposition and two-level map making. I do not analyse these sessions as most of the children in session 1, and all of the children in sessions 3 and 4 were not study participants. In session 6, the interactions were short and the children lost interest early in the activity, which meant that the information gathered was not significant enough to report. Also findings related to hierarchy use cannot be disclosed, as the children who used the hierarchy templates were not study participants.

In contrast to the other sessions, in session 2 and 5, five children responded positively to the material presented, perhaps because the activity encouraged independent behaviour, and was built on prior knowledge and interests. Of the five children, two were not study participants, therefore, here I only report on three children, aged between 4.6 and 5.6 years.

In sessions 2 and 5 these three children 'read', discussed the pictures of the illustrated book 'The Egg' (Mettler, Bourgoing & Jeunesse 1990), and used the BDP to make knowledge representation activities (KRAs) of what they remembered about the ideas they had 'read' and discussed. The book was chosen based on the children's interests and prior knowledge. In a conversation prior to this day, the teacher/director of the preschool mentioned that the children were familiar with the egg cycle. A few weeks before my intervention, the children had eggs hatching in the classroom.

I had assessed that the descriptive images and design within the 'Egg' book were appropriate for helping the children to access prior knowledge of the hands-on and concrete experiences they had with eggs. The book presented some content, I thought, that would be familiar to the children as well as other content that would not be so familiar. I planned neither to teach the children new conceptual knowledge nor to correct misconceptions; as the activity was designed to disclose the children's own knowledge.

Sessions 2 and 5 were structured in three stages first reading, second discussion and third knowledge representation activity - KRA (individual activity). The 5.6-year old of session 2 was invited to participate in the activity earlier that day while picture-reading a book together. Session 5 was arranged in advance with the 4.6-year old who asked to play with the activity on a previous day. The under-5-year old joined the activity when the 4.6-year old and I were 'picture-reading' about the snakes. This occurred a few seconds after minute 29.

The children were invited to work their KRAs individually and were only offered teacher mediation if they requested it. Two of the participants were familiar with the BDP components, as they had worked with the BDP previously in session 1. Session 5 was the first time this child had interacted with the BDP.

My role as a facilitator was to let the children's knowledge emerge and help them to make it explicit with the BDP. My role was solely to observe and record. Only at the children's request I paced the interactions (e.g, turn-taking), stimulated discussion, prompted questions, demonstrated how to make the KRA, how to use the BDP components, or provided direct support in the making of the KRAs. I did not plan to work one-to-one with the children. However, because every child I worked with was at a different level of development and had different needs, I found myself working with children individually.

In the following three sections, I present the analysis of the KRAs developed by three of the children. Each child performed differently due to level of knowledge and ability to carry out the teaching instruction. These results are presented to help understand the particular factors intervening in the children's ability to represent, or not represent, conceptual organised knowledge using the BDP for preschool concept mapping.

KRA of a 5.6-year old

The 5.6-year old engaged in the activity for 77.3 minutes (reading: 21.9, discussion: 10.3, KRA: 45.4 minutes). During the KRA, the child worked independently during the session; asked questions, created symbols and voice-recorded their respective meanings in the form of concepts (egg) and propositions (the egg is wet, the egg is dry), and connected the verbally-labelled symbols with arrows to show reading orientation, see Figure 7.2.

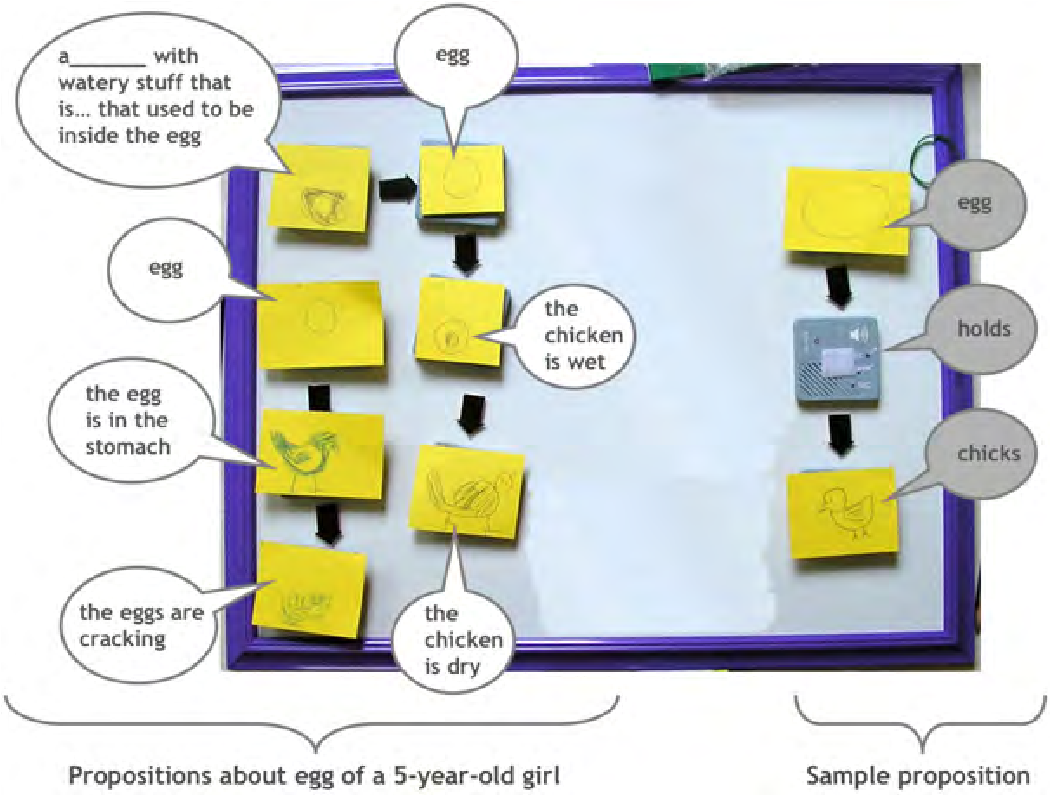


Figure 7.2 – the completed KRA of a 5.6-year old on chicken eggs

Building instruction

The goal was to encourage these children to use the BDP for representing 'little stories' of what they remembered about the 'picture-reading'. We discussed ideas that they remembered, I summarised them and then proceeded to demonstrate how to draw the 'little stories' with the BDP components: 1) draw an idea on a paper card, 2) voice-record the meaning, 3) Velcro the drawing to the voice-recording, 4) place them on the magnetic whiteboard, and 5) use arrows to show reading orientation.

Figure 7.2, right side, shows the proposition ‘the egg --> holds --> chick’. I demonstrated to the children how to make it. The KRA of the left side, Figure 7.2, shows what the child understood of my explanations and demonstration. Notice that the child did not separate concepts from linking words because the child was only demonstrated, but not explicitly instructed to do it.

Mapping the KRA

The child created two ‘little stories’. One story had three verbally-labelled symbols connected with arrows, the second story had four verbally-labelled symbols connected with arrows. In concept mapping terminology, the child created two sets of propositions. The first set of propositions was ‘egg’ --> ‘the egg is in the stomach’ --> ‘the eggs are cracking’. The second set of propositions was ‘a [inaudible] with watery stuff that is... that used to be inside the egg’ --> ‘egg’ --> ‘the chicken is wet’ --> ‘the chicken is dry’. See Figure 7.2.

What we can see in this KRA is that some verbally-labelled symbols represent concepts and others represent propositions. Conceptions and misconceptions were expressed using vocabulary at hand and with a combination of idiosyncratic and formal knowledge. The KRA is comprised of a combination of valid, invalid, and non-sensical propositions. For instance, ‘the chicken is wet’ and ‘the chicken is dry’. What did the child mean by that? The origin of these propositions is clarified later in this chapter.

An analysis of KRA tells us that the BDP enabled meaning to be attributed to drawings and the insertion of linking phrases. Also the KRA made explicit that ‘A’ could explain the concept ‘yolk’, but that s/he did not yet know the name for it, which is an example of Vygotsky’s (presented in Ausubel, Novak & Hanesian 1978) and Macnamara’s (presented in Novak 1998) theories on representational and conceptual learning, and concept naming respectively. Finally, it explains that the way the child used the arrows shows how these conceptual and propositional ideas are organised in the child’s thinking. The implications of these results for concept leaning, representation, and instruction are discussed in the next chapter.

Tracking idea generation

The origin of the conceptual and propositional knowledge is explained in this section. The ideas of the first set of propositions came from the comments the child made in ‘picture-reading’. The child verbally-expressed 10 concepts and 10 propositions in relation to the pictures seen, see Table 7.1 and Figure 7.3.

Table 7.1 – List of concepts and propositions that a 5.6-year old communicated verbally

Verbally-expressed knowledge of a 5.6-year old	
Concepts	**Propositions**
‘Yellow stuff’ [referring to the egg yolk]	[The chickens eat] ‘Like crumbs of bread and things’
‘In her tummy’ [the chicken’s]	‘Showing in the picture how the egg looks in the tummy’
‘The chicken’	‘The rooster sits on the nest’
‘The rooster’	‘They have different colours’ [referring to the rooster]
‘A bird’ [referring to a turkey]	‘They are much better…’
‘This is a duck’	‘The eggs are cracking’
‘…and more ducks’	‘The chicken, because they get bigger and bigger… ’ [Explanation given when asked how eggs and who makes them crack]
‘This is a bird’ [looking at the images of various pigeons]	‘That’s how they crack’
‘And and and these are all the eggs, the ducks here…’	‘… They used to be in those kinds of eggs’
‘This is the egg of an emu’	‘It got the way out of that’ [referring to ducks hutching]
‘This is the egg of the owl’	

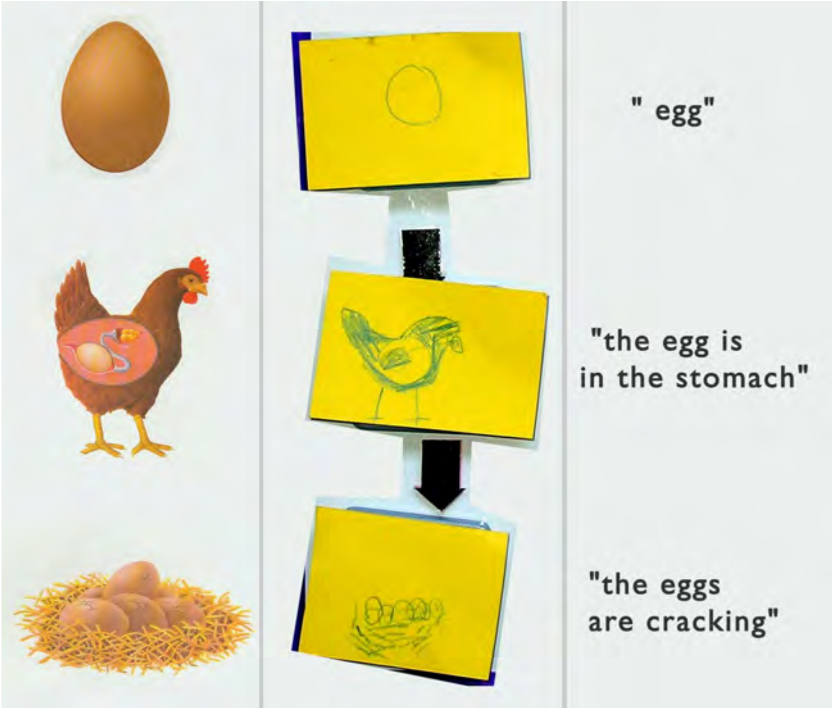


Figure 7.3 – first set of propositions of a 5.6-year old on chicken eggs

The concept (‘egg‘) and proposition (‘a [inaudible] with watery stuff that is... that used to be inside the egg‘) of the second set of propositions are ideas that the child planned to draw, Figure 7.4. When asked what it was remembered from the book, ‘A’ uttered the following sentences: ‘Egg, egg, [inaudible], when you open them you see a yellow round thing around it’, ‘And a kind of watery stuff, a kind of watery stuff’, ‘It is rounded by the watery stuff’, and ‘the egg is rounded by the watery stuff’. When ready to start drawing, again, I asked ‘A’:

Glo: [Undisclosed] What are you going to draw [child’s name]?

A: The egg, the yellow stuff that is watery

With these descriptions, the child was making reference to the egg yolk. ‘A’ was capable of providing different versions of the conceptual meaning using vocabulary at hand, but was not able to provide the formal label for it. Maybe she did not know it or remember it.

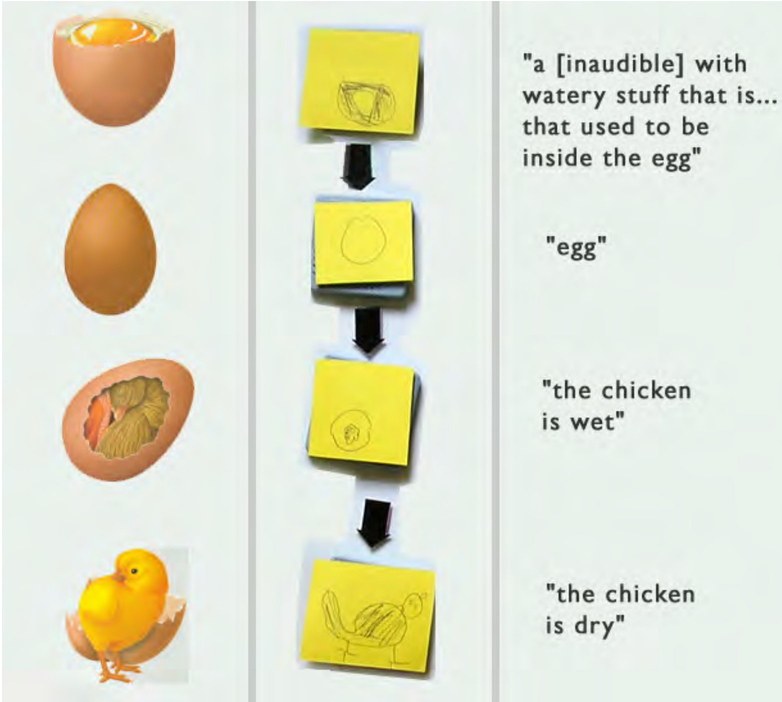


Figure 7.4 – second set of propositions of a 5.6-year old on chicken eggs

The other two propositions ‘the chicken is wet’ and ‘the chicken is dry’ were not picture-read or discussed by child ‘A’, see Figure 7.4. Another child who participated in the activity shared these ideas with the group. As noted previously two more children worked in this activity together with ‘A’. It appears to be that ‘A’ integrated these ideas or propositions into her ‘little story’. The situation just described is an example of concept assimilation where the child integrated the ideas (knowledge) of a peer into her KRA without assistance of the teacher. To further corroborate this point the content of the proposition in Figure 7.3 and Figure 7.4 are compared with the concepts and propositions presented in Table 7.1 and with the transcript of the dialogue that ‘A’ and ‘Glo’ had about what ‘A’ remembered.

The integration of ideas or propositions into the story of ‘A’ demonstrates that the BDP components enabled the child to: 1) reproduce some knowledge product of ‘picture-reading’, 2) represent an interpretation of knowledge held in memory, and 3) to represent the knowledge product of group discussions.

Autonomous knowledge representation

Child ‘A’ autonomously represented 2 concepts and 6 propositions, and formed two propositional sets. This result shows that the child was able to work with the BDP components and understood the instructions given for the KRA.

Self-regulating the KRA process

In the following transcript, we can see an example of the child’s control over the making of a concept map, and his/her use of self-regulation skills such as, planning and monitoring. ‘A’ was invited to make a second ‘little story’ or set of propositions, whose content was not discussed. This time our discussion was around the BDP components needed for making it:

Some time after 55.0min

	A:	I need two more cards
	Glo:	You need two more cards? Yeah, I am gonna give you more cards [inaudible]
	A:	You gave me four
56.0min	Glo:	How many do you need?
	A:	Four
	Glo:	I gave you four before, OK [for the first set of propositions]
	Glo:	Can I give you two tinnies? [Two smaller cards]
69.5min	A:	I need those pointy things
	Glo:	You need a pointy… what do you need? A pen? Tell me sweetie… Ah! Pointy things. How many? [She was referring to the arrows]
		[undisclosed]
	Glo:	You need how many?

	A:	Three
	Glo:	Three
	A:	Actually, umm
70.7min	Glo:	Remember, ‘A’, that you are making a sort of a story that other people can understand what are you saying
	Glo:	Is that enough? [Referring to the number of arrows I gave her]
	A:	I made three stories [meaning three propositions]
	Glo:	That’s very good
		[I continued working with other children]
71.4min	A:	I made all these ones
		[I continued working with other children]
71.8min	A:	I’ll do the whole. I’ll do my my little story. I want to read my little story

Self-regulation and knowledge retention

As you can see in Figure 7.2, ‘A’ drew more ideas than s/he verbalised when asked about what s/he remembered from ‘picture-reading’. The second set of propositions includes the idea that s/he remembered ‘a [inaudible] with watery stuff that is... that used to be inside the egg’, see Figure 7.4. This idea was not drawn first, meaning the child retained the idea in her mind, until she found a way to connect it sensibly to other ideas. Self-regulation and knowledge retention were evident in this process. These results are discussed further in the chapter 9.

Autonomous drawing and autonomous labelling – use multiliteracy skills

‘A’ was confident communicating ideas with drawings. His/her drawing skills were well developed. Since I did not pay close attention to the drawing process, I cannot say with certainty if the child used the book for guiding the making or if the drawings were drawn from memory. Of relevance to this research is that ‘A’ was able to make knowledge explicit through drawings and verbal inputs. Independently, the child operated the voice-recorders to make the drawings meanings explicit by labelling them. From minute 49.4 to minute 52.7 'A' worked on her voice-recordings independently. It is clear that the child neither asked questions nor asked for teacher mediation.

49.4min A: the egg is in the stomach [voice-recording]

A: the egg is in the stomach [voice-recording]

Vrec: the egg is in the stomach [playing back what's been voice-recorded]

Glo: Hear, yeah (?)

Glo: Ok, we need a different one; we have to pay attention to this, otherwise it won't work

A: eggs are cracking [voice-recording a new idea]

Vrec: eggs are cracking [playing back what's been voice-recorded]

From where I was sitting across the table I could hear 'A' pushing the play button of the voice-recorders to hear what had been recorded. She was playing an arranged sequence for the story

52.7min Vrec: Egg

Vrec: The egg is in the stomach

52.9min vrec: The eggs are cracking

In chapter 9 this child's drawing skills are discussed together of those of the children of case study two (chapter 8). Developing the children's drawing skills is important for mapping, as drawings are means of accessing their knowledge. The more advanced a child's drawing skills are, the easier it is to interpret that knowledge, that it is the more likely that such knowledge will be communicated. My findings are consistent with the findings of Mérida (2002) and Mancinelli et al. (2004).

Autonomous knowledge organisation

Mapping of propositions or mapping of verbally-labelled symbols occurred when the child read the first ‘little story’ or set of propositions. The story was read by playing the voice-recorders back and listening to each drawing label in the order indicated by the arrows. After listening each of the drawings’ labels in the order given to them, ‘A’ changed the sequence of two verbally-labelled symbols. Figure 7.5a shows the child holding the verbally-labelled symbol ‘the eggs is in the stomach’. Figure 7.5b shows the same symbol, ‘the egg is in the stomach’, in a different position. By revisiting the verbal labels, the child was able to recognise that there was something wrong in the way the ‘little story’ was told. This KRA created with the BDP components enabled knowledge organisation. The child re-organised the sequence of the verbally-labelled symbols after listening to the meanings assigned to the drawings and in the planned sequence.

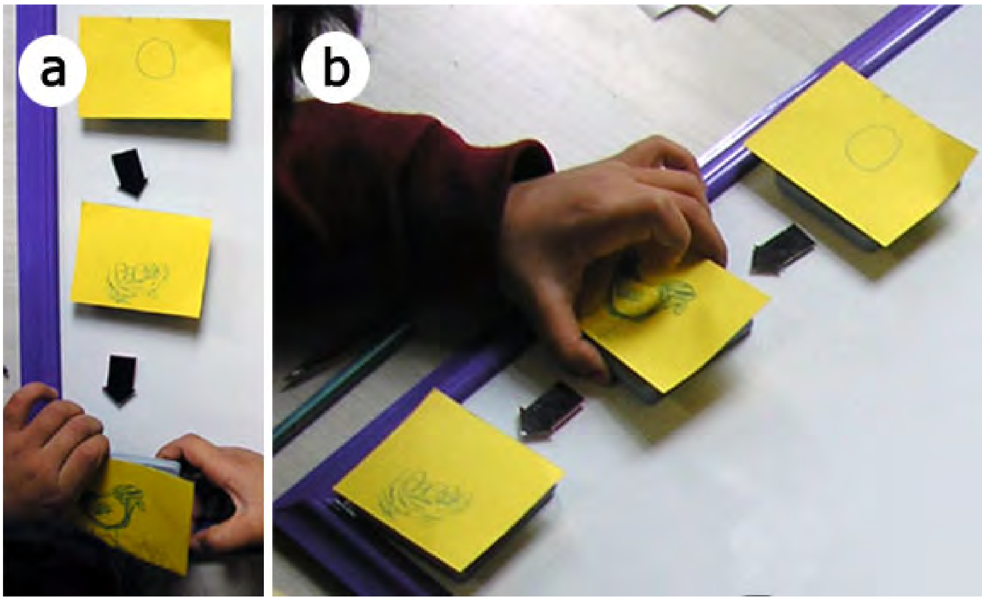


Figure 7.5 – mapping and re-organising verbally-labelled symbols

Teacher’s mediation

‘A’ asked for help when labelling the first set of drawings, and when she had some trouble operating one voice-recorder, s/he used her/his problem-solving skills to address the situation, once the teacher motivated her/his to find a way to solve it. The child’s way of addressing this was to change the phrase from ‘the egg is in the chicken’s tummy’ to ‘the egg is in the stomach’.

The problem that 'A' experienced was related to fine motor skills. The child had trouble operating the voice-recorder because the record button was being released just before the entire sentence was fully recorded into the device. The red light went off before the complete proposition was fully recorded. 'A' did not notice this situation (that the push button was being released before having all the words in the vrecorder), and I, as the teacher, did not notice it either. This was the only time the problem presented, as the child was able to voice-record the other 6 concepts without trouble.

The child addressed the voice-recording issue by changing the proposition for one that was shorter, but that encapsulated the same meaning. The analysis of the approach taken made explicit that the child knew two labels for the same concept, tummy and stomach. More on this topic is discussed in chapter 9.

The nature of the mental interactions

Active inquiry and meaning negotiation with teacher

Coffey et al. (2003) argue that among the factors that affect the nature of mental interactions with a concept map are a device and the teacher. In the case of this research, active inquiry, in the form of questioning and the teacher asking for clarification, animated by the child interacting with the KRA components was evident in one occasion. Meaning negotiation is also present when Glo suggests to the child ways s/he might approach voice-recording. Glo suggested an approach for planning what to say about the drawing and for discarding the drawings that did not represent desirable ideas.

The following transcript represents a discussion that began after I finished demonstrating how to make verbally-labelled symbols and organise them with arrows. This dialogue between 'A' and Glo was about 'A' deciding and negotiating with Glo how to label the drawing related to the concept 'a [inaudible] with watery stuff that is... that used to be inside the egg':

46.5min	Glo:	So you guys now do yours…[undisclosed dialogue]… So follow the instructions. This is a way to organise the things that we say so other people can understand.

46.9min	A:	It's gonna be a bit hard
		Glo: Why , why is gonna be a bit hard?
		A: I don't know what to say first. I don't know how to say it.
	Glo:	Aah. So maybe we need to re-organise it. Maybe you can change the way we have it. Let me give you, do you want another card? So you can do it again? [The child was suggested discarding the drawing made and starting on a new black piece of paper].
	A:	[inaudible]
	Glo:	Ah, OK
	A:	[inaudible] So what should we draw again?
	Glo:	So first draw the image, and [then] plan what do you want to say
	A:	Do we press the button [inaudible]?
	Glo:	Ah, Ok sweetheart, when the light is on you say the word, OK?
47.8min	A:	mmm [inaudible] is wet in the egg [voice-recording]
	Vrec:	[inaudible]
48.0min	Glo:	Can you hear it? You can play it again. You can say it again. Play it again
	Glo:	Oh, that's good

Negotiating meanings independently

Another factor that affects the nature of mental interactions with a concept map is the learner himself/herself Coffey et al. (2003). Every time a verbally-labelled symbol was created and connected to another verbally-labelled symbol the child was negotiating meanings. The propositions built during the KRA are examples of this, Figure 7.2.

In the process of verbal-labelling the proposition ‘the chicken is in the stomach’, ‘A’ negotiated meanings to solve the voice-recording problem by using the label ‘stomach’ instead or the label ‘tummy’ in the proposition. The child used reflective thinking to solve the problem, which is essential to the organisation of any piece of knowledge (Brown and DeLoache 1978 in Bransford, Brown & Cocking 1999) and also a concept-mapping related characteristic (see chapter 4).

Independent meaning negotiation was also evident when deciding how to label each of the drawings and organise them sequentially in order to tell the ‘little stories’. A good example of negotiating verbal meanings is the process of labelling the concept ‘a [inaudible] with watery stuff that is... that used to be inside the egg’. Table 7.2 shows the changes the proposition underwent from conception to verbal-labelling.

Table 7.2 – conceptual changes of a proposition about the concept ‘yolk’

Concept evolution	KRA stage
‘yellow stuff’	Picture-reading
‘Egg, egg, [inaudible], when you open them you see a yellow round thing around it’ ‘And a kind of watery stuff, a kind of watery stuff’, ‘It is rounded by the watery stuff’ ‘the egg is rounded by the watery stuff’	Discussion [These three sentences where uttered when asked what was remembered]
‘The egg, the yellow stuff that is watery’	Discussion [when asked what you are going to draw]
‘mmm [inaudible] is wet in the egg’	Voice-recording
‘a [inaudible] with watery stuff that is... that used to be inside the egg’	Verbally-labelled proposition

KRA of a 4.6-year old

The 4.6 year old engaged in the activity for 61.5 minutes (reading: 35.9, discussion: 17.5, KRA: 44). During the KRA, child ‘N’ worked independently on the creation of 2 drawings (symbols) and with teacher assistance on the third one (frog); independently voice-recorded labels to add meanings to the three symbols (cracked egg, frog, egg), did not produce conceptual relationships, as the child was not instructed in the use the arrows. I did not introduce the use of arrows because symbol-drawing took most of the time available for the activity. Figure 7.6 shows the KRA of ‘N’, which reflects the child’s understanding of the instructions and the activity.

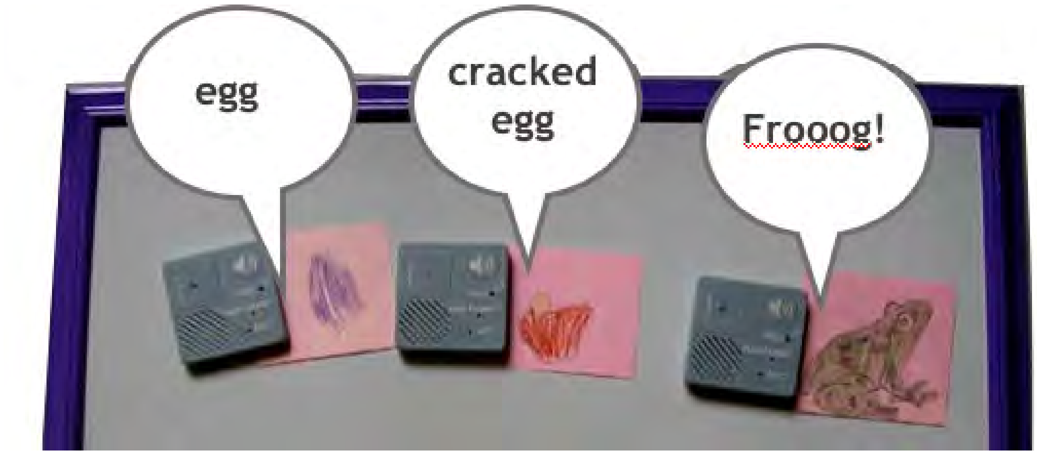


Figure 7.6 – three verbally-labelled symbols of the 4.6-year old on the egg

Building instruction

The goal was to encourage ‘N’ to use the BDP for representing remembered ideas from ‘picture-reading’. I explained to the two children, ‘N’ and ‘C’, what we would be doing: first identify and draw each idea, then add meanings with voice-recorders, and then place the verbally-labelled symbols on the magnetic whiteboard. ‘N’ already knew how to use the voice-recorders from previous interactions with the BDP. Therefore, there was no need to demonstrate how to voice-record.

Arrows were not introduced in this KRA because we ran out of time. ‘N’ spent the available time in drawing the ideas, around 19.9 minutes. By the time we were ready to incorporate the arrows, we were close to finalising the session. However, it is important to highlight that ‘N’ asked for the arrows. One possible explanation for this is that the child interacted with arrows in session 1 and saw ‘A’ incorporating them to the KRA in session 2. The child’s familiarity with to the arrow component of the tool may come from these interactions. This is the short conversation about the arrows that ‘N’ and I sustained:

A few seconds after 36.8 min

N: When are we going to use the arrows?

Glo: We are going to take the arrows out, when we have done some of the drawings.

The building instruction was different in session 5. I did not use the 'little story' metaphor. This was in line with approaches throughout the study where I tried different strategies to elicit children's knowledge. Chapter 9 discusses instruction, as, according to Novak (1998) the quality of instruction can also affect the output of a learning experience.

Mapping the KRA

The child created three verbally-labelled symbols. In concept mapping terminology, the child represented three concepts and zero propositions. The concepts are 'egg', 'cracked egg', and 'frog'. Conceptions were expressed with vocabulary at hand and using formal knowledge. The absence of arrow connections prevents to see how this child thinking related the three concepts in his/her mind.

Tracking idea generation

The three concepts that 'N' represented with the BDP came from the comments the child made in 'picture-reading'. The child verbally-expressed 23 concepts and 26 propositions in the relation of the pictures seen (Table 7.3).

Table 7.3 – list of concepts and propositions that a 4.6-year old communicated verbally

Concepts	Propositions
'Cracked' [egg]	'That egg is enormous!'
'A yolk'	[The chicken is] 'Laying an egg'
[the chickens are] 'Eating'	[The chick] 'It's trying to get out of the egg'
'yum, yum, yum' [child makes sound of chicken eating'	'The chicken is pushing its way out' [of the egg shell]
'It's an egg'	[The eggs are] 'Starting to crack'
'And that's the chicken'	'Now it got out…' [of the shell, the chick]
[The chicken is] 'Picking' [the egg's shell] 'To get it out'	[The turtle] 'it's cracking its way out'
'Quack, quack, quack' [child makes duck sound]	'Snakes, it's [cracking] way out'

'It's [inaudible] the egg'	' I know that little, little. I know when I was little, little, little' 'Cause I have a little baby brother'
'Very bright' [the chicks]	'[inaudible] all the feet that it has' [the croc]
'A turkey' [the child repeated after me]	'it's showing two here' [two croc feet]
'A goose' [the child repeated after me]	'I bet, it's something [inaudible]'
'Goslings' [the child repeated after me]	'And when we step on them, [frogs] they make like a cracking sound like chips underground'
'ow, ow, owls' [the child repeated after me]	'Stingrays doesn't sting nothing, doesn't sting anything'
'Owl's eggs'	'it doesn't sting anything, stingrays don't at all'
'An enormous egg'	'Stingrays don't sting people'
'An ostrich'	[sting rays] 'They can sting you…'
'A snail'	'No, it doesn't [hurt a little], it does, it does, it floats around. It looks like it can sting, but it doesn't' [referring to sting rays]
'Turtles'	'It doesn't look like it sting'
'From the egg'	
'A crocodile!'	
'Crocodile [inaudible]'	
'No… It's up that way'	
'one, two, three' [feet has the baby croc]	
'it is a [inaudible] frog'	
'[inaudible] round]' [frog related]	
[frogs live] 'underground [inaudible]'	
'The different kinds of eggs'	
'Oh, here are all the eggs' [we saw in the book	
'And this is a bird shop (?) [inaudible] This is a present egg'	

The three concepts are consistent with what the child planned to draw. When s/he was asked what it was remembered from 'picture-reading', 'N' said: 'I want to draw the egg', 'I am gonna draw the egg, the [inaudible], and the frog', 'a crocodile', 'that chicken' (pointing at the picture of the chicken with the egg in the stomach).

A comparison of Figure 7.6 to Table 7.3 shows that 'N' drew fewer ideas than were 'picture-read' and discussed (the crocodile was not drawn). The reason for the fewer expressions of ideas was the limited drawing skills of ‘N’ in comparison to ‘A’. One of the ideas ‘cracked egg’ is the result of autonomous concept retention and representation. This is explained further in next section.

The BDP components enabled the child to reproduce a knowledge product of ‘picture-reading’ and to represent an interpretation of knowledge held in his/her memory.

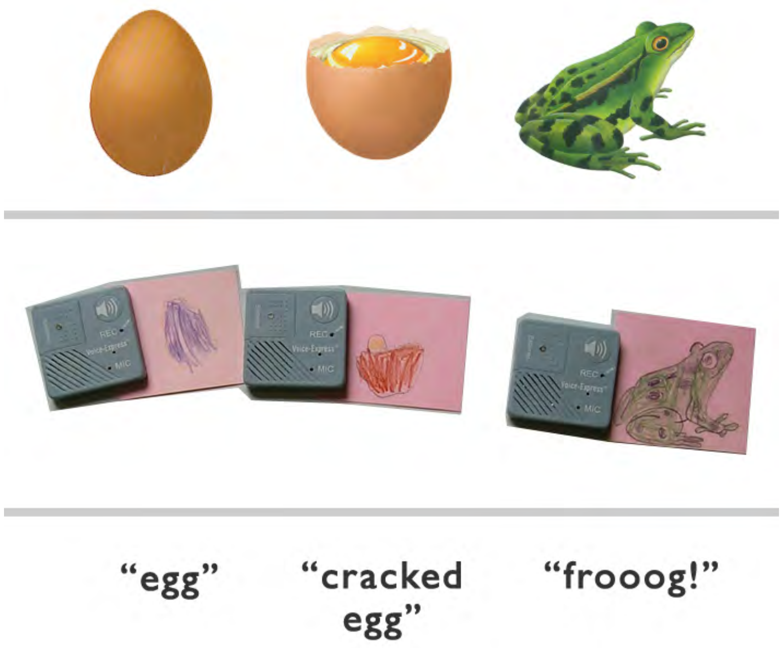


Figure 7.7 – these are the book images (top) that inspired the drawings (centre) and voice-recorded labels (bottom) of the 4.6-year old

Autonomous knowledge representation

Autonomously child ‘N’ drew two symbols and added verbal meanings to three symbols with the BDP. This result shows that the child was able to operate the BDP components and understood the instruction given for the KRA. Drawing two recognisable symbols (labelled ‘egg’ and ‘cracked egg’) was a big advancement for ’N’, who had previously stated that s/he did not know how to draw what was remembered.

Child ‘N’ demonstrated autonomy in regard to self-regulation, knowledge retention, and representation skills in this session. Using the example of the verbally-labelled symbol ‘cracked egg’: when ‘N’ had finished working on the frog, s/he asked to draw a 'cracked egg'. With some encouragement from me, autonomously the child drew the cracked egg with a 'little yolk' in the middle and verbally-labelled it as 'cracked egg'. To make the yolk explicit the child painted a section of the drawing yellow (Figure 7.7).

Evidence of autonomous knowledge organisation was visible in the process of idea generation to idea representation. The child decided what to draw, made the drawings, verbally labelled them, then matched the drawing with the corresponding meaning, and finally placed it on the magnetic whiteboard.

Despite the limited drawing skills of 'N', the ability to represent three concepts, one with teaching assistance, was an instructional achievement. 'N' was not as confident at drawing, but the instruction somehow worked. Maybe the repetitive and constant motivation influenced the child to try a little bit harder. Motivation, or 'wanting to learn', is one of the conditions of meaningful learning and is further discussed in chapter 9.

Teacher mediation

The child requested for drawing assistance at various stages of the KRA and repeated several times not knowing how to draw one thing or the other. I drew the first drawing: the frog, and then 'N' coloured it in. Even though I was helping at request, I kept using motivational speech regarding draw making. To convince 'N' to draw something, in different ways, I repeatedly motivated 'N' and 'C' to draw what they remembered, offered assistance with sections of the drawing, showed examples of how to draw, explained how to make it. This is a dialogue transcript showing aspects of the motivational speech:

Some time after minute 49.5

Glo: You can try to do it sweetheart. [inaudible] very well. Now try to make the egg cracked with the yolk in the middle [the child is drawing]… very good!

N: That's a little yolk

50.1 min	Glo:	That's a little yolk, fantastic, fantastic. What else would you like to draw? What else do you remember?

The KRA of Figure 7.6 is a result of using the instructional strategy above described.

The nature of the mental interactions

Active inquiry

Active inquiry, that is questioning and asking for clarification was evident during 'picture-reading'. There is no evidence of 'N' using these strategies when creating the KRA content.

Negotiating meanings independently

Independent meaning negotiation was evident when 'N' verbally-labelled the drawings. This process involved deciding what to say about each drawing. Visual or transcript evidence of this process is not available, as while 'N' worked on drawings labelling, I was heavily mediating the work of 'C'. However, aspects of his/her activity were audio-recorded in the background of my conversation with 'C'. 'N's' use of the voice-recorders, for verbally-labelling the symbols, is presented in Figure 7.7.

Concept retention and assimilation

The concept 'cracked egg' as it was represented in the KRA is a product of our discussions between child 'N' and myself. Tracking the concept from generation to representation shows how the child assimilated and retained it in memory for later representation. See Table 7.4 and Figure 7.7.

This concept has an explicit meaning, which is the one that the child verbally-expressed when using the voice-recorder, but also it has an implicit meaning, cracked egg with a little yolk. In the dialogue the teacher and 'N' had, the child stressed the importance of having drawn the little yolk. See dialogue in teacher mediation section.

Table 7.4 – tracking the concept 'cracked egg'

Concept	Activity stage
'<u>cracked</u>'	Picture-reading
'…egg <u>cracked</u> with the yolk in the middle…'	Teacher's comment while guiding the child in the making of a drawing related to this comment
'… so the egg, and the yolk, so now we have the cracked egg with the yolk, and we have here, the crocodile with the cracked egg'	Teacher's comment when revisiting some of the children's drawings
'So this is the egg, the egg with the <u>cracked</u> egg yolk inside it, the chicken, and the chicken lay an egg, and before laying the egg, the egg comes from inside the chicken, the egg is kept in the tummy'	Teacher's comment while revisiting some drawings and ideas with the children to motivate them to draw more ideas
'cracked egg!'	Voice-recorded label

Self-regulation and assisting knowledge retention

'N' employed a problem-solving strategy to aid memory recall when asked to draw something remembered from the book. The child claimed not to remember anything and offered to solve the lack of remembering by revisiting the book. The first time the child said, 'Maybe we can, maybe we can have a look again and look at [inaudible] things [inaudible] draw'. The second time said, 'have a look at the book'. This self-initiated planning strategy worked for 'N', as the concept 'cracked egg' is a result if its application. Planning is an important strategy used in concept mapping processes and evident when a learner is selecting the list of concepts that will be used in the map (see chapter 4).

KRA of an under-5 year old

The under-5 year old 'C' (unconfirmed age) engaged in the activity 55.5 minutes (reading: 29, discussion: 17.5, KRA: 44). The child joined at the reading stage of the activity, we were 6 minutes into it. During KRA, the child produced 5 drawings (two independently, three with researcher/facilitator assistance), but did not represent their meanings with voice-recorders. The child declined to use the voice-recorders and did not respond to the different motivational strategies to do so. Figure 7.8 shows the KRA of 'C', which reflects the child's understanding of the instructions and the activity.

Figure 7.8 – four unlabelled symbols of an under-5-year old on the egg

Building instruction

'C' (together with 'N') was encouraged to use the BDP for representing ideas from 'picture-reading'. I also explained to 'C' and 'N' the sequence of the activity, draw - first and voice-record -second. How to voice-record was also explained to 'C' as, unlike 'A' and 'N', this was 'C's' first time with the voice-recorders. This is the dialogue transcript:

71.3 min	Glo:	… And now we are going to make the sounds for your drawings. You we have three drawings here. Do you wanna learn how to?
	Glo:	When you, we press [pushing recording function down with the pen pointer the read light is on], we talk and then we speak to it!... And to record we need to have the light [of the voice-recorder] on all the time, to hear what we say.
	Vrec:	Light on all the time to hear what we say
	Glo:	If we don't press it, if we don't have the light on , it [the voice-recorder] won't record anything
	Vrec:	Light on all the time
	Glo:	If we have the light on [by keeping the record button pressed], hello, hello, hello [recording]
	Vrec:	hello, hello, hello

Glo: So you try it now [talking to 'C']

Arrows were not introduced because we ran out of time for the same reasons as explained in the KRA results of the 4.6 year old. We spent the available time making drawings. I have no records of 'C' being familiar with the arrows or any BDP component.

Mapping the KRA

The child represented five drawings, but did not verbally-label them. In concept mapping terminology, the child represented zero concepts and zero propositions. I cannot arbitrarily assign meanings to the child's drawings. While I could assign a meaning to the drawing by analysing the dialogue transcript and selecting one to match it, however in my view, such symbols-dialogue matching cannot be justified if the researcher is unfamiliar with the child's intention when the drawing was created. In case study two, this issue of not knowing the intentions behind a drawing became more evident, when a child drew one thing and verbally-added a complete different meaning to it. This meaning had no visual relation with what the drawing was showing. This is where the importance of autonomous verbal-labelling lies in KRAs related to mapping.

Tracking idea generation

The five symbols that 'C' produced originate from 'picture-reading' and in autonomous book explorations during the KRA. During the 'picture-reading', the under-5 year old verbally expressed three concepts and eleven propositions (see Table 7.5).

Table 7.5 – list of concepts and propositions that an under-5-year old communicated verbally

Under-5 year old concepts and propositions about the pictures of the Egg book	
Concepts	**Propositions**
'Yes, a <u>crocodile</u>'	'Even when they are not adults they could bite' [referring to crocodiles]
	'It could be very hard to get up side down' [referring to the crocodile in the picture]
	'They carry them in their mouth' [the crocodile mummies carry baby crocodiles around in their

	mouth]
	'Yeah, because the crocodile is so big because it's an adult'
	'Yes, it is a frog'
	'Yeah, also frog, it can jump, it can jump'
	[the frogs] 'We can find them in our [inaudible] at home'
	'like in my garden, we find them' [referring to frogs]
	'And also, sometimes I've seen [inaudible]'
	'Oh, cause they sting' [answering the question: why are the call stingrays?]
	[stingrays] 'it does sting'
	'Yeah, like Easter bunny comes' [looking at Easter eggs]

The five symbols that 'C' drew are consistent with what that child planned to draw. When asked, 'do you remember lots of things of what you just saw?' [Meaning, what we just 'picture-read'], 'C' did not respond. When asked, 'what are you going to draw', 'C' said 'the snake and the crocodile'. Some time later, during the KRA, when asked to draw more ideas, the child expressed wanting to draw a 'cracked egg'. The cracked egg and the crocodile were drawn in the same card (see Figure 7.9).

Figure 7.9 – The book images (top) inspired the drawings of the under-5-year old (centre). The voice-recorders do not contain meanings because the child refused to label the drawings.

In tracking the origin of the ideas, I noted that the drawings of the snake and the crocodile were a result of the discussions between ‘C’ and myself, while the drawings of the hen and the rooster and the hen nesting originated from ‘C’s’ individual interactions with the book during the KRA. When the children were encouraged to draw more ideas, ‘C’ chose to go back to the book to find more ideas to draw.

Autonomous knowledge representation

Autonomously ‘C’ drew two symbols, a snake and a cracked egg, and coloured in the crocodile. The representation of these concepts can be also considered an achievement from the point of view of the child, considering that the child throughout the KRA expressed not knowing how to draw the ideas remembered from the book.

The concepts and propositions listed in Table 7.5 show that the child had conceptual knowledge, idiosyncratic and formal, to say about the book pictures. Similarly to ‘N‘, this child had some, or maybe many, ideas, but did not have the drawing skills to ‘off-load’ or externalise them. The drawing skills of ‘C’ were not as evolved as the drawing skills of ‘A’, and the ‘C’s’ willingness to try independent drawing was not as strong as ‘N’. Despite the fact that ‘C’ was not able to draw ideas s/he showed self-regulation skills when indicating what s/he wanted to illustrate from the book.

‘C’ declined to operate the voice-recorders, for no apparent reason, and declined to place the drawings on the magnetic whiteboard. When encouraged to try the voice-recorders the child stated, ‘I don’t wanna say anything’. It is not possible to assess what a child knows if that child is not willing to tell us. While the BDP was designed to facilitate such communication ‘C’s’ refusal to use the tool means that it is not possible to make any claims about the child’s knowledge acquisition. Neither should this be seen as evidence of the failure of the BDP as this was ‘C’s’ first interaction with the BDP components.

Teacher mediation

‘C’ asked for instructions on how to draw most of the ideas throughout the KRA, and all the time repeated not knowing how to draw them. I demonstrated how to make a crocodile and completed that drawing. I also drew the rooster and the hen, and the hen nesting. The child drew the snake and the cracked egg independently (see Figure 7.9). Such dependency on my help during KRA could be a result of the child's limited drawings skills, however, the two drawings created independently indicate that with training the child could develop the skill.

'C' barely responded to my motivational speech, 'let's make some drawings'. My reaction was to help the child with the drawings. This response was an issue for me in a number of ways. First, making drawings for children was completely opposite to the teacher/director's teaching philosophy. This mediation was highly intrusive, requiring me to take control of the child's KRA. Second, making the drawings at the child's request resulted in symbols that did not represent the child's ability and conceptual knowledge. Thus, I cannot claim that it was the child's knowledge that was made explicit.

'C' also declined to use the voice-recorder, perhaps because the instruction was confusing and was not understandable. In case study 2, some children also declined to use the voice-recorders, but they asked the teacher to operate them on their behalf (chapter 8). 'C' was not offered this option, as that teaching strategy had not been developed at that point.

Heavy teacher mediation, in the case of this KRA, did not allow for children's conceptual knowledge to become explicit. Some teachers of the online forum (FOD 2004a) and Mérida (2002) commented having experienced a similar situation when they directly intervened in the knowledge representation process of their students.

Throughout the KRA I prompted 'C' to draw ideas and explore the book again to help his/her memory. This prompting was repetitive and motivational and resulted in 'C' representing (with heavy mediation) two more drawings, the hen and the rooster, and the hen nesting. 'C' was not present when 'N' and I, 'picture-read' this book section. This suggests that, at some point and independently, 'C' did explore the book again, and it suggests that the 'C' assimilated the strategy proposed by 'N' and reinforced by me. One interpretation of this is that 'C' understood that a way to help himself/herself to remember what to draw was to review the book. Children of case study two also used this same strategy to help themselves remember. This is an example of self-regulation and the use of learning-how-to-learn skills. More on concept assimilation is explained in the chapter 9.

These results on heavy teacher mediation are further discussed in chapter 9, as there is teacher mediation that encourages autonomous learning and teacher mediation that makes children further dependant on teacher interaction.

The nature of the mental interactions

Active inquiry

Active inquiry, that is questioning and asking for clarification was evident during 'picture-reading'. If a comparison was made, 'C' was more knowledgeable about the topic covered in the 'Egg' book than 'N' or the teacher (see Table 7.3 and table Table 7.5). However, when it came to representing it with the BDP components the child performance was limited. The KRA of 'C' cannot be analysed as the drawings unwire not labelled, therefore, active inquiry based on the KRA did not occur.

Negotiating meanings with the teacher

Despite the heavy mediation meaning negotiation was still evident when 'C' and I worked on the drawings of the ideas s/he wanted me to draw.

Independent meaning negotiation

In the process of deciding how to draw the snake and the cracked egg the child had to negotiate meanings autonomously. The child had to decide how to make the drawings based on the mastered skills and understanding of book pictures. Tracking the evolution of a concept from generation to explicit representation, as I did with the KRA of 'A' and 'N', was not possible with the KRA of 'C'. This was due to the child's refusal to label the drawings. Figure 7.9 shows the book pictures that inspired the snake and the 'cracked egg' that 'C' drew.

Summary

In this chapter I presented the results of case study one that took place in an Australian urban preschool. I worked with the whole class of 25 children aged 3 to 5. The children interacted with the BDP during free-choice playtime for 6 sessions of

1½ hour each. The activities observed were undertaken in the classroom's natural setting. The ethics approval requirements of this research meant that this thesis could only report on nine children, who were aged 4 to 5.

The study goal was to identify if, and to what extent, children could independently make knowledge explicit with the BDP for preschool concept mapping (chapter 5). The children were invited to perform different knowledge representation activities (KRA). These KRAs were created with the BDP components and allowed the use of skills involved in concept mapping. The children's KRAs made their individual knowledge explicit. The activities that followed allowed me to map the content of these, which were: 1) verbally-labelling symbols that helped to distinguish concepts from propositions, and 2) identification of abstract concepts and what relationships were formed between concepts using linking phrases

During free playtime, the children worked with me individually and in small groups of two and three. The methods used in this study were participatory observation and informal conversations with the teacher/director of the school. The data collection techniques were: 1) anecdotal notes, 2) photos of the activity and activity product, and 3) audio recording (when possible).

Of the 9 children, three children used the BDP more than once and it is the KRAs of those three children which are reported in this chapter:

- The 5.6-year old, alias 'A', managed to produce two propositions independently following given instructions; created drawings, voice-recorded the meaning of the drawings, Velcro-ed the drawing to the voice-recorder to form verbally-labelled symbols, and linked these drawings using the arrows to represent organised knowledge.
- The 4.6-year old, alias 'N', managed to label three concepts; created two out of three drawings with no help and with my assistance created a third one, and then voice-recorded the meaning of the symbols, but time did not permit the use the arrows. However, the child identified the arrows.

- The under-5-years of age, alias ‘C’ created 5 drawings, two without help and three with my assistance, but did not add meanings with the voice-recorder. ‘C’ declined to use the voice-recorders.

Verbally-labelled symbols related to each other by the use of arrows made conceptual understanding explicit, showing 1) how this knowledge was organised in the thinking of ‘A’, and 2) that instruction is required for separating concepts and linking phrases. On the other hand the absence of arrow connections prevented understanding how the thinking of ‘N’ related the three concepts. Even more difficult, unlabelled symbols and the absence of arrows prevented understanding the meaning and the relations behind the 5 drawings of ‘C’. Thus, it is reasonable to claim that when a child was able to interact with all the BDP components knowledge was made explicit.

The difference in KRA output can be attributed to knowledge and instruction. Limited drawing skills was the main reason that ‘N’ and ‘C’ had difficulty ‘off-loading’ or representing ideas held in their memory. The outcomes demonstrate that the children were able to express more knowledge verbally than visually. A limitation of this study was my failure to recognise this as demonstrated by my promotion of drawing over the use of verbal communication.

The children’s stage of development was not considered as the reason for limited participation because they were able to verbally-express conceptual and propositional knowledge, and to assimilate concepts according to Ausubel’s theory and Novak’s anecdotes explaining how verbal communication reveals the way children acquire conceptual knowledge (see chapter 4). There were stages in the mapping activity in which children did not require drawings skills and could use self-regulation skills involved in learning-how-to-learn: planning and deciding what to draw, revisiting a book alone for aiding memory, and taking-turns at expressing what they knew about the pictures.

In this chapter I have documented three children’s use of the BDP. In the next chapter I present the results of case study two. Chapter 9 discusses the implications of the results presented in this chapter and the following one, for concept learning, knowledge representation, and instruction.

Chapter 8 – Case Study Two

Overview

This chapter reports on case study two. While case study two was different to case study one, it was also designed to observe teachers and children incorporating the BDP for preschool concept mapping into classroom activities. This chapter is divided in three main sections: preschool description, case study design, and results. Site selection and gaining entry were explained in chapter 6, and results of both case study one and case study two are discussed in chapter 9.

In case study two, a classroom of 5 to 6 year olds built group maps for a teacher-designed activity where their knowledge about big cats was evaluated. The BDP was repurposed to meet their needs. Novak's concept maps were not introduced, as teachers claimed to know another mapping strategy.

In this chapter, aspects of different activity stages are reported in the results section, showing evidence of the children's knowledge acquisition, autonomy at organising, and making that knowledge explicit with the BDP components. With the BDP labelled symbols disclosed conceptions and misconceptions, and facilitated knowledge categorisation and manipulation. Children could also revisit, edit and negotiate meanings alone, with peers and/or teacher, and knowledge could be shared.

The evidence shows that the BDP components put children in control over many aspects of the map building, transformed teachers into partners, transformed the classroom, and transformed mental interactions with the map content individually or collectively

Similarly to case study one, each child performed according to mastered representation skills and teacher instruction. In this case study, two unexpected outcomes were the level of involvement of an autistic child, and the first writing attempt of a 6-year-old.

Preschool description

Background

This is a university laboratory preschool, run by Carnegie Mellon University's Department of Psychology, in which it is possible to study children in the preschool age range. In this setting, the developmental psychology faculty test the theoretical models that they developed with the control and intensity demanded by the research protocols. The United States' National Academy of Early Childhood Programs, a division of the National Association for the Education of Young Children, accredits the programme of this preschool. They implement a thematic approach curriculum and classroom centres, where children are placed according to their age. There are four classroom types: the three-year-old preschool, the four-year old preschool, the kindergarten, and extended day. Chapter 6 includes an explanation of how this US-based preschool became one of my research sites.

Initial meeting

The preschool's director showed interest because, after reviewing the materials sent (chapter 6), she stated, 'I… can see some clear connections between your work and our school's philosophy, particularly in the area of our thematic units when some teachers already create webs as they are adding new concepts during circle time' (Personal communication).

This meeting was an opportunity to see the preschool and assess whether collaboration could be possible. I was given informative booklets about the school, including the teachers' guide and the parents' guide. The director and I explored the BDP, discussed the research goals, my research background, and observation options, and toured the school together.

Research familiarity

Since it is a laboratory school, the children were familiar with ongoing research activity. The director teaches at the Department of Psychology – Carnegie Mellon University and her undergraduate students regularly perform research activities in the preschool. Also, with the director's approval, students from other Universities can have access to perform research activities in the preschool. Ethics approval requirements for this current research were addressed in chapter 6.

Teacher involvement

Informing the teachers

The director showed my information package (chapter 6) to the Kindergarten teachers and discussed it with them. Based on this information, the teachers were to decide whether they would participate in the study. Their decision was based not only on their interest, but also on an assessment of the tool and its relevance to their teaching programme.

Pre-study meeting

Due to logistics, the director recommended working with the Kindergarten class, as these children spent longer at school than the others. The director and I then met with one of the Kindergarten teachers (alias teacher-B), to discuss how to incorporate the BDP into classroom activities. Teacher-B represented the group, the other Kindergarten teacher (alias teacher-A) did not participate in the meeting, as she had to stay with the class. In this meeting, which lasted around 30 minutes, teacher-B was briefly instructed on how to use the BDP. In turn, teacher-B was to instruct and explain the decisions taken to teacher-A. I did not meet teacher-A until the day of the activity. This was the only preparation meeting we had before the sessions.

Teachers' profile

Both teachers held bachelor degrees and certifications in Early Childhood. One of them held a Masters of Science Education. Between them, these two teachers had 35 years of teaching experience.

Children's profile

The class was comprised of 18 children, ages ranging from 5 to 6 years. Since a blanket consent form covered the children's participation, parents' individual consent was not needed. (See chapter 6 for more on ethics approvals).

All the children worked in a big open space, similar to the preschool classroom described in case study one (chapter 7). For organised activities, the children were divided into groups of between eight and 12. Each group was given an animal name, for example the Tigers, the Lions. The children who participated in case study two were all in the Tiger group or The Leopard group.

The Tigers were comprised of 8 children age 5.5 to 6 years. Three children in this group were 6 years old. The Leopards were comprised of 11 children age 5.3 to 6. One child was 5.3 and one was 6 years old. One of the Leopards was an autistic child, who was accompanied by an aid teacher. Similarly to study one, I did not record details about gender and ethnicity, as these details were not relevant to my study.

Prior knowledge about Novak's concept maps

The director and teacher-B expressed confidence in the children's ability to use the BDP components and to achieve my study goals. These teachers were unfamiliar with Novak's maps, but familiar with webbing, another mapping tool that was briefly introduced in chapter 2. In addition, teacher-B mentioned Knowledge Forum as a technique for doing mapping. She thought it had similar goals to the BDP.

For these reasons, both teachers were briefly instructed in Novak's tool, but were not encouraged to apply it. It was not possible to evaluate concept mapping, as training of teachers and children was not agreed to with the director. In addition, teachers were volunteering their time to evaluate the tool, so did not have time to learn about this tool. The inability of instructing teachers on the technique was not seen as a disadvantage. Instead, such limitation was seen as an opportunity to learn about more about the interests of my user community: the teachers' mapping strategies.

The study goals thus had to be shortened and reworked to the extent that the school participants wanted to be involved. There were other contributing factors to this decision: the ethics or IRB approval process at the host University took some time, school closed for national holidays, one of teachers had a conference travel schedule that overlapped with the programme, and I had my own tight schedule at the University.

Sessions Design

Goals

Similar to case study one, I sought to identify if and to what extent children could independently make knowledge explicit with the BDP for preschool concept mapping (chapter 5). Another goal of this session was to observe teachers and children using the BDP in the context of a classroom activity of their choice.

Planning

In contrast to study one, in this study the director and the teachers led the activity preparations. They took charge of the process by taking decisions about the BDP incorporation into classroom activities, the topics to be mapped, and classroom organisation.

Incorporation to classroom activities

Teacher-A and the director decided that the BDP would be used to evaluate concepts about big cats, which was the current thematic unit.

There were not enough voice-recorders for the whole class to work together, therefore, it was split into two groups: Tigers and Leopards. Teacher-A worked with Tigers. Teacher-B worked with Leopards.

Each group was to work with the BDP in activity time on one day (approx. 45 minutes), and the next day they were to present the completed map to the other group at the start of circle time (approx. 10 minutes).

Adaptations to BPD components

The BDP was re-purposed for working collectively. The director and teacher-B decided it was not possible to use any of the pre-constructed farm animals project (chapter 5). They thought the size of the cards was too small. The director suggested using post-its, making reference to the children and stating ‘they will destroy them too, so why bother’ using durable and expensive materials, as the children would probably discard these drawings immediately after the session. Based on her comment, I evolved the post-its idea to use blank construction paper, which aids manipulation better than post-its. The teachers were asked to provide the construction paper with which paper cards were made, small enough to fit children's hands, but two or three sizes bigger than the ones employed in study one.

The director and teacher-B reckoned that 20 voice-recorders (vrecorders) would not be enough, 'they will go through them pretty quickly'. Since there was not time to order more voice-recorders, I gave the children small pieces of sticky magnetic strips, for placing unlabelled drawings (symbols) on the whiteboard. The magnetic strips were place on the side of the board, for the children to help themselves.

In case study one, verbally-labelled symbols were made by Velcro-ing drawings to voice-recorders containing verbal meanings. In this case study, Velcro was not used for making these symbols. Instead, the symbols were created by holding the drawing against the whiteboard with its respective vrecorders. As explained in chapter 5, this was possible because magnetic backing was added to each vrecorder.

At my request, teachers incorporated some class materials: pens for operating the voice-recorders, and markers for drawing connecting arrows or adding titles. I provided two teamwork-sized magnetic whiteboards, which allowed several children to work on them at the time.

The paper arrows used in case study one were upgraded to colourful foam arrows, as the foam material afforded greater durability.

To enable children to complete the activities faster, to lower cognitive load, and to minimize distractions, I eliminated time-consuming tasks. Magnetic strips, the Velcro replacements, were pre-cut and placed on the whiteboard. In study one, 'Velcro-ing' was found a time-consuming task for children with poor fine motor skills. Also attaching and detaching Velcro pieces much too often could potentially destroy the drawings. The main goal of this activity set was for children to independently attach drawings to voice-recorders to make meanings explicit. Independent cutting of Velcro or magnetic strips was not crucial to the mapping activity.

The teacher and director had one major concern 'How to keep the maps?' I offered to take photos of the children's final concept maps, make videos of the activities, printouts with annotations for them to keep, and to implement a computer version of the maps. This computer version was created with Flash and placed on the computers of the teachers and the children.

The teachers were invited to incorporate any material considered necessary to do the activity. These materials are described later in the results section.

Observations

Observation methods used were participant and direct observations, informal conversations or meetings, and unstructured interviews.

Participant observations

In activity time I planned for direct observations, however, at teacher request, I switched to participant observation. At different stages of the activity, the teacher asked for my opinion, or for me to clarify the operation of a BDP component, or to help with material distribution, or to assist the children.

Direct observations

In circle time I performed direct observations from within the classroom because the space where circle time occurred was not visible from the observation window. I sat in an area away from the circle time activity.

Post-observation interviews and informal meeting

The teachers were interviewed for approximately 20 minutes each about their opinions on children's performance with the BDP. Their viewpoints added another perspective to my findings.

The two interviews took place after the last circle time and on the same day. 14 open-ended questions were prepared, based on notes taken throughout the week. Questions were asked in no particular order.

Data collection instruments

I created photographic records of both sessions and audiovisual records of activity time with the Leopards. The Tigers' session was not audio or video- recorded because the session was changed to an earlier date, which did not give me enough time to set up the equipment. Note-taking was related to informal conversations and observations, and occurred during conversations and after the observations.

Ending of observations

The relations with the preschool regarding the study lasted around 9 weeks and included: school familiarization, session planning with teachers and director, and activity execution. The interactions ended with a meeting where the director and I discussed her views on the results.

Transcriptions

The dialogues of the Leopards' video recording and the teachers' interviews were fully transcribed. Photos were also extracted from the video for analysis. Similarly to study one, I used aliases to identify study participants: T/CHER-A stands for Teacher-A, T/CHER-B stands for Teacher-B, vrec stands for voice-recorded spoken words, and Child represents any participant child whose activity was reported. When the dialogue is unclear [inaudible] is used and [undisclosed] is used when the information cannot be disclosed.

Results

Next I present the results of the concept mapping session of the Tigers and the Leopards. These results describe how teachers and children incorporated the BDP in the classroom in relation to building instruction, mapping, tracking idea generation, autonomous knowledge representation, teacher mediation, and the nature of the mental interactions. These same categories were used to describe the results of case study one (chapter 7).

Building instructions

Use of the tool was explained to teacher-B as follows; with this tool children were to draw their ideas about a particular topic, big cats in their case, on a small piece of paper, then verbally record the meaning of the drawing, and place the verbally-labelled symbol on the whiteboard. To form a verbally-labelled symbol, the child should attach the drawing to the vrecorder with the magnetised vrecorders or the magnetic strips. To show relationships between concepts, the child should use magnetised arrows or draw connections on the whiteboard with a marker.

Teachers carried out the building instructions in activity stages. They presented the topic, described what and how it would be done, introduced and delivered the materials to work with, encouraged individual performance and demonstrated achievement of tasks, revisited work with the children, and assisted them at request. A new activity stage was only presented when the previous one was largely completed. Despite working in the same classroom and with the same children, the teachers' individual instructional approach was quite different and reflected individual understanding of the researcher's instructions.

Teacher-A building instructions

Following the teacher's instruction, the Tigers drew their individual ideas first and voice-recorded meanings second. Wooden boards, pieces of construction paper and markers were handed to each child for drawing their ideas. When it came to verbally-label meanings of each drawing, teacher-A and myself operated the voice-recorders for the children. The Tigers did not learn to operate voice-recorders. Instead, they worked as follows: one by one, each child placed a voice-recorded meaning, and placed the magnetised vrecorder, next to their idea or ideas on the magnetic whiteboard. At teacher request, arrows were introduced, but neither the teacher nor the children used them to connect their ideas. I tried to explain how to organise the ideas using the foam arrows, and under themes (e.g. 'there are seven big cats', see Figure 8.1 – , number 1), but the explanation was not reinforced by the teacher. Consequently, such instruction was forgotten once the children started working with the voice-recorders. As a result or not re-enforcing this instruction, the children placed their labelled symbols in no particular order on the magnetic whiteboard.

The Tiger's original map (see Figure 8.1 –) was modified by the teacher so that the verbally-labelled and unlabelled symbols (ideas, thoughts) were hierarchically organised with connecting arrows (see Figure 8.2). The reasons for the teacher modifying the Tigers' maps are presented later in the chapter and also discussed in chapter 9.

Teacher-B building instructions

Teacher-B introduced the activity with a discussion, where the children were asked what they knew about big cats. Each child was asked to verbally express an idea. After this, teacher-B introduced the BDP materials one by one. First, the whiteboard, wooden boards, pieces of construction paper, and markers were introduced. With these materials at hand, the children started working on the drawing of the one idea discussed with the teacher. Second, once some children had finished an idea drawing, the voice-recorders were introduced. Teacher-B asked me to demonstrate and assist with voice-recording, as was done in the Tiger's session. However, on this occasion, since I was working with children one by one, I saw the opportunity to teach some of the children to voice-record autonomously. Children unable to operate the voice-recorders were assisted at request, by the teacher or by me. Third, finished drawings with voice-recorded meanings were placed on the magnetic whiteboard and children were encouraged to represent more ideas if they wanted to. After everyone had completed their verbally-labelled ideas and we had run out of voice-recorders, the teacher gathered the class together again, this time to review and categorise the ideas.

Mapping the content

In case study two, three concept maps were built, and their content is analysed in this section to see what kind of knowledge they make explicit. Each map has two versions. The first version was created by the children or with children's intervention, (see Figure 8.1 and Figure 8.5 respectively). Teacher-A alone built the second version of the Tigers' map by re-organising the children's labelled symbols.

As in study one, labelled symbols represent concepts or propositions: sometimes their label meaning matches the symbolic representation, other times it adds to the symbolic representation. Symbols were labelled with spoken language, emergent-writing or were teacher annotated. Symbolic representations are drawings again. Drawings can be schematic illustrations of a concept (e.g. tiger, lion, cheetah), an aspect of that concept (teeth, whiskers, fur, claws, tail, mane), or a description of their habitat (e.g. the savannah, tall trees, mountain). Linking phrases are included in the propositions. Some children drew a concept and the verbal meaning was a proposition such as C1 in Figure 8.1, where the drawing represents a jaguar and its verbal label says, 'jaguars have a spot, a little spot in the middle'.

Labelled-symbols made explicit less idiosyncratic knowledge than that of the children in study one, probably because in case study two qualified teachers were accompanying the representation process and made sure that the children used appropriate vocabulary. Teacher-A commented that 'the kids were able to use the right words, use the correct vocabulary [inaudible]… kind of was a good evaluating tool for the teacher to use.'

The maps of Figure 8.1 and Figure 8.5 give evidence of children's concept assimilation of facts about big cats, and make explicit individual and collective knowledge acquisition. The maps lack explicit relationships among the concepts as children were not instructed in arrow usage, for reasons explained later. However, such an outcome was expected, as the teachers did not use Novak's concept mapping technique. Nevertheless, the absence of arrows did not affect their ability to organise the labelled symbols into meaningful categories, either hierarchically or thematically.

The three subsections following are dedicated to the built maps. For content analysis, these were annotated and divided into sections. Capital letters identify each section.

Tigers' original finished map

The map was built with 29 labelled symbols representing ideas about big cats. 7 children represented 28 ideas and I (the researcher) represented one idea (verbal label #1: 'there are seven big cats') when demonstrating voice-recorders. Each child created one labelled symbol at least. However, it is possible to say that some children represented two or more ideas, because their names are written on the cards.

6 labelled symbols represent concepts and were labelled with drawings and emergent writing, see 'A', 'B', 'Za', 'F', 'C2', 'I'. The children alone created this symbol.

17 labelled symbols represent propositions, of which:

12 propositions were verbally labelled by the children, see 'G', 'M', 'N', 'P', 'S', 'U', 'W', 'D', 'E'

3 propositions were verbally –labelled by the children and annotated by the teacher see 'C_1', 'K', 'X'

5 propositions were labelled with emergent writing by the children ('R', 'T', 'V', 'Y', 'Z_b'), and 1 was teacher-annotated ('Q').

4 complex ideas were represented by the children and annotated by the teacher, see 'H', 'J', 'L', and 'O'. Complex ideas were built with propositions and concepts representing different aspects of a more inclusive concept.

Most labelled symbols clearly represent one conceptual or propositional idea, including those symbols whose emergent writing was somewhat unclear (e.g. 'G', 'P', 'T', 'Z_b'), or at the verge of becoming unreadable (e.g. 'O', 'N'). Unreadable emergent writing was only possible to interpret if it was accompanied by a verbal-label (e.g. 'J' and 'O'), in contrast to the writing that did not have a verbal-label (e.g. 'Y' and 'V').

The propositions 'V' and 'Y' are unidentifiable because the emergent writing is unreadable and the drawing of 'Y' does not show any identifiable feature allowing interpretation of the knowledge represented. 'Z_b' represents an incomplete proposition 'cat clos go in and' (the word 'clos' was written with an inverted letter 's'). The child tried to represent a proposition that was also represented by two other children, see 'G' and 'O'.

The representation of complex ideas is the result of little instruction on idea organisation for representation. Nevertheless, the representation of complex ideas shows how children used visual, spoken and written language to represent different propositions of a same concept on the same paper card. 'H', 'J', 'L', 'O' are the four complex ideas represented in the Tiger's original map. Figure 8.1 shows these ideas in context and Figure 8.2 provides a close up of each of them for perusal. The following section analyses one of these.

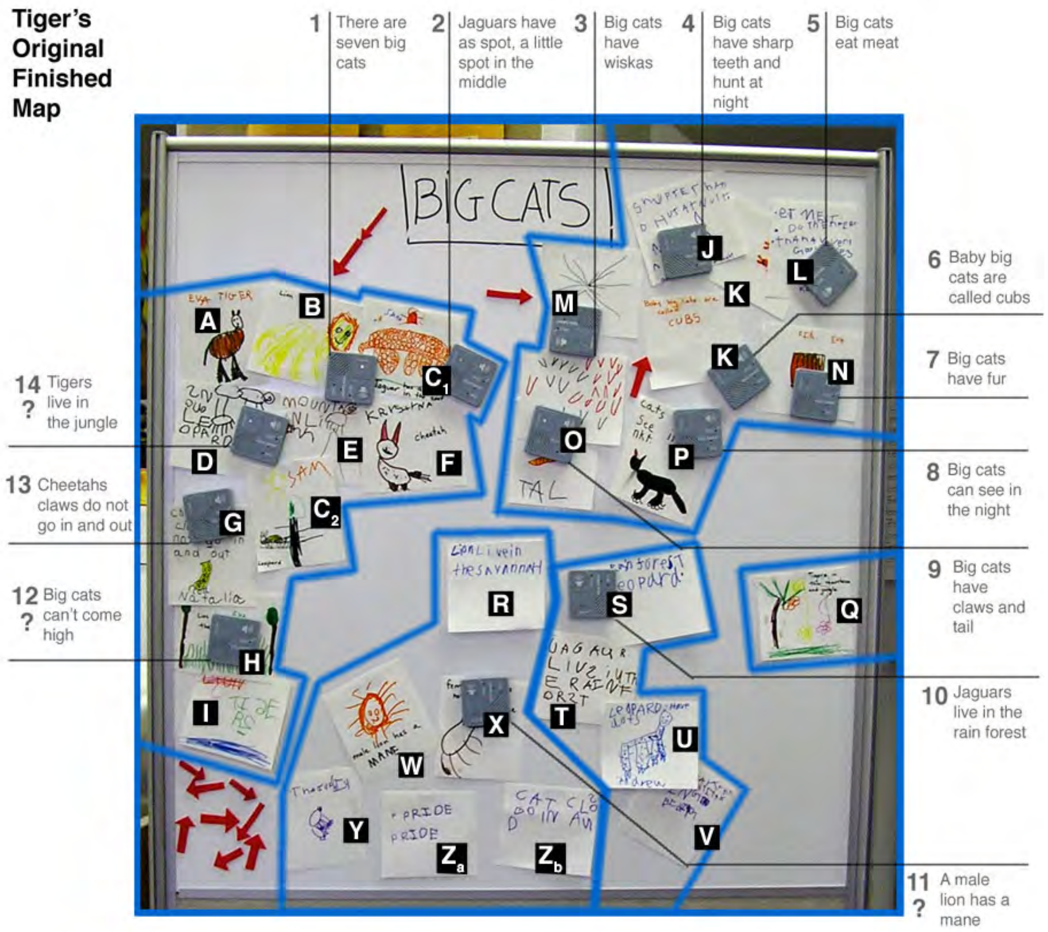


Figure 8.1 – original completed map of the Tigers (black-boxed letters are not part of the map)

Complex idea ‘L’ comprises six propositions. One proposition was verbally-labelled ‘Big cats eat meat’. The other five were represented with emergent writing in one paper card: ‘[proposition one] et meyt, [proposition two] do th enpero, [proposition 3] tha hav very good eyes, and [proposition four] th can run fast and [proposition 5] i the can klim’. In this case, the child represented five ideas about big cats with emergent writing. The verbal label assigned to them is what contextualises these propositions and makes their meaning explicit. Without the verbal label, we would not know what the child was referring to, as the child forgot to include the word ‘big cats’ at the beginning of the list created with emergent writing on the paper card. In the case of this complex idea, the verbal and written labels complete each other and tell us that the child knew 5 propositions about big cats. Four propositions are interpretable (big cats eat meat, they have very good eyes, they can run fast and they can climb), one is not ‘do th enpero’.

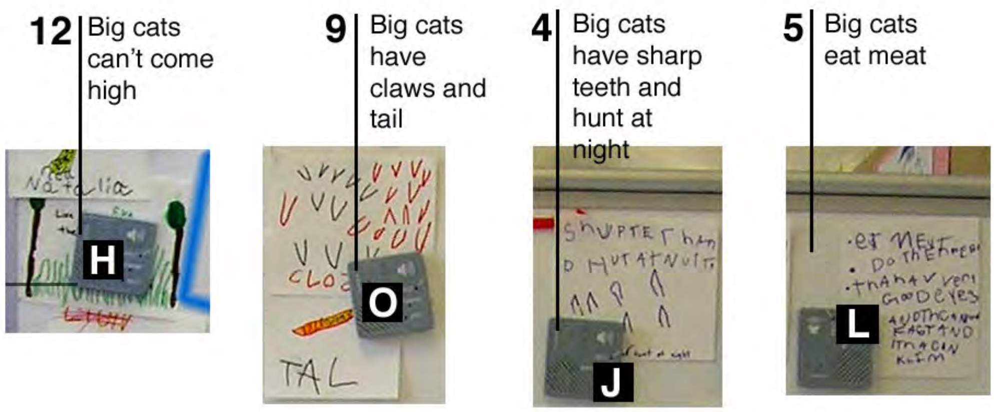


Figure 8.2 – complex ideas represented with verbal, visual and written language

Labelled symbols enabled identification of 10 conceptions, 4 misconceptions, and 2 unidentifiable ideas. These can also be called valid, invalid, and nonsensical propositions respectively, according to Novak’s classification (see chapter 1). Misconceptions, unidentifiable propositions, and representation of incomplete knowledge show limited writing skills or lack of attention to the building process. Misconceptions originated because drawings did not match the verbal-label assigned to them, see ‘D’, ‘E’ and ‘S’. For instance, the labelled symbol ‘S’ is comprised of two propositions, which cannot be organised thematically. We do not know if they should be placed under the concept 'leopard' or 'jaguar'. The verbal-label reads 'jaguars live in the forest' and the emergent-writing label reads 'rain forest leopard'. The concept 'rain forest' is the concept common to both representations. 'Rain forest leopard' is a nonsensical proposition, because it is missing the verb. This labelled symbol shows that the child had two ideas in the head that were not clearly externalized, so that incomplete knowledge was represented, and consequently the child's meaning was not clearly made explicit. We are left to wonder: perhaps both jaguars and leopards live in the forest or the jaguar lives in the forest and the leopard does not live in the forest.

A case of lack of attention or reflective thinking was made explicit in the labelled symbol 'X'. The child mistakenly related the verbal label 'a male lion has a mane' to the drawing of a female lion with a teacher-annotation 'female lion[s] do not have a mane'. The child's drawing shows conceptual assimilation of the difference between a male and a female lion: the female was illustrated without a mane.

Tigers' modified finished map

The labelled and unlabelled symbols of the Tigers' original map were hierarchically organised with connecting arrows using some of the rules for concept mapping (see Figure 8.3). Teacher-A modified the Tigers' map for presentation, under the claim that this would enhance understanding. The Tigers' original map looked messy, and some drawings were hidden behind the voice-recorders. Also, the grouping did not show a coherent pattern of meaning (see Figure 8.1).

The modified map represents teacher-A's understanding of concept mapping, achieved through two brief instructional encounters with teacher-B and me. As explained earlier, teacher-A could not be instructed. However, while we worked with the children, I demonstrated the use of arrows and voice-recorders, and after the session I provided clarification of concepts regarding connecting concepts with arrows and organising them hierarchically.

By herself and prior to circle time, teacher-A re-organised the drawings and the labels of the map using one of the rules for concept mapping: built hierarchical organisation of concepts and propositions using arrows. This map represents teacher-A's conceptual understanding of how the students' facts should be related. To build it, teacher-A organised the labelled symbols in 4 hierarchical groupings, from the more inclusive idea to the more specific ideas. Level 1 are facts common to all big cats, level 2 are kinds of big cats, level 3 are facts related to where they live, and level 4 are particularities of each big cat. Level 1 represents the more inclusive ideas. Levels 2, 3 and 4 represent more specific ideas in the order of a hierarchical relevance given by the teacher.

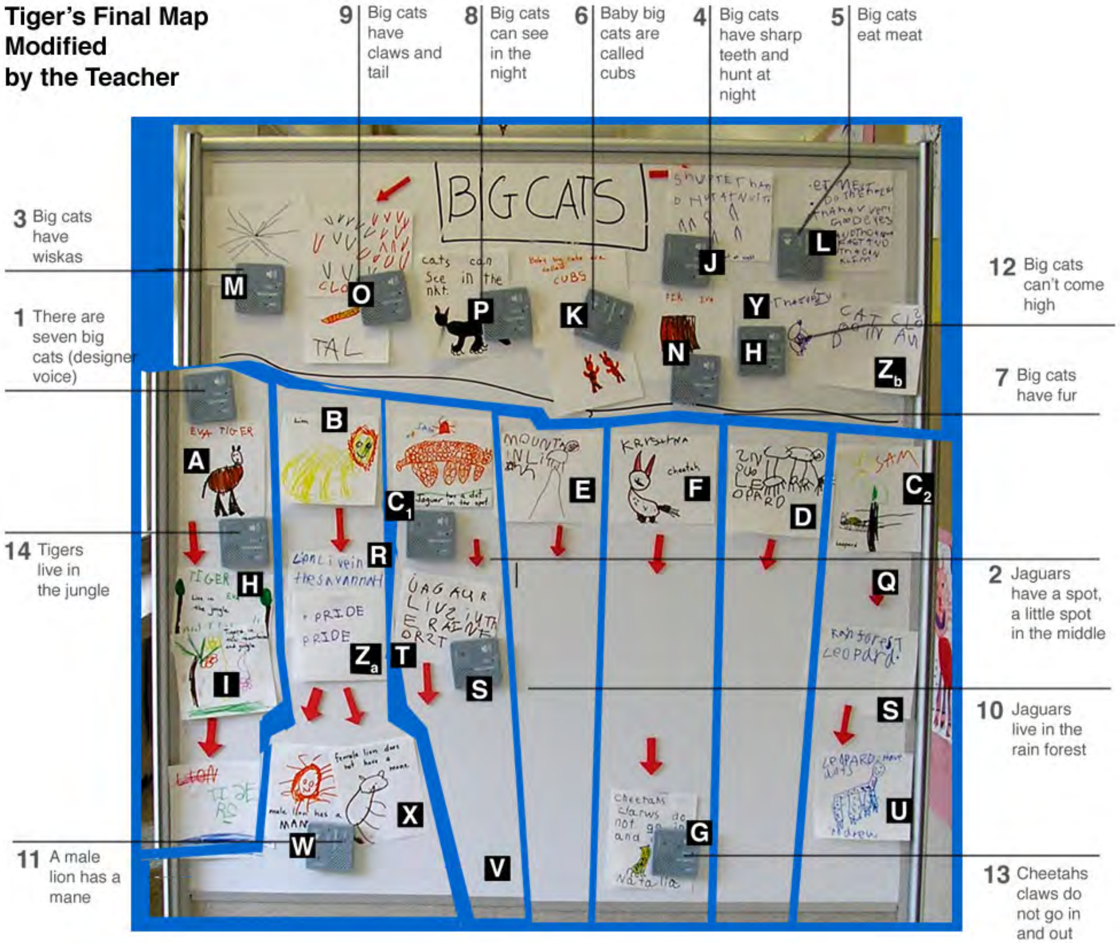


Figure 8.3 – modified completed map of the Tigers (black-boxed letters are not part of the map)

The teacher mainly modified the arrangement of labelled symbols. When comparing the two maps, the original and the modified, it is clear that when the children labelled their ideas correctly by relating the verbal label to its correspondent symbol, teacher-A did not 'play around' with the meanings. The teacher only separated verbal labels from drawings when the symbols were not clearly labelled or understandable, or the children represented misconceptions. When any of the described situations occurred, the teacher separated the drawings and the verbal labels and re-assigned them to others. This finding shows that labelled symbols, despite the language used to represent them, enabled the teacher to make valid conceptual relationships, which then enabled her to create thematic groupings.

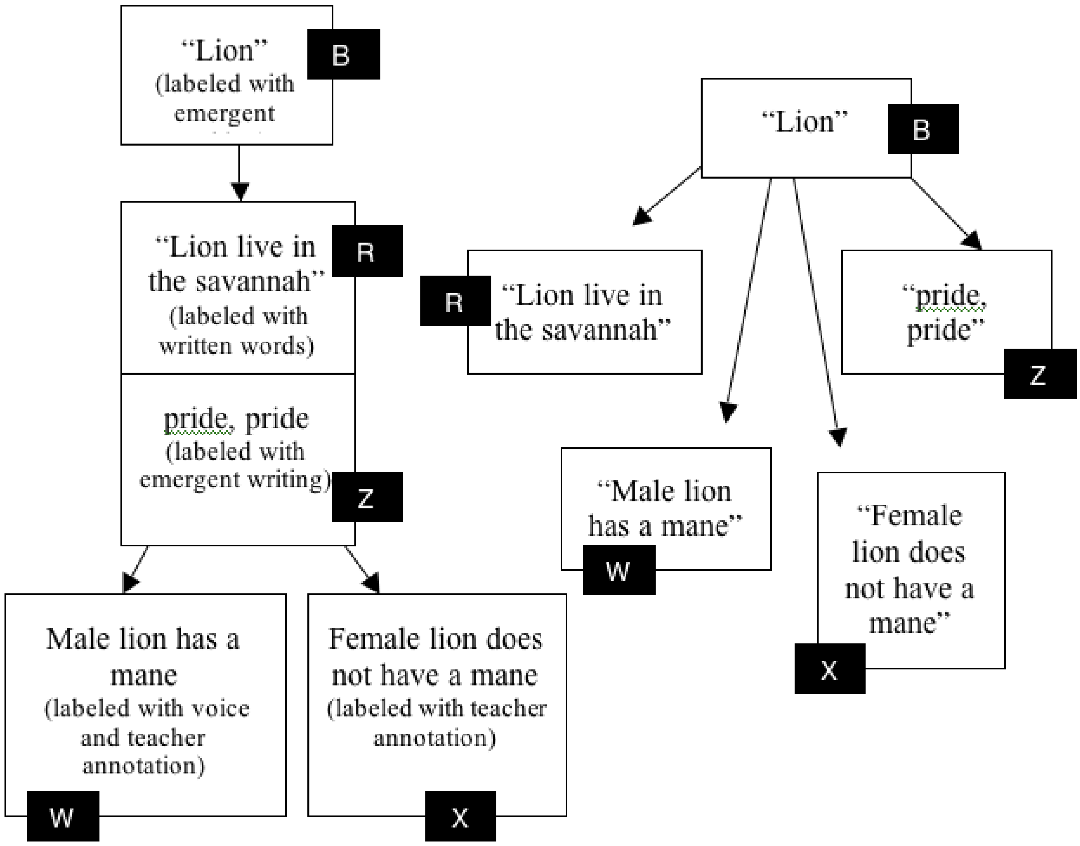


Figure 8.4 – a) left: a set of propositions about the lion taken from the Tigers' modified finished map, b) right: the same set of propositions modified for enhancing understanding

There is only one situation where the teacher modified propositional meanings to create a new one. A child created the verbally-labelled symbol using a verbal label 'big cats can't come high(?)' and a drawing that represents tall trees, grass and the sun, see Figure 8.1, 'H'. The child wrote the word 'tiger' on the paper card, instead of drawing a big cat. Teacher-A discarded the child's reasoning and used each of the symbol elements to create new meanings with other symbols: the verbal-label was used to create a new proposition with somebody else's drawing. This is the reason why there are two letters 'H' in the map. In the modified map, the drawing 'H' was placed in the column of concepts about the tiger and the verbal label was related to unlabelled and unidentifiable symbol 'Y' and placed with the ideas common to big cats (see Figure 8.3).

Either because there was little instruction or because there was not enough space on the whiteboard, the relationships between labelled symbols were poorly constructed. This building issue is visible in the propositional arrangement in Figure 8.4a. This is the map branch explaining the features of lions in the Tigers' modified map. According to concept mapping, this propositional arrangement has very little sense. A more logical arrangement can be constructed with the same elements by making sure that all the secondary labels are directly related to the concept they are referring too (see Figure 8.4b.). Webs of knowledge diagrams look like this arrangement, which means that, with instruction, children could independently represent webs of knowledge with the BDP for preschool concept mapping, as all the elements for doing so are present. The BDP was designed for this purpose too (chapter 5).

The analysis of both versions of the Tigers' map was only possible because of the labelled symbols. The original map made by the Tigers (Figure 8.1) is a representation of the children's understanding of the instruction. It was built with concepts and propositions representing unrelated factual knowledge about big cats that the children had assimilated into their cognitive structure. In the words of teacher-A, with the map elaborated with this tool 'from my point of view… I could see [what] they learnt from the previous weeks'. This map shows that the BDP enables 5-year olds to independently make complex or simple knowledge explicit because abstract concepts and linking phrases can be included verbally or with emergent writing. A consequence of this ability is that a child can represent complex ideas describing different aspects of the same concept with voice, emergent writing and drawing. However, they need instruction so that such ideas are constructed free of misconceptions or misinterpretation or teacher 'free' manipulation.

The Tigers' modified map (Figure 8.3) does not represent children's understanding of how the verbally-labelled symbols should be related. Instead, it represents teacher-A's understanding of how these symbols should be organised and based on what she understood during the brief concept mapping instruction that was provided. The BDP components enabled this teacher to flexibly manipulate the children's labelled symbols and re-arrange them hierarchically into meaningful relationships by using arrow connections. However, to access children understanding of the relationships between those symbols, children should be instructed to perform the same process by themselves.

Leopards' finished map

11 children built a map comprised of 19 verbally labelled symbols or propositions about big cats:

- 10 propositions were created with a drawing and voice.
- 7 propositions were created with drawings, voice, and emergent writing. The verbal label and the drawing of two of these propositions complement each other. They only make sense if these two halves are placed together.
- 3 propositions were created with emergent writing and voice.
- Complex ideas like those occurring in the Tigers' map were not created, probably due to the building instructions: the children were to work on one idea at a time, which was also discussed with the teacher.

In contrast to teacher-A, teacher-B organised the map together with the children. This was the last stage of the Leopards' activity. Teacher-B led the mapping process and used clustering to organise the children's propositions. The clustering strategy is often used in preschools, as an approach for organising knowledge thematically (chapter 4). Using this strategy the 19 propositions were organised in seven groups according to the verbal label the children gave to the drawing. Figure 8.5 shows the map with highlighted groupings and labelled with letters to facilitate identification during the analysis. Group 'A' includes concepts and propositions representing features common to all big cats. Groups 'B' to 'G' include concepts and propositions representing features particular to one particular kind of six big cats: lions, cheetahs, tiger, jaguars, leopards, or snow leopards. Arrows were not introduced in this activity. The reasons for this are explained later.

Verbal labels made evident peer influence and knowledge sharing. The same verbal label 'big cats hunt at night' was assigned to 3 different drawings, #2, #4 and #5. The same situation applied to the proposition 'claws go in and out', but the difference lies in the language employed. One child used drawing, #17, and the other child used emergent writing, #14. Despite copying each other's ideas, the children's individuality in labelling becomes clear in their drawings.

Two drawings can represent the same concept, but can be assigned different verbal meanings. The drawings of #1 and #5, Figure 8.5, depict a tiger. The verbal labels, however, refer to generic ideas about big cats, #1 'big cats have teeth' and # 5 'big cats hunt at night'.

Two children represented the same proposition with different language, which reflects prior knowledge. One child used idiosyncratic knowledge, verbally-labelled symbols #3, and the other one used formal knowledge, verbally-labelled symbol #6, to represent the concept 'paws'. The child who drew #3 did not know the formal label for the lower extremities of big cats, therefore, used the label for naming the lower extremities of humans: 'feet'. The schematic illustration is also a human like foot. The child who drew #6 did know the formal label 'paws' or its representational meaning, but did know the conceptual meaning, and to explain it, the child used prior knowledge. This example is in the same category as the concept 'underbrella' that Novak used to explain how young children incorporate knowledge into their cognitive structure (see chapters 1 and 4). In concept mapping instruction, this representation of knowledge can be used for discussing the meaning of the concept 'paws' and 'feet'.

Labelled symbols also made explicit the fact that general and specific concepts are not clear in children's thinking. Some children assigned general features common to all big cats to one kind of big cat. For instance, proposition #7 'cheetahs have paws' and #10 'leopards have paws' refer to the concept 'paws' again, but this time they have only been assigned to the concepts 'cheetah' and 'leopard'. Drawings also demonstrate this. On one occasion the drawing shows a particular big cat and the label meaning refers to all big cats (see proposition #2.) What this means is that child owners of these propositions have not yet generalized the concept to all big cats.

Concept mapping instruction with the BDP components could assist these children to refine symbol labelling, the representation of their thinking, and make better conceptual generalizations. Children would be asked to organise knowledge by representing different concepts separately to make them more explicit.

Verbally-labelled symbols made possible the process of analysing the Leopards' map. Even when the drawing was not available, as in the case of proposition #9 'cheetahs claws [inaudible] out', verbal-labels make knowledge explicit and enable categorization and discussion about its content. There were no misconceptions about knowledge in the Leopards' map, probably because the ideas were discussed with the teacher at the beginning of the activity, concepts were clarified and valid propositions were encouraged using demonstration and repetition strategies to avoid mistaken representations.

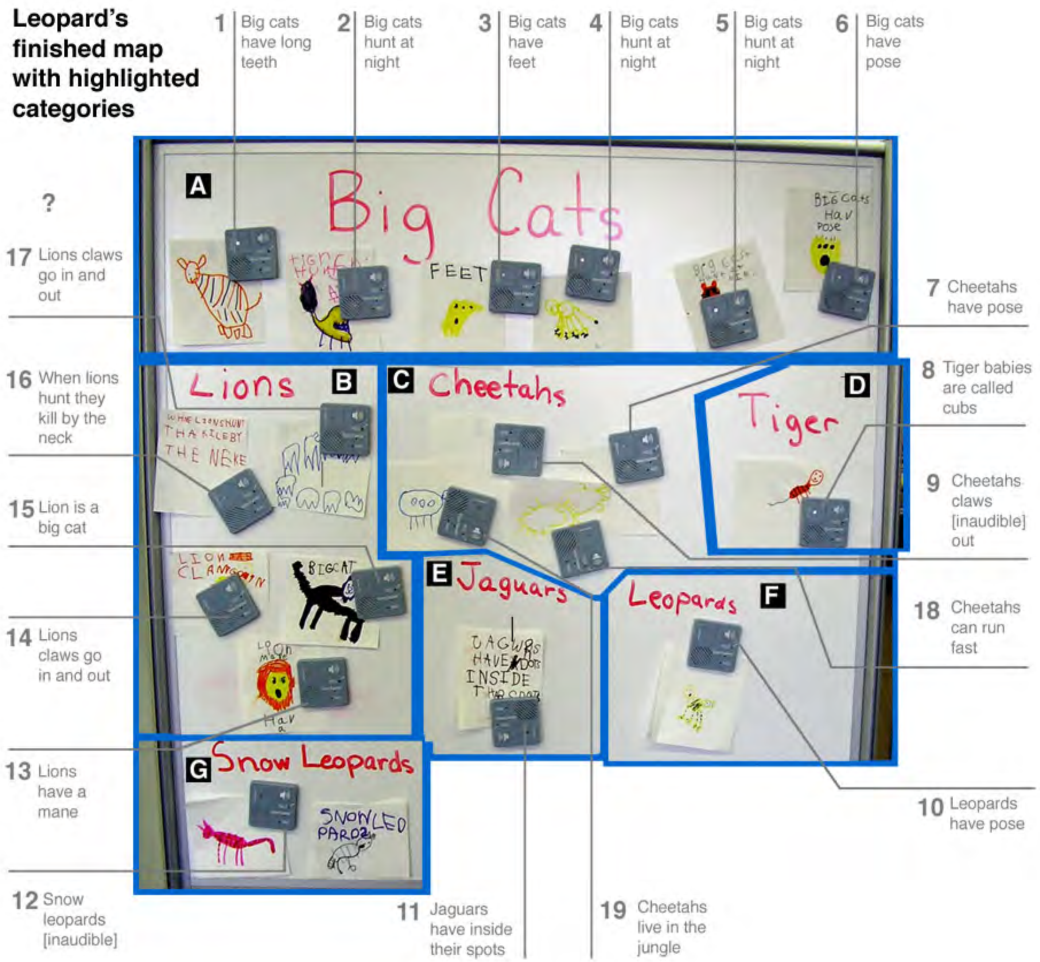


Figure 8.5 – completed map of the Leopards

Tracking idea generation

Teacher-A and teacher-B guided the children through idea generation. The concepts and propositions represented in the maps originated in the children's memory and were products of peer influence or reading a book on the topic or of group discussions. In contrast to case study one, it is not possible to determine the exact origin of most of the ideas, apart from a few. For example, the 'lion live in the savannah' is the product of book reading, said Teacher-A. The same applies to 'leopards have dots' (Figure 8.6).

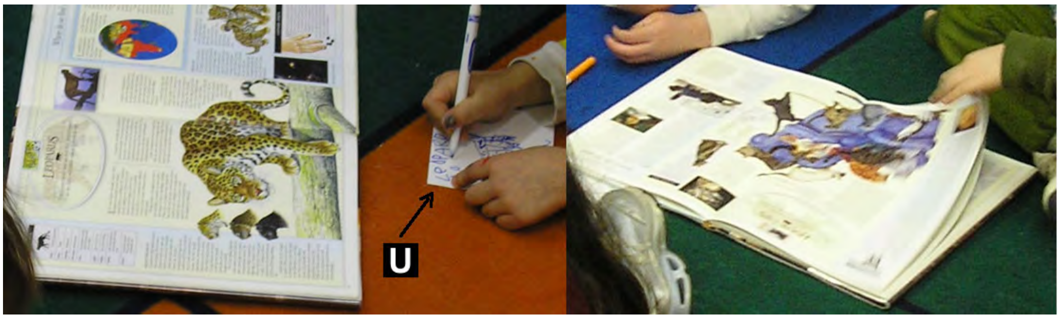


Figure 8.6 – book 'reading' inspired generation of some conceptual ideas

Autonomous knowledge representation

Every child represented at least one concept or proposition autonomously. A few children in the Tigers' group signed their names on the drawings, while photographic evidence shows a few children in the Leopards' holding two voice-recorders and two paper-cards in their hands. Transcripts also made evident that one child drew the two ideas about snow leopards.

Again in contrast to study one, children were not able to self-regulate the complete process of building the map. They were only allowed to self-regulate drawing and verbal labelling, and content reviewing. Teachers mediated the other aspects of the building process, such as organisation of labelled symbols into meaningful groupings. In the next section, I present some outcomes of having children to independently work with the BDP components during a concept mapping activity.

Verbal labelling

As predicted by the director and teacher-B in the pre-study meeting, children who mastered voice-recording, learnt to use them rather quickly. They took control of every aspect of drawing labelling. For instance, the child of Figure 8.7 is voice-recording ‘cheetahs hunt at night’. This process involved vrecording, reviewing (listening to), and editing of what has been recorded, and was performed until a satisfactory vrecording of the verbal meaning was achieved. Such a process enhanced the children’s’ ability to disclose thoughts, as teacher-B noted, ‘it is hard for them to get their thoughts down in writing’.

Figure 8.7 – the verbally-labelled symbol ‘big cats hunt at night’ was first verbally-labelled ‘cheetahs hunt at night’. The child performed this process by herself

When interviewed, teacher-A said, ‘They were able to independently do that, you know, by the end they were pushing their own buttons. It was very simple for them to use.’ Teacher-B said, that once they were shown ‘…how they could do it on their own, that was very simple to use it, I think that was really good, good tool.’

Some children vrecorded meanings by themselves, others did so with assistance. The children liked the voice-recorders a lot. When teacher-B asked the Leopards what they liked about the voice-recorders, five children raised their hands and two children, who were given permission to talk, said that they liked them because 'they can repeat your words' and 'I like them too' respectively.

Symbol organisation

Symbol labelling was the only opportunity for children to autonomously organise knowledge. Labelling revealed singularities in the children's representations that otherwise would not be noticeable, such as the ability to represent an idea or several aspects of the same idea using three languages (voice, drawing and emergent writing). On the other hand, labelling also revealed that children experienced trouble organising knowledge for representation. On this teacher-A said, 'There was a lot of kids say would say I don't know how to write(?) and some of them were just writing, writing, writing and we couldn't figure out what they said at the end. But still they were able to put their thoughts down into some kind of words.'

Teacher mediation

Teachers attended to children's various needs throughout the activity, guided the process of generating, drawing and labelling an idea, monitored that each child had the materials to work with, and checked that completion of required tasks. Heavy teacher mediation was provided with unfamiliar activities such as voice-recording and arrow use. Teacher-A annotated children's drawings. Assistance to individual children was provided at request or at teachers' leisure.

Organised knowledge

As explained in the mapping section, teacher-A and teacher-B organised the children's labelled symbols hierarchically and in thematic groups. The Tigers did not participate in this process while the Leopards did. Children were present during the process, but they were not consulted either in the labelling of groupings or the symbol classifications.

Guiding idea generation

Teachers supported children in the process of narrowing down ideas for labelling by asking questions, prompting them to work on one idea at a time, helping them to choose drawing labels, and supporting thinking so they could access their ideas.

As a rule, Teacher-B constantly reminded the children to draw one idea on one piece of paper and then add the verbal meaning with vrecorders. If they finished with the representation of this idea and had another idea to say, they were instructed to request another paper card. Children asked teacher-B for suggestions on how to draw aspects of an idea, or on what to say about the idea, or on how to operate the voice-recorders.

Helping remembering

Teachers used repetition and/or enaction as strategies for helping remembering. The goals of activity stages were explained in different ways to increase understanding and avoid forgetfulness. To help children hold an idea in their head, for instance, teacher-B used enacting to trigger children's memories about characteristics of big cats.

Figure 8.8 – the teacher is enacting that big cats have whiskers, claws, and fur

Verbal labelling aided children's remembering because children could revisit the labelled symbols at discretion and with the teacher. To organise symbols thematically, teacher-B pushed the vrecorder button and spoke the meaning aloud to clarify. Each labelled symbol was repeated at least once.

Annotating drawings

To disclose drawing meanings, teacher-A annotated some children's drawings. One apparent reason for this was to use annotations as cues for voice-recording meanings. Some children voice-recorded the teacher's annotation. Teacher-A operated the vrecorder while children read the annotation of the paper card. Annotations were not always vrecorded to the letter. Symbol C_1, Figure 8.1, was annotated with 'jaguar has a dot in the spot', but the child's verbal label was 'jaguars have a spot, a little spot in the middle'. Teacher annotation and verbal label are quite different.

Operating voice-recorders

Teacher-A always operated the voice-recorders for the children. Teacher-B assisted children at individual requests, such as when a few children failed to learn, or could not get all the words into the device because of operational issues or because of the novelty of the activity. The transcript below describes teacher-B operating a voice-recorder while explaining to the child how it works:

T/CHER-B: when it turns red [inaudible]

Child: Snow leopards live in the cold

[Teacher-B prompts her to do it again]

T/CHER-B: when it gets reds

Child: Snow leopards live in the cold

To check that all the words had been recorded, teacher-B played the vrecorder back for the child to listen. The child smiled at listening to her own voice and teacher-B smiled. Teacher-B commented on the difficulty this child had in voice-recording by herself:

> [The child] is very very shy and… uncomfortable with the newness of the person in the classroom... She was very uncomfortable speaking into the recording device. I had to actually put her onto my lap and I did it first. I said what she said. She was very afraid, of trying it. She did it eventually, however, she is just fearful. After many experience she could be fine, it was just the newness of the tool that, you know, she did not know what was going to happen… but… it depends specifically on the child…

Using arrows

In case study one, the 5.6 year old connected verbally-labelled symbols with arrows after instruction. In case study two, teachers beliefs and forgetfulness contributed to the lack of instructions to children in arrow use. This was despite the fact that children recognised the arrow symbols and that I was asked to demonstrate them. Consequently, the teachers heavily mediated the use of arrows.

In my view, teacher-A modified the tigers' map to include arrows in order to meet the activity goals. However, when I asked, I learnt that teacher-A associated the way arrows were used in this mapping activity with the concept of orientation that is applied to written language. She thought that children would not get an understanding of the concept of orientation until second grade, no matter if they were exposed to arrow use regularly:

> They didn't get the arrows yet. Because in their world orientation doesn't matter… even when the children are writing, they sometimes write backwards… it doesn't matter to them... They flip letters constantly. They write the names completely backwards...

Teacher-A was not sure if the children would understand her explanation about arrows, but in addition, she just did not think they needed to use arrows yet because 'they are not making those categories yet'. When it came to making categorizations, teachers mediated the process but it was hard to know if the children understood. At that time, and with teacher support, children organised knowledge using colour cues, 'arrows are much more abstract for them'.

> ...you can keep trying arrows and see. It helps for a teacher and even when we did our bulletin board that was over there, and we had different colours where the lion was on a certain colour and the tiger was on a certain colour and I guess that helped them. But I was definitely the one that said to do that. You know they never...

Teacher-B only included arrows until Leopards' circle time. When asked why she had not used arrows, the teacher said, 'yes, we know what arrows are, they are for telling the direction they can go. The reason why we didn't use them is because I couldn't find them.' After this answer, the teacher tried adding arrows to the map, but there was not much space left on the whiteboard. When interviewed and asked if the concept 'arrow' was unfamiliar to the children, the following comments were provided:

> No, we actually, [I don't know if](?) you can see on the playground, they are used to arrows pointing directions to things. The arrows on the playground out there show the direction that they can ride the bikes, they are used to arrows, we used them, umm, [for life?](?) things on the computer, sometimes there is an arrow that shows which direction a [inaudible] goes. They're definitely used to seeing arrows and have an understanding that they are a directional tool.

Children liked the colourful foam arrows and talked about them on several occasions. Some of the children in case study one were similarly interested in the arrows, but did not have the opportunity to use them. For example, the 4.6 year old in case study one (chapter 7) also recognised the arrows, but we did not get to use them. In the last circle time when teacher-B asked the class what was different between the maps, one child noted that 'we didn't use the arrows', referring to the Leopard's map.

From the conversations held with the teachers, it can be concluded that these children were familiar with instances of the concept arrow in three contexts, writing, the playground, and the computer, and they understand that they were a directional tool.

The instruction provided to the 5.6 year old in case study one (chapter 7) shows that children of this age can quickly learn how to use arrows for showing reading orientation of verbally-labelled symbols. In chapter 9, the results of arrow use of both studies and implications for concept mapping are discussed.

Researcher's mediation

In both sessions, I demonstrated the operation of unfamiliar BDP components, voice-recorders and magnetic strips, and answered teacher questions in relation to these. In the Tigers' session, I titled the map, demonstrated how to label symbols with voice-recorders, and making relationships with arrows. In the Leopards' session, I taught children to voice-record, assisted with voice-recording at teacher request, and placed verbally-labelled symbols on the magnetic whiteboard. If I introduced a confusing word or unfamiliar concept, the teachers immediately provided a clearer explanation.

My mediation with BDP components did not last long because both the children and the teachers learnt to operate them quickly. For instance, once I showed a few children how to voice-record and attach magnetic strips to drawings, these children taught peers to do it. Teachers also learnt to voice-record and took control of teaching the children who required assistance with it.

The nature of the mental interactions while mapping

The BDP for preschool concept mapping transformed the way the user community, teachers and children, interacted with the mapped content individually and collectively. It enhanced children's autonomy during knowledge representation, manipulation, and revisiting. Such autonomy, in turn, liberated teachers, transforming their facilitation from intensive intervention at symbol labelling to supporting the children's own labelling process. Also the BDP promoted peer-mediation, active learning (e.g. motivated one child to write for the very first time), as well as knowledge retention, sharing, and preservation. This section further discus the results described here.

Transforming classroom interactions

Figure 8.9 several children working independently on different aspects of the map, placing objects on the whiteboard, voice-recording, drawing, peeling off sticky magnets, and revisiting verbally-labelled symbols. Autonomy at map building enabled group members to perform activities at their own pace, and increased collaborative interactions among peers and between teachers and students. Children's autonomy transformed teachers' roles. Teacher-B said, 'the teacher who becomes a partner, it's like, what we are seen it…' and she added, 'once I was able to step back, it was really fun to watch how everyone was helping each other.'

Figure 8.9 – children interacting autonomously on different aspects of the construction of the map

Active inquiry and learning

As a consequence of the ability to interact autonomously with the BDP components, the children became more focused and engaged in every aspect of the activity where they were active participants. Revisiting the finished map enabled discussions and commentaries about drawings, voice-recorded meanings, and similarities and differences between the maps. These will be presented later in this section. These activities demonstrate that the mental interactions with the map in-progress or completed were not passive, all due to the BDP.

Teacher-B associated the children's activities performed with the BDP to the concept of active learning. The tool changed the class dynamic, she said,

> It brought more life to them because it wasn't my interpreting of their words, it was their words. Cause usually when we do it, we put a big piece of paper on the wall, they'll dictate and I will write. I think there was more active participation on their part rather than me, them sitting talking and me writing. I think, it is very much more the preschool mentality cause it is active learning, it is not sitting and being passive...

Negotiating meaning independently or in small groups

Teacher-A commented that the BDP helped the children develop independence, allowed them to make the activity their own, and enhanced interactions with peers, which '…is good for them too, because they never get to do that here. This was another way that they give importance to what they are learning. They made the picture. It was their voice, they had to stand up, and this was something everyone had a listen to, a little burst on their self-esteem that they can do this.'

Similarly to children 'A' and 'N' in study one (chapter 7), the children who mastered voice recording had the opportunity to negotiate meanings by themselves during symbol labelling, which implied the use of skills for choosing or editing the label to be assigned to the drawing.

Remembering and reflective thinking skills were also rehearsed when revisiting own or peer ideas on the whiteboard individually and at own discretion. On this, and referring to the autistic child, teacher-A said this would be a 'wonderful' tool for children who have some special needs 'because they need that extra reinforcement. And you know a teacher can't always be doing the same thing over and over again. This way they can go back and help themselves…'

In groups, the children also revisited the map content at own discretion, such as some children who continued exploring the finished map after the class was dismissed. When the director saw this, Figure 8.10, she said that these children were pre-literate.

Figure 8.10 – preliterate children revisiting the completed map

Children revisited own and peers' verbally-labelled symbols. These interactions with the map content sometimes provoked giggly comments, and repetitions of voice-recorded sentences previously recorded by a peer with imitation of vocal intonation at times. Probably such interactions provoked a child to retain an idea in memory. This will be discussed later.

As soon as verbally-labelled symbols were placed on the whiteboard, and before the teacher gathered the group to work on the map together, children in both sessions started making comments on the labelled symbols. Two Leopards' children had the following dialogue:

> Do you want to hear this one or this one? [One child says to the other]… No, Let's hear this one [says the other child].
>
> Do you wanna hear my tiger one, my tiger one.... [undisclosed]!

Negotiating meanings with the teacher

Only teacher-B mapped the content with the children. Mapping involved playing each voice-recorder, asking for its owner, making comments on its content, and re-arranging the verbally-labelled symbol under its corresponding category of big cats. While revisiting the content, the children made comments such us 'let's play it again'.

The next results show that the BDP allowed for interactions with the content that made explicit some concept mapping characteristics: knowledge organisation, retention and sharing, revisiting and commenting.

<u>Knowledge organisation</u>

Organising the verbally-labelled symbols in thematic categories made explicit the identification of a missing concept. In circle time, the teacher prompted the children to think about what idea was missing from the map: they had nothing about white lions, no one had produced an idea about white lions. Identification of missing concepts is a characteristic of concept mapping.

<u>Knowledge retention</u>

When teacher-B revisited the voice-recorded meaning 'jaguars have dots inside their spots', this meaning somehow stimulated memory recall in a child. This child remembered that this same idea was in the map of the Tigers. This is the transcript of that conversation:

06.45min	vrec:	jaguars have dots inside their spots
	T/CHER-B:	jaguars have dots inside their spots
	A child:	[inaudible] said that
	T/CHER-B:	[inaudible] that's what <u>[undisclosed]</u> said too, ah!
	[Inaudible group talk]	

	A child:	jaguars have a spot, a spot in the middle [This is the meaning that this child says that a friend said in the Tigers' circle time.]
	A child:	what did you say?
07:05min	A child:	it's kind of funny, because he said, jaguars have a spot, a spot in the middle
	T/CHER-B:	a spot in the middle, [undisclosed] what did you want to say?

The circle time of the Tigers, when teacher-A presented their map, occurred two days before this session. Listening to a verbal label with similar content brought this idea back to the child's memory. After the child made the comment, several other children repeated or uttered the sentence said by the friend. What is curious and charming is that these children tried remembering the exact wording and rhythmical intonation. Maybe the way or style that the Tigers' child voice-recorded the meaning was so catchy or interesting that it helped children's memory to store it.

Teacher-B said that the voice-recorders enabled children 'to keep a record' or '...making a memory' She added 'It is hard for them to get their thoughts down in writing because their are not able to do it yet, but the fact that they were able to record what they drew about…that was really good…' The voice-recording ability solved children's memory recall issues, and to illustrate this comment, teacher-B described a child who was able to remember the verbal meaning assigned to a picture the day after the activity was performed. The child remembered the meaning, in her view, because the idea was drawn, voice-recorded and practiced by playing the recording back. 'I don't know if he have would done that otherwise'.

<u>Concept assimilation</u>

The child, whose conversation with Teacher B is recorded above, assimilated the proposition into her cognitive structure, as this proposition, 'jaguars have a spot, a spot in the middle' was stored in her memory somewhat differently from the original idea. See Table 8.1 for seeing how the voice-recorded meaning changed. The three propositions explain the same fact about the jaguar, but with a slightly different wording.

Table 8.1 – changes in the meaning of an idea

	Leopard's circle time	**Tiger's circle time**
Voice-recorded meaning	'jaguars have dots inside their spots'	
Child's comment (what the child recalled)	'jaguars have a spot, a spot in the middle'	
Tigers' finished map		'jaguars have a spot, a little spot in the middle'

Unlabelled symbols do not aid memory

Contrary to voice-recorded meanings triggering memory recall, there is an example of how unlabelled drawings do not promote knowledge retention. A day after the activity of creating the unlabelled symbol, one child did not remember the meaning of her own drawing. The symbol was left unlabelled because the voice-recorders ran out. Consequently, the teacher recommended adding the meaning with emergent writing. The next day, in the Leopards' circle time, the child was asked about its meaning. The dialogue transcript is given below:

00.07:48	T/CHER B:	here there is one [drawing] about snow leopards
	vrec:	snow leopards...
	T/CHER B:	snow leopards... And [undisclosed] has one that she didn't have a recorder for, but do you remember what you said [undisclosed]?
	Child:	snow leopards
	T/CHER B:	snow leopards
	Child:	snow tigers have teeth

T/CHER B: snow leopards, not snow tigers [inaudible] [teacher corrected mistaken fact.]

T/CHER B: snow leopards [inaudible]

The child did not recall the meaning of her own drawing. The meaning of unlabelled symbols can soon be forgotten, while verbally-labelled symbols support children's poor memory.

Knowledge sharing

The ability to voice-recording a meaning enabled children to share verbally-labelled ideas with peers and/or the teacher. See Figure 8.11.

Commenting on the meaning of concepts is an important characteristic of concept mapping. The following dialogue shows one child commenting on the picture of a lion and being ignored by the teacher. In a mapping session, the child's comment would not be dismissed, as comments provide opportunity for enhancing knowledge:

T/CHER B: tiger babies are called cubs. [undisclosed], what did you want to say

06.35min child: that picture of the lion is scary to me [The child is referring to Figure 8.5 -13]

T/CHER B: it's scary to you, thanks for telling us that…

Figure 8.11 – voice-recording enabled meaning sharing with peers and with the teacher

Peer influence

The BDP promoted peer influence in demonstrable ways. Some children who mastered voice-recording assisted peers with their own voice-recorders, or taught them how to do it. Teacher-B described a situation where children were teaching each other:

> Little [undisclosed]…was able to go out and show everyone what you showed him, how to use the recorders, he was going and helping the other to do that… he's very mature in that respect, has very good skills and it was peer teaching and they were also able to go back and forth… they were able to compare notes with each other…

Children’s ability to revisit and discuss each other’s ideas during map building created another opportunity for peer influence. Some children copied each other’s ideas, despite having been discouraged to do so. It may be that they found it hard to develop their own ideas. The 5.6-year old in case study one also commented finding what to say about s/her drawings a ‘little bit hard’. In our interview, teacher-A highlighted that keeping an idea alive for representation is difficult for preschoolers.

Teacher-B said that the Leopards' activity was greatly influenced by the Tigers' modified finished map. When the content of both maps is compared, (see Figure 8.3 and Figure 8.5), the content similarities become clear. Teacher-B may be correct, but it is unclear how this influence occurred, considering that the Leopards were only exposed to the Tigers' map for around 10-minutes. Teacher-A presented the Tigers' map in circle time, where she played each voice-recorder and made comments. This short interaction may have been enough for some of the Leopards' children to keep the material in memory and use it in their own mapping activity the next day.

Unexpected interactions

Two unexpected interactions emerged from using the BDP: a child used emergent writing for the first time and an autistic child actively participated in the session.

Teacher-A commented on a 6 year old who had not been writing independently,

> …I have never seen evidence of that and yet he sat there and did… I told his dad when he came yesterday…I have not seen that in him. He was very confident… we couldn't remember what he was saying. But that was a huge step forward, I think he just got into the fact that I want to say this. I have no time to learning from Mrs [undisclosed] because she is helping everybody else…

As explained earlier in this chapter, the autistic child could help himself, and repetition was a good thing said teacher-A. The child's interaction with the BDP greatly surprised the teacher. These unexpected findings will be discussed in the next chapter.

Summary

This chapter reported on case study two that was performed in a laboratory preschool. Two teachers incorporated the BDP into a classroom activity for evaluating knowledge about big cats by their students aged 5 to 6. Two groups created maps and built them in one session and presented them to the other group in another session. I instructed teacher-B, who then instructed teacher-A. The BDP components were adapted for collective use. I observed the classroom while using the BDP and interviewed both teachers afterwards. I took notes during sessions, and sessions were, audio and/or video recorded.

All children, emergent writers and preliterates, achieved the activity goals individually or with teacher mediation. They represented at least one idea about big cats with mastered representation skills. Labelled symbols were created with drawing and voice, emergent writing and voice, drawing, voice and emergent writing.

Labelled symbols made explicit knowledge in the form of propositions and how children's cognitive structure organises or integrates it for representation. It was possible to identify formal and informal knowledge, valid, invalid and nonsensical propositions because such symbols included concrete and abstract concepts as well as linking phrases. Children's verbal language was well developed. Unreadable emergent writing and poor drawings were only identifiable because of the assigned verbal label.

Labelled symbols enabled children to choose, edit, revisit, and share meanings. Only verbally-labelled symbols showed as aids knowledge retention, in contrast to unlabelled symbols. Peer influence was noted in the number of similar labels assigned to different drawings.

The BDP enhanced interactions with the map content. Magnetised objects facilitated manipulation of labelled symbols. Children could easily place, edit, and explore them on the whiteboard. Comparison and sharing was supported because the components fitted children's small hands. Teacher-B and children together formed thematic groupings. Labelled symbols facilitated the constructions of the maps. Teacher-A organised them hierarchically using the arrows, without child participation. Teacher-B organised these symbols thematically with child participation. These groups could be easily labelled with markers while the content of each of them was discussed. Teacher-A said this tool allowed them to see children's learning on big cats and vocabulary use. Arrows were not used as the teachers had differing opinions on children's understanding of the concept. Despite not using arrows, mapping verbally-labelled symbols into categories enabled teacher-B and her students to identify a missing concept.

At request, teachers facilitated voice-recording and idea generation. Otherwise children self-regulated labelling of drawings or were peer-supported. The BDP increased children's intrinsic motivation, peer-to-peer teamwork, and autonomous behavior. The positive involvement of an autistic child and the first writing attempt of a 6-year-old surprised the teachers. One teacher equated these resulting interactions with active learning.

Similarly to case study one, these results are modest and cannot be generalized. However, they provide important insights on the introduction of concept mapping in traditional preschools, as educational tools that make children active learners without greatly affecting classroom operations and teaching styles. Children's level of autonomy with the BDP components was related to the mastery of representation skills. Children's individual or collective autonomy transformed teachers into facilitating partners.

It can be claimed that 4.6 to 6 year olds can be effectively instructed in Novak's concept maps, as their constitutive elements are present in the maps built in the both case studies. The problems revealed, such as bad integration of knowledge, can be resolved with instruction. The same applies to arrows, as the teachers commented, the children already understand their conceptual meaning: to indicate direction. This claim is discussed in the next chapter and is theoretically supported.

Chapter 9 – Discussion, Future Work, and Conclusions

Overview

Chapters 7 and 8 reported the results of the case studies where two preschools incorporated the BDP into classroom activities. This chapter discusses those results, and presents the research conclusions and future work.

The significance of the diversity of data collected lies in the different approaches that teachers and children used to incorporate the BDP in the classroom. The combined results produced from both studies are examined from several perspectives: child autonomy, knowledge mapping, instruction facilitation, and concept mapping. These showed that child appropriate authoring tools are needed for effective concept mapping instruction in preschool, while further evidence for this claim is provided in the related work section. The literature reported in chapters 1, 2 and 4 was used to support the discussion of results from those perspectives. The results section closes by discussing unexpected outcomes in relation to children with mild special needs, non-typical classroom tools, and of designer involvement in the classroom. The future work section introduces related work by an expert in psychology and other avenues of research.

In the conclusions, Novak's theories regarding young children's abilities to make concept maps are reiterated. The key ideas introduced in chapter 1 are revisited and arguments in support of the research claim that children are able developmentally to build Novak's concept maps are summarised. The failure of preschool children to succeed in building such maps is primarily attributed to the use of unsuitable tools in preschools, and to ineffective mapping instruction. The chapter finishes by highlighting the benefits of investigating this particular concept mapping issue from a design perspective, discusses the research limitations and breakthroughs.

Stating the significance of this research

Five different types of experiences occurred with the BDP for preschool concept mapping. Three of these experiences (case study one) were individual and two were collaborative (case study two). Due to individual characteristics, each child performed differently. Due to group characteristics, each group performed differently. In both studies, the children were at different stage of development, and the teachers had different instructional styles and understanding of concept mapping.

Individually, the results reported in chapters 7 and 8 may not appear to be highly significant or appear to be conclusive, but when analysed together, they provide significant data to explain the research claims (chapter 1) and address some of the issues in preschool concept mapping identified in chapters 2 and 4. The outcomes of this research advance understanding of preschool concept mapping, and will assist in the future development of child-friendly alternatives (chapter 5) to Novak's concept map template.

Differences

The case studies were different at many levels: state school vs. private school run by a University Psychology Department, researcher facilitates activity vs. teachers facilitate activity, 3- to 5-year olds vs. 5- to 6year olds, free-play time vs. activity time, individual work vs. collaborative work, and finally, working on small table vs. working on the floor.

The two preschools provided different examples of use and interpretations of the BDP. Profile differences were not seen as a problem to achieve the research goals because the BDP was designed to perform in a variety of classroom settings (chapter 5). As explained in chapter 6, the case studies were to adapt to the circumstances of each participant preschool and to the ways teachers were willing to lend their time. Every child or teacher interaction with the BDP was counted as important, as each one identified an environmental issue that could inform further product development.

Multiple interpretations

The reviewer of a paper I wrote on using the BDP for investigating concept mapping in the preschool community (Gomez 2007) commented that the case studies (chapters 7 and 8) were poorly controlled. The evaluation of this CHI2007 reviewer is not argued, however ‘control’ was not an issue in the context of this research. Different teachers and classroom set-ups allowed for multiple interpretations of the BDP use. Case study, a type of qualitative research method, was chosen because it allowed me to collect information regarding the social interactions that ensued when the children used the BDP (chapter 6). From a product development perspective, lack of control and the ‘dirty’ character of the collected data all contributed to my understanding of the design issues in preschool concept mapping. After all, the BDP, once fully developed, will be used in preschools with similar characteristics to the ones that participated in the studies.

In ‘rapid ethnography’ (chapters 3 and 6) iterative observations are performed that provide quick answers to move the product development forward. In the case studies, the BDP showed itself to be highly flexible within this methodological framework. Not only was it easily adapted from one session to the next, but it also could be changed from one study to the next in response to the particular needs of an individual classroom.

Free-play time: child-led

The results of case study one were achieved during free-play time, with children who had little or no previous interactions with the BDP components, and with a teacher who was inexperienced in giving instructions on how to use them. The children who were reported in this study always perceived the activity as a game, participated in it voluntarily, and remained in it for as long as they pleased. The results presented in chapter 7 and discussed in the following sections might appear modest, but they provided information about the concept mapping-related skills that these children used or could not use when they ‘played with the BDP’. As explained in guideline 1 (chapter 4), children perform at their actual levels of understanding and mastered skills during play (Owocki 1999).

Activity time: teacher-led

In contrast to case study one, the results of case study two were achieved during a teacher-led activity designed for evaluating knowledge acquisition. Two teachers worked on the activity, but due to classroom schedules, I was only able to directly instruct one teacher. The children worked on activities mediated by teachers who had little knowledge of concept mapping. As explained in the chapter 5, the BDP was designed to perform under the circumstances just described: teachers who had no time to be trained and/or were inexperienced in concept mapping. These results show how teachers incorporate the BDP into classroom activities, provided information about instruction facilitation, and teacher understanding. The results illustrate many of the issues reported in chapter 2, including among others, whether children: can only represent simplified mapping structures, cannot make concepts maps due to their stage of development, should only use concrete materials and simplified conceptual representations.

Brought autonomy and expected interactions

The BDP features brought autonomy to the children's concept mapping process, but only when children had control over every aspect of it. Different levels of autonomy and control were evident due to each child's prior knowledge or understanding of instruction, and reflected their individual mastery of the cognitive, motor and representational skills that were involved in operating the BDP components. These results confirm Bransford et al.'s (1999) claim that different levels of learning depend of children's control over the strategies used for organising such knowledge (see also commentary on Brandsford et al.'s claim in chapter 4).

Child authoring when manipulating the BDP components enabled the expected interactions, such as self-idea exploration with multiliteracy, voice-recorders and/or arrows. When instruction was effective (discussed in section 'facilitated instruction?'), it constrained undesired interactions, such as having teachers heavily mediating the process of labelling or organising ideas with verbally-labelled symbols (see complete in Table 4.2).

Automation

Voice-recorders allowed each child to add verbal labels to concepts represented with drawings or emergent writing. Voice-recording, drawing and emergent-writing allowed children to 'off-load' (as defined in chapter 2) in the form of verbally-labelled symbols, conceptual or propositional ideas held in their heads. The implications of such interactions were discussed in the section 'mapping of knowledge'.

Placing magnetised symbols on the whiteboard was a non-pivotal mechanical activity that not only promoted autonomy during map building, but also automated and simplified this task. In case study two, for instance, teachers assist students to place work on the bulletin board by using scissors and/or staplers. Commenting on the use of staplers, teacher-A stated: 'they couldn't [inaudible] the staplers on the bulletin board. It is too hard… Everything was child, child-friendly, teacher-friendly, and easy. It's really good.'

The ability to perform the interactions of voice-recording and manipulation of magnetised objects produced the kind of process automation (as defined in chapter 5) that needs to be incorporated into resources used for concept mapping instruction in preschools. These objects improved the mapping experience of the children who participated in the case studies by: making verbal knowledge explicit, removing the performance of unnecessary tasks, and helping children concentrate on relevant activities. Opportunities for training motor skills are common in the preschool classroom, but opportunities for exercising concept mapping-related skills are few to non-existent.

Voice-recording and use of objects with magnetic properties have been incorporated into other knowledge representation tools. Voice-recording features are present in AudioMC (Sánchez, Alarcón & Flores 2006), a concept mapping software for blind people, and Kidspiration (www.kidspiration.com), a mapping software for 5-plus children. Picture cards with magnets have been used for mapping Biology concepts (Britton & Wandersee 1997) and in prototyping sessions involving the design of technological artifacts (IXDA-members 2007).

Direct manipulation

The interaction of voice-recording allowed children to choose how to label knowledge represented with drawings or emergent writing: we could hear the verbal meanings children applied to their symbols. Together with magnets and hand-sized elements, these interactions enabled direct manipulation of knowledge in the form of creation, edition, sharing, and revision of verbally-labelled symbols.

Distractions were minimised because the BDP components responded to immediate manipulation, such as attaching a recorded voice-recorder to a drawn paper card. The children had access to every map element at all times, and, in contrast to other concept mapping approaches (see chapter 2), drawings on paper cards could be easily re-arranged, discarded, or interchanged.

Easy to use

Because the BDP design was based on suitable theories and an understanding of the user community (see chapters 2, 4, and 5), most components, such as paper cards, markers, wood surface, were familiar to the children and the teachers. When elements were unfamiliar, such as voice-recorders or arrows, children used them only if they understood instruction and mastered how-to operate them. The voice-recorders had a non-intrusive appearance and most children who attempted to use them were able to master voice-recording rather quickly after a demonstration of how to operate them by a teacher or peer and a few minutes of experimentation.

Amongst those children unable to voice-record independently factors identified were: age under 4.5 (under-developed motor skills), lack of confidence, and shyness possibly due to the novelty of the device. During the BDP design, it was forecasted that children with developing motor skills would find voice-recorders difficult to use (see chapter 5). Teacher-B in study two commented that steady exposure to a new educational resource resolved shyness and increased confidence. The next phase of product development should further investigate the design issues around voice-recording.

Adaptable

The BDP flexibly adapted both to classroom situations and to individual and collaborative interactions. Features could be changed on the spot if something was not working. For instance, in case study one, I stopped using Velcro because it destroyed the children's drawings and instead used magnets to hold drawings on the whiteboard. The BDP also accepted the incorporation of classroom materials. In case study two, teachers added wooden boards that facilitated children's interactions performed on the floor.

Mapping of knowledge

> Mapping is both a metaphor for connecting and overlapping knowledge structures…is also the name for practical tools for mental fluency. Mapping is a rich synthesis of thinking processes, mental strategies, techniques and knowledge that enable humans to investigate unknowns, show patterns of information, and then use the map to express, build and assess new knowledge (Hyerle 2000, 8)

Knowledge mapping is not an activity limited to Novak's concept maps. It can also occur with other graphical representations such as schemas, cycle diagrams, charts, diagrams, tree graphics and webbing, amongst many others (Birbili 2006; Hyerle 2000). Effective mapping, as briefly explained in chapter 2, relates to the map elements and their ability to assist the reader in the process of making inferences for acquiring knowledge.

Mapping was possible because verbally-labelled symbols made knowledge explicit and facilitated knowledge organisation with the strategies of clustering and hierarchy, and using the pattern verbally-labelled symbol → verbally-labelled symbol (Figure 9.1and Figure 9.2). Once organised with any of these strategies and patterns, an audiovisual representation emerged whose elements facilitated mapping of concepts and propositions.

Identifying when mapping occurred

Mapping occurred when children and teachers listened to the voice-recorded verbal labels, not when viewed the graphical components, as usually occurs with concept maps and other knowledge representation techniques such as flow-charts (Novak & Gowin 1984). I see this as a logical mental interaction, considering that these knowledge representations have audio components.

The verbally-labelled symbols enabled to organise knowledge with the following mapping strategies:

- Clustering strategy led teacher-B to identify a missing concept: ideas about white lions were not represented in the map of the Leopards (Figure 8.5).
- Revisiting verbal labels, assigned to symbols, with teacher-B led a child to identify a propositional similarity between maps. The proposition 'tigers have a spot, a little spot in the middle' was used in the Tigers' map (Figure 8.3) and Leopard's map (Figure 8.5).
- Revisiting propositions organised with the pattern verbally-labelled symbol → verbally-labelled symbol led to correction of a misconception. In case study one, after revisiting his/her 'little story' or set of three verbally-labelled symbols connected with arrows, child 'A' re-arranged two of the verbally-labelled symbols 'the egg is in the stomach' and 'the eggs are cracking' to correct a misconception regarding the lifecycle of chicken eggs (Figure 7.5).
- Organising verbally-labelled symbols with hierarchy, clustering, and the pattern verbally-labelled symbol → verbally-labelled symbol facilitated teacher-A to group propositions according to different categories such as features common to all big cats, common to tigers, lions or cheetahs or lions, and according to living and eating habits (Figure 8.3).

The described situations show that the BDP features enabled concept mapping, as defined by Hyerle (see quotation at beginning of this section). The mapping structures represent a synthesis of thinking processes, and show patterns of information that facilitated construction and evaluation of knowledge. However, these structures cannot be considered Novak concept maps, because they are missing structural components: In the 5.6-year old's pattern, Figure 7.2, hierarchy was not used and concepts have not been separated from linking phrases. In the Leopards map, Figure 8.5, arrows and hierarchy are missing and concepts have not been separated from linking phrases. In the modified Tigers' map, Figure 8.3, arrows and hierarchy are present, but concepts have not separated from linking phrases. The constitutive elements of concept maps were introduced in chapter 1 and discussed in relation to the thesis in chapters 2 and 4.

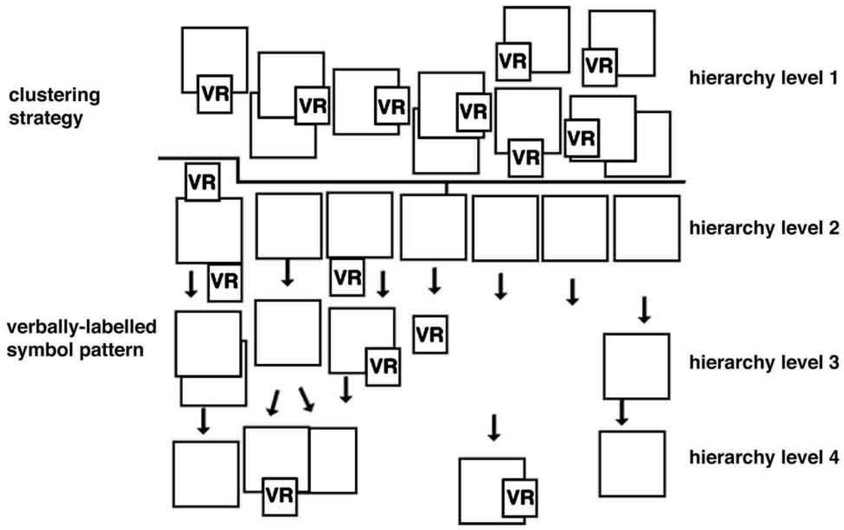


Figure 9.1 – the knowledge structure of the Tigers' map was built with clustering, hierarchy and the pattern verbally-labelled symbol → verbally-labelled symbol

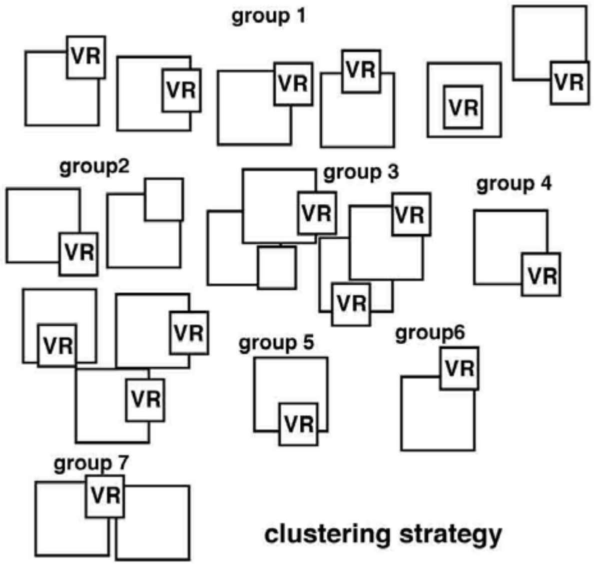


Figure 9.2 – the knowledge structure of the Leopards' map was built with clustering strategy

The pattern verbally-labelled symbol → verbally-labelled symbol

Relationships among concepts and/or propositions were formed when the 5.6-year old of case study one (chapter 7) organised verbally-labelled symbols by connecting them with arrows. Such relationships created the pattern verbally-labelled symbols → verbally-labelled symbols, which made explicit how this child thought those concepts and propositions on the topic of chicken eggs should be related to each other. Two sets of propositions were created with the pattern and the orientation of the arrows shows how concepts and/or propositions should be 'read': one set shows clarity in thinking and use of formal knowledge (Figure 7.3), while the other shows confusion and use of idiosyncratic knowledge (Figure 7.4).

This same pattern is present in the maps of Mancinelli's (Figure 2.1) and Mérida's students (Figure 2.3). Consequently, this fact indicates that by age 5, children who have mastered representational skills can represent organisational structures with a pattern symbol → symbol. Figure 9.3 shows a schematic diagram of the structures.

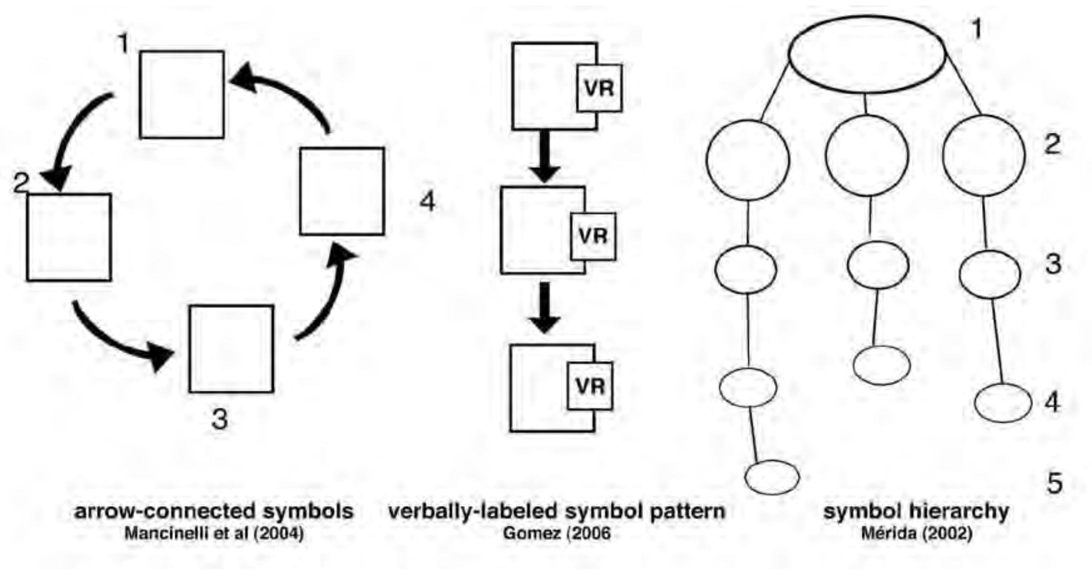


Figure 9.3 – These knowledge structures were built by 5-year olds, left side: connected drawings, centre: connected verbally-labelled symbols, right side: connected drawings and arranged them hierarchically

It is my view that the pattern symbol → symbol created with the BDP has an advantage over the ones that children created with the approaches of Mancinelli et al's (2004) and Mérida (2002). The BDP allows for building the pattern verbally-labelled symbol → verbally-labelled, revealing the logic behind this organisation structures and how a child understands them. Two examples can be given:

- The pattern of Figure 7.4 represents a section of the lifecycle of the chicken egg and was built with valid propositions labelled with formal and idiosyncratic knowledge: 'Egg' and 'the chicken' are examples of formal labels for concepts. 'A [inaudible] with watery stuff that is... that used to be inside the egg' and 'chicken is wet' are examples of idiosyncratic labels for propositions attempting respectively to explain the concept of 'yolk' and that a chick is inside the egg and covered in yolk.

- The arrow-connections among verbally-labelled symbols show that the child observed a conceptual relationship between the following concepts: the wetness of the chicken and the yolk. Such a relationship was not clearly represented.

With the mapping approaches of Mancinelli et al. (2004) and Mérida (2002), children can create the pattern unlabelled symbol → unlabelled symbol. This pattern does not allow for interpretations of concepts, proposition and/or conceptual relationships of the kind above described. The logic behind this organisation structure is only explicit with teacher-annotations, as I have previously argued in Gomez (2005b) and in chapter 2.

Use of hierarchy

Hierarchy within a concept map template is essential to show how one's brain organises pieces of knowledge in the cognitive structure (chapter 1). However, as reported in chapter 2, few mapping experiences for preschool have investigated children's abilities to organise knowledge hierarchically as stated by Novak (Figueiredo et al. 2004; Mérida 2002). Novak's template (see chapter 4) is built with abstract symbols or conventions such as hierarchy and written words that are not yet mastered by preschool age children.

The movable hierarchical template of the BDP was developed based on the mapping approach of Figueiredo and colleagues, which provided children with a template to scaffold hierarchical organisation of symbols (chapter 5). Interactions with the hierarchical templates of the BDP (chapter 5) were not reported because the children who used them were not participants of case study one (chapter 7) and the teacher-B of case study two decided not to include them in their activities (chapter 8). Therefore my comments on hierarchy are based on analysis of the modified map of the Tigers and on experiences reported in the literature.

To build the modified Tigers' map, teacher-A organised the verbally-labelled symbols of her students, using the following strategies: clustering, the verbally-labelled symbol pattern, and hierarchy (Figure 9.1). Comparing these organisational structures to those created by 5-year olds in other studies (Mancinelli 2004; Mérida 2002) and by the 5.6-year old of case study one (Figure 7.2), reveals that these children used at least one of the strategies employed by teacher-A (Figure 9.3). Therefore we can conclude that the map that teacher-A built in absence of her students (Figure 8.3) revealed organisational structures that 5-year olds also can build if appropriately instructed.

Comparison of these mapping structures challenges the viewpoint of teacher-A regarding 5-year olds ability to categorise knowledge with hierarchy and arrows (see discussion in chapter 8), and of three forum teachers (FOD 2004a), who think that concept maps may not be appropriate for young children, due to their developmental stage and understanding.

Empirical research by Greene (1994) on class inclusion hierarchies with kindergarten-age children 'suggested that 5- and 6- year old children can use a tree diagram as an external visual memory aid for the content of information represented in a hierarchy' (p. 83). Therefore some elements preventing children from rehearsing the skills for representing hierarchy, at least with 5-year olds, are adequate concept mapping instruction and effective scaffolding tools, such as the ones designed by Mérida. The scaffolding tools that she used to facilitate her students understand the concept 'hierarchy' were ordinal numbers, colour-coded connecting lines, and boxes of different sizes to differentiate more inclusive concepts from the more specific ones (Figure 2.3).

Facilitated instruction?

Novak and Gowin (1984) comment that the educational experience is a complex event involving teachers, learners, curriculum, and milieu. Teachers set the agenda and decide what knowledge should be considered in the sequence of instruction. Learners must choose to learn because learning responsibility cannot be shared. Curriculum, they continue, comprises the knowledge, skills and values of the educative experience that meet the criteria of excellence making them worthy of study. Finally, the milieu is the context in which the learning experience takes place. Their commentary about the operations of the educational experience, was construed with supporting ideas of Schwab (1973), Bloom (1968, 1976), Gowin (1981), and Holt (1964).

Dissatisfaction with concept mapping due to ineffective instruction led teachers to claim that creation of Novak's concept maps by preschoolers was not feasible (chapter 2). Ineffective instruction of concept mapping can also occur due to other classroom factors including ineffective teaching strategies, concept mapping inexperience, and the preschool operational curriculum. In this section research outcomes are discussed showing why this can occur, despite the availability of a suitable instructional tool, such as the BDP, that children can autonomously interact with, and which teachers can easily incorporate into classroom activities.

Supported instruction of mapping rules

Followed mapping steps

The teacher/director of case study one stated that children might not follow the rules (steps) required in concept mapping because they were not used to working that way during free-play time. Her comments applied to sessions 1, 3 and 4 that were heavily directed by an inexperienced teacher (myself). In sessions 2 and 5 however, the children followed and understood the building rules, perhaps because some activities were familiar, for example 'reading' picture books, drawing ideas on paper, and cutting out pieces of stuff. The unfamiliar activities of Velcro-ing and voice-recording were easily learnt because these were demonstrated, and involved actions using previously mastered motor skills. In case study two, a similar situation occurred: the children easily followed both familiar and unfamiliar rules when they were allowed to perform aspects of the mapping activity autonomously.

These results demonstrate that children were able to follow rules for mapping because the design of the BDP features simplified the tasks to be undertaken (chapters 4 and 5). The steps for map building were presented in a simple structure: make verbally-labelled symbols, place these symbols on the whiteboard, connect them with arrows. This simple structure minimised the amount of planning and problem solving required, while the unnecessary tasks were restructured with the use of magnets and pre-cut paper cards. The children's ability to perform such tasks and interactions is evidence that supports one of Norman's user-centred design principles: simplifying the structure of tasks transforms complex tasks into simple ones (Norman 1990).

Scaffolded required activities

Building maps with the BDP has shown to enhance the performance of children's cognitive skills (as discussed in the section 'knowledge retention and self-regulation') and to facilitate teacher scaffolding support during mapping activities. In some situations scaffolding involved demonstrating one, two, or more of the following how-to activities: voice-recording, creating a pattern with arrows, and object placement on the whiteboard. On other occasions scaffolding involved answering children's questions about idea representation, supporting thinking processes such as what idea to draw or how to keep an idea in memory, or leading the organisation of labelled symbols with a mapping tool.

For these reasons it can be said that the BDP design allowed teachers to 'build on what children know and extend their competencies by providing supporting structures or scaffolds for the child's performance' (Wood et al. 1976 in Bransford, Brown & Cocking 1999, p. 104). Some of the characteristics of scaffolding (as described by Brandsford and colleagues (1999) – see chapter 4) can be seen in the mapping activities of the case studies, and include: 1) children showed interested in the task, 2) every step of the task was simplified for enhancing understanding, 3) children could manage the process to accomplish the task and able to recognise when aspects of it could be successfully or unsuccessfully completed.

Prevented instruction of mapping rules

Some children were unable to make knowledge explicit with the BDP features. Reasons for these include teacher instruction, which failed to recognise that a child did not have the prior knowledge to build a map with given tools, or because teachers did not have confidence in the performance of their students' skills in relation to concept mapping.

Teaching inexperience

The BDP was designed to enable the use of multiliteracy, however due to the researcher's teaching inexperience and unfamiliarity with the children's background, instruction in case study one failed to promote children to represent knowledge with preferred representational skills.

Instead of presenting the children with different representational options for verbally-labelled symbols, the instruction only indicated one way: first - draw idea, second – verbally record the meaning of the drawing. When asked following such instruction, many children stopped 'playing' with the BDP elements. The transcript analysis showed that some of them stopped because they did not know how to draw an idea held in the head (or memory). As a consequence of not offering alternatives, the instruction failed to include the majority of the study participants, six children.

This instruction was an issue on different occasions, throughout the activities, the three children who participated in the reported sessions verbally expressed conceptual and propositional knowledge about the topics being mapped (see Table 7.1, Table 7.3 , and Table 7.5). The inability of children 'N' and 'C' to draw ideas was a knowledge-related limitation that the teacher addressed by heavily mediating the drawing process (see Figure 7.6 and Figure 7.8). Such type of mediation should not be encouraged in concept mapping activities because it does not make children's knowledge explicit. An appropriate way to address such issue should have been to re-design the instruction to promote use of verbal language more than symbolic language.

This result affirms Vygostky's conclusions, reported by Owocki (1999), that language is the main vehicle which young children use to communicate knowledge, and that without language, activities cannot be achieved (chapter 4). The voice-recorders were added to the BDP to promote multiliteracy by expanding representational options for children. As reported in chapter 7, these options worked for children 'A' and 'N' who showed interest in using them, but for unknown reasons, child 'C' expressed no wish to learn to voice-record. Despite that this child knew more about the topics treated in the 'Egg' book (Mettler, Bourgoing & Jeunesse 1990) than the other two children.

There is one occasion during the case study that inexperience acted in favour of the research outcomes. Teacher inexperience of the children's backgrounds enabled child ‘A’ to show that the BDP could be used for organising and making knowledge explicit by using the pattern verbally-labelled symbol → verbally labelled symbol. This pattern (Figure 7.2) is the only evidence that I have showing that 5-year old preschoolers can autonomously represent and organise knowledge if provided with a child-friendly tool. In relation to effective instruction this result is discussed at the end of this section.

Concept mapping inexperience

Lack of instruction of teacher-A and limited instruction of teacher-B contributed to ineffective student instruction regarding building maps with the BDP features. For instance, teacher inexperience of concept mapping prevented the emergence of the pattern verbally-labelled symbol → verbally-labelled symbol and the use of hierarchy in case study two. The reasons for these teachers not using arrows were presented in chapter 8 and are discussed in the curriculum section of this chapter.

Both teachers performed aspects of the mapping activity because they thought that their students would not have understood instruction on the use of arrows, or the operation of voice-recorders (chapter 8). Time constraints also affected the emergence of child autonomy in the mapping process. Referring to the organisation of verbally-labelled symbols with clustering strategy, teacher-B commented ‘… I would have liked to see how they would have put it together on the board, but we were pressed for time’. Time constrains were also a factor commented by Figueiredo *et al.* (2004) and by teachers in the online FOD forums (2004a; 2004b) . A tool like the BDP could positively address this classroom issue because, with suitable instruction and when permitted to, children can rapidly master the BDP components to make knowledge explicit within the allocated time. This was the case of child ‘A’ from case study one who created two sets of propositions in less than 50 minutes (chapter 7), typical of the time allocated in preschool activities involving the learning of new topics.

Despite that teacher instruction was very limited, the resulting maps show that limited instruction is better than the lack of it. The instruction provided by teacher-B facilitated children to represent clearer verbally-labelled symbols (one idea per card, one verbal label per symbol, promoted autonomous voice-recording unless a child asked for direct support) and that mapping of these was performed in company of the students. These results are opposite to the instruction provided by teacher-A whose children presented more than one idea per card, who operated the voice-recorders for all of her students, and mapped the verbally-labelled symbols of the students without their participation. Limited teacher instruction positively influenced student instruction: the students of teacher-B could rehearse some of the activities involved in building a map with the BDP.

The experienced teachers, however, had an advantage over the inexperienced one: they knew their students' background well. Consequently they provided instruction enabling their students to make knowledge explicit in the form of verbally-labelled symbols with the BDP features. These teachers instructed the children to represent knowledge on 'big cats' either with voice, drawings, and/or emergent writing. This strategy allowed more children to participate (preliterates and emergent writers) and avoided the effect of the strategy that the inexperienced teacher used of drawing symbol first and voice-record the meaning second.

Concept mapping and preschool experience, unsuitable tools

The presence of a teacher trained in early childhood education and concept mapping topics is pivotal for effective instruction in preschool concept mapping when utilising a tool such as the BDP. This tool was designed as a child-friendly alternative to Novak's concept map template (chapters 4 and 5).

Child 'A' represented conceptual and/or propositional relationships about 'chicken eggs' with the pattern verbally-labelled symbol → verbally-labelled symbol, because with the BDP features s/he could complete the teacher instruction (first –draw, second –voice-record). As reported in chapter 7, dialogue transcripts show that this child autonomously worked on his/her patterns and that the teacher barely interfered in their construction.

The outcome achieved with child 'A', in my view, is what ECE teachers with expertise in Novak's concept maps would like to achieve in their own instructional programmes. One of their major concerns is to avoid interfering in the mapping processes of the students. The paragraph below is an English translation of a comment by a teacher in relation to this concern:

> Careful attention has to be placed in avoiding manipulating the authenticity of a child's map, especially in front of the children. Many times and with the intention of furthering content development, a teacher reconstructs or improves the map, and in this process, ends up amputating the ideas of the owner of that map: the students. Most care must be placed in avoiding direct interference with the student's ideas. If by definition a map should represent prior as well as acquired knowledge of a student's learning experience, then there is a need to respect and provide that space where students can exercise their capacities, while searching for alternative ways for a teacher to give feedback to the learning process, but without altering the authenticity of the students' maps (FOD 2004a).

This quote was taken from an online forum on preschool concept mapping. As explained in chapter 2, the teachers participating in this forum were 1) experienced in ECE, 2) familiar with their students' backgrounds, and 3) trained in how to build concept maps and in their underlying theories (Alí-Arroyo 2004). Despite this they appeared to instruct students with unsuitable mapping tools that did not harness mastered representation skills. More effective tools such as the BDP encourage scaffolding and should help to avoid these types of heavy teacher mediation issues.

An understanding of concept mapping, coupled with suitable mapping tools promoting autonomous knowledge representation, may prevent ECE teachers from modifying their students' maps, 'forcing' instruction, and making biased decisions on what children can or cannot do in terms of mapping. Teachers modifying students' maps is an issue which was discussed by forum teachers (FOD 2004a, b), reported by Badilla (2004), and occurred in case study two when teacher-A modified the Tigers' map (Figure 8.3). The related work section of this chapter discusses the work of an expert investigating child metacognition with the BDP. Her results further support my argument that ECE teacher instruction in concept mapping is essential for enabling children to autonomously represent knowledge with Novak's concept map template.

Curriculum

The differing opinions of the participant teachers about concept mapping in preschool showed that limited instruction in concept development may have more to do with the design of teaching programmes and/or chosen educational resources than with children's developmental stage.

Mapping is usually teacher-led

The case study results appear to support Mérida's (2001-2002) observation on concept mapping and the ECE curriculum. This expert reported that teacher training is mainly focused around strategies that develop children's observation, hands-on experimentation, and socialisation skills, rather than around strategies that develop their metacognitive, reflective and autonomous thinking skills. Mérida continues that despite preschool being one of the educational stages where instructional innovations are most practiced, these are usually built around a methodological approach defined as 'global y activo', instead of been built around strategies and instruments promoting learning-how-to-learn skills. My understanding of Mérida's 'global y activo' (which is somewhat difficult to summarise in English) is 'global' has the meaning rounded education (introducing variety of knowledge), while 'activo' refers to action, play, hands-on activities, and interaction. Birbili's (2006) recent report further supports Mérida's observation by making the case for organising preschool instruction 'around concepts and generalisations instead of inert facts' (p. 141). Propositions are also called facts (Novak 1998).

The literature (Fleer 1996; Helm & Katz 2001; Hyerle 2000) promotes teacher-led mapping with young children: using guided conversations and according to their students' responses, a teacher organises concepts and propositions related to a topic of study on a whiteboard or butcher paper. Only Helm and Katz (2001) report on a teacher encouraging their students to participate in the construction process. I believe the teachers of case study two led mapping of the knowledge produced by their students because the literature suggests this is appropriate. Therefore, the differing arguments of teachers ‘A’ and ‘B’ about their students’ ability to independently use arrows are not surprising. As reported in chapter 8, teacher-A said that her students do not understand arrow orientation until second grade due to development while teacher-B said that they understand that arrows show the direction that one can go, left or right. Grounded on different observations of the same experience, these teacher arguments are examples of what is occurring in the preschool classroom in relation to knowledge mapping: universal and systematic experiences have not been designed to scaffold these children into autonomous mapping processes that involve the use of abstract symbols such as arrows and hierarchy (see chapter 4 for more on abstract conventions).

Using concept maps in classroom activities

The teacher/director of case study one stated that she would not use concept-mapping in the future. In her teaching programme, she has to look after many aspects of the child’s development, of which concept development is only one. Concept mapping requires teacher mediation and one-to-one teaching, which is an instructional strategy that her classroom cannot afford. This teacher could not incorporate concept mapping because of the class size (25 children), the age diversity (3-to-5), and the limited teaching support available. She recommended that a Reggio-inspired centre might be more suited to this teaching style for future trialing of the BDP.

Teachers of case study two stated they would definitely use the BDP for preschool concept mapping, but with enhancements. Teacher-A would use it from the beginning of a thematic unit, allocating a wall with a huge whiteboard, and using many more voice-recorders (20 were not enough) to map how the children’s concepts progress in time (Gomez 2007). The greater hindrance the teachers saw was related to group size: eight children in the Tigers and eleven in the Leopards. Teacher-A thought that it ‘would have been a lot easier’ to use [the BDP] with individuals or with small groups of 5, 6 or fewer children, and then possibly work in larger teams once everyone has mastered it. Chapter 2 reports on some teachers who also preferred the small group approach, while others worked with larger groups.

Change in teacher views

One of the research goals was to change teacher views on children's abilities to use the skills required in concept mapping. This was achieved by convincing teachers to incorporate the BDP in classroom activities, so they could see their children performing mapping-related interactions that have been reported as not possible with this age group (see chapter 2).

The time spent using the BDP was not long enough for teachers in the case studies to see a significant change in children's learning. However, the outcomes of the children's autonomous and scaffolded interactions with the BDP promoted discussions about the BDP design, alternative uses, autonomous labelling, and use of hierarchy.

The teacher/director of case study one stated if she had access to the BDP, she would like to have it in the classroom and find a creative use for it. Her children are in a developmental stage where they are exploring play and fantasy, and she thought that the BDP features could be used for making this visible.

Her students' performance with the BDP, in her view, showed their developmental stage, in other words, what these children could and could not do. She felt that the mapping-related activities that were tried contained too many rules, which might have been confusing for the children. She suggested reducing these. Her students may have underachieved during mapping-related activities because of ill instruction and/or underperformance of their relevant cognitive skills. Conversely the teacher said that effective performance of child 'A' during the activity was due to her upbringing: the child's parents are university people. Developmental stage and cultural background have been reported to influence learning (Kozulin et al. 2003; Novak & Gowin 1984).

The BDP changed the views of teachers in case study two on autonomy at concept representation. Children's autonomous interactions with the BDP showed them that with instruction children could quickly learn to concept labelling with multiliteracy, which in turn, promoted active learning (see discussion in section concept-mapping related characteristics). Conversely, their interactions with the BDP and teacher instruction were insufficient to transform teacher-A's biases regarding the use of hierarchy and generate and good understanding of arrows in relation to concept mapping.

The quality of teaching instruction and teachers' educational philosophies, issues such as staffing capacity and time constraints, facilitated or complicated instruction of Novak's concept maps with the BDP features. When teacher instruction scaffolded children to perform mapping activities autonomously or with support, the BDP features facilitated instruction, while in other occasions, these replicated teacher-led mapping tasks.

Concept mapping-related characteristics

I cannot claim that the BDP features promote meaningful learning, as this aspect was not investigated in the thesis. However, the results discussed in this section show that some of the mapping activities that children performed with the BDP promoted the conditions for meaningful learning (as defined in chapter 1): prior knowledge, familiar languages, and wanting to learn (Ausubel 1968 in Novak 1998).

When instruction was adequate, the structuring features of the BDP enabled children to: 1) represent concept acquisition with their preferred multiliteracy skills and known vocabulary, 2) control the skills for knowledge retention and self-regulation during concept labelling and organisation, which in turn, 3) facilitated knowledge sharing. Knowledge retention and sharing facilitate meaningful learning, together with self-regulation (Novak 1998).

While Novak's concept maps were not instructed, as a consequence of having developed the BDP under the same underlying principles (chapter 4), the activities that teachers and children performed showed characteristics of concept mapping.

Concept assimilation

Concept assimilation is characterised by the following active processes: relating, differentiating, and integrating new concepts with relevant concepts that already exist in a child's cognitive structure (see chapter 4). One of Novak's (1998) anecdotes illustrates: he knew that his grandson effectively integrated the concept of ‘annoy’ (a new piece of knowledge) into his cognitive structure because the child used the concept in the right context and correct tense: ‘grandpa take this thing off [referring to his life jacket]. It is annoying me’ (pp. 42-43).

In this research, the BDP design harnessed children’s ability to communicate concept acquisition with verbal and symbolic language (chapters 1, 2, 4) and Novak’s assertion that concepts can also be labelled with symbols (Novak 1998; Novak n.d.). Some children used one or more BDP features to externalise concept acquisition on the topics of ‘chicken eggs’ or ‘big cats’ with prior knowledge and familiar languages.

Verbal labels

As planned in the design guidelines (chapter 4), verbal labels created with voice-recorders disclose the particular way a child assimilated concepts or propositions with mastered vocabulary:

- Conceptions and misconceptions, idiosyncratic and formal knowledge: a child knew the meaning of a concept but not its label. This is the case of the concept ‘yolk’ in case study one (Figure 7.4): a child could explain the concept meaning with idiosyncratic vocabulary, ‘a [inaudible] with watery stuff that is... that used to be inside the egg’, but had not yet assimilated it’s formal label: ‘yolk’. The concept ‘paws’ in case study two is another example, [a child use a different label ‘big cats have feet’ to explain the lower extremities of big cats (see Figure 8.5, verbal label #3).

- Undecipherable drawings or poor emergent writing: the labelled symbols of many of the Tigers children fall under this category (Figure 8.2). Children’s language is more developed than their limited representational skills, as the literature reported in chapter 2.

- Reflective thinking: voice-recording enabled children to negotiate concept labelling with themselves because labels could be created, revisited and edited. During representation child ‘A’ changed the label of a symbol from ‘tummy’ to ‘stomach’. The transcript of the child’s mental interaction with this content can be found in chapter 7.

- Differences in thinking, despite similar drawings: comparing the drawing labels of different children in the same class showed knowledge differences. Child ‘A’ and child ‘N’ drew a similar symbol: half an egg with a yolk and watery stuff. However, ‘A’ labelled it ‘…watery stuff…inside the egg’ while ‘N’ labelled it ‘cracked egg’ (See Figure 7.4 and Figure 7.6 respectively.)

As reported in chapter 4, the literature says that young children become proficient at using spoken language early and that this proficiency plays an important role in their processes of knowledge acquisition (Bransford, Brown & Cocking 1999; Cadwell 2003; Novak 1998; Owocki 1999). As seen in the results of the case studies, voice-recording was shown to be an effective way of harnessing child proficiency with spoken language, and for producing an alternative to concept labelling in addition to symbolic language.

Verbally-labelled symbols made conceptual knowledge explicit of preliterate and emergent-writing children, and especially in those children whose ideas otherwise would have not been understood due to poor representation skills. One of the teachers (chapter 8) said that voice-recording allowed her to evaluate vocabulary use.

Symbolic labels

In the case studies, only the symbolic labels of children who have mastered drawing representation skills made explicit knowledge acquisition. Preschool programmes use drawing as a tool for disclosing knowledge acquisition of students (Brooks 2004; Edwards, Gandini & Forman 1998). For drawing to become a suitable alternative for promoting knowledge acquisition, children require training in making drawings with recognisable features and/or reflect the development of abstract thinking.

Mérida (2002) trained students in drawing abstract symbols so they could achieve the goals set by her mapping approach. A child’s ability to represent abstract symbols indicated to her that s/he understood that a simple schematic drawing (symbol) could stand for a more complex reality. Understanding what an abstract symbol stands for, she argued, is indicative of the level of development of a child's abstract thinking.

Brooks says when drawings are used for recording or representing products of child observations (e.g. lifecycle of a living butterfly) this process can lead to knowledge acquisition:

> Through the process of redrawing, Jenn's thinking about the caterpillar's growth and development changed. Drawing at an interpersonal level helped Jenn integrate her new knowledge with her previous experiences and ideas. In her reconstructed drawing, we see evidence of both previous and new thinking. The drawing reveals a transformation of thinking that is indicative of an interpersonal dialogue or internal revisualization (Brooks 2004, p. 48).

Knowledge structures or pattern

The case studies (chapters 7 and 8), Mérida's research (2002), and Mancinelli et al's (2004) teaching experience reveal that by having each child to represent their own mapping structure, individual cognitive structures become evident. This characteristic was not seen in maps built with pre-determined symbols that were discussed in chapter 2. For instance, the propositional set created by the 5.6-year old disclosed how this child integrated this piece of knowledge with self-created verbal and symbolic labels. As explained in an earlier section, one set shows conceptions while other represents some confusion between concepts: what goes first '…watery stuff…' or 'egg' (Figure 7.2). On the same topic, Mancinelli and colleagues (2004) say 'each drawing included in the concept map refers to the child's thoughts' (p. 2). If we compare the mapping structures of two students, see Figure 9.3, it can be noted that two children represent a same topic (parts of the pumpkin) differently.

Knowledge retention and self-regulation

Children of the case study rehearsed their developing knowledge retention and self-regulation skills, when the BDP features were used to represent and organise verbally-labelled symbols. Some results show the ability to perform these activities increased memory (attention span, remembering) and self-regulation (monitoring for success, planning, and connecting errors when appropriate) in some children.

Novak's concept maps promote meaningful learning because they facilitate knowledge retention and self-regulation (see chapter 4). The BDP design has been shown in this study to support children's developing working memory, and skills for effective intentional learning during mapping-related activities, as intended in the design phase (chapters 4 and 5).

Retention

The BDP features, as planned in the design requirements, enhanced the performance of the children's knowledge retention by enabling them to use rehearsal strategy during mapping activities (e.g. concept labelling with verbally- labelled symbols). As reported in chapter 4, experts assert that children's memory performance can increase if they can use rote and elaborative rehearsal strategies (Bjorklund & Douglas 1997; Cowan 1997b).

Rote rehearsal means going over the information exactly. In case study one, a 5.6-year old created seven verbally-labelled symbols, which means that the child repeated the same actions involved in this task several times: voice-recording seven times, drawing on cards seven times, and connecting with arrows four times (Figure 7.2). Here failed attempts were not counted. In case study two, verbally-labelled symbols placed on the whiteboard could be revisited by the children alone or in teacher company. Each voice-recording got played at least 5 times (Figure 8.7 and Figure 8.11).

Elaborative rehearsal allows making meaningful connections and it is characterised by an individual's knowledge structure and creativity. Children autonomously rehearsed elaboratively during concept and proposition manipulation (see Figure 7.5, Figure 8.6, and Figure 9.4). These mapping-related activities probably enabled two children to make meaningful connections among ideas. One child realised that two verbally-labelled symbols of his/her propositional set on chicken eggs required re-arrangement (chapter 7). A second child established that the proposition 'jaguars have a spot, a spot in the middle' was represented in the Tigers' map and the Leopards' map (chapter 8).

The BDP features provided opportunities to systematically rehearse some concept-mapping related activities: label concepts, placement of concepts on the whiteboard, and/or connecting concepts with arrows. Rote rehearsal appeared to promote elaborative rehearsal in the situation where a child was able to keep track of one idea in a meaningful way. Probably this is what Teacher-B was referring to when she commented that voice-recorders enabled children 'to keep a record' or '… mak[e] a memory…' (see chapter 8).

The literature says that young children cannot hold more than one idea at the time due to poor memory performance (Cowan 1997b). The commentaries of a child and of a teacher of the case studies support this: the 5.6-year old said that it was a 'little bit' hard knowing what to say about his/her drawing (chapter 7) while teacher-B said that children have difficulty putting their ideas down on paper (chapter 8). Despite these commentaries, many children were able to overcome them due to the control provided by the design of the BDP (chapter 5), including this child who thought that it was hard, because they could rehearse mapping activities over and over.

Self-regulation

The self-regulation of concept or proposition labelling, a mapping-related task, was greatly improved because the BDP features enabled children to label ideas with voice-recorders and paper cards that fitted a small hand. In other words, they understood the tasks. See Figure 9.4

Figure 9.4 – self-regulating map building activities

Ideas represented with verbally-labelled symbols could be monitored for success (see Figure 8.7), as the child could decide how s/he wanted to represent it, and allowed correction of errors (see Figure 7.5). Some additional examples where children performed these aspects of self-regulation include: when a child changed the word tummy for stomach (chapter 7), or edited a drawing after being placed on the whiteboard (see Figure 8.9).

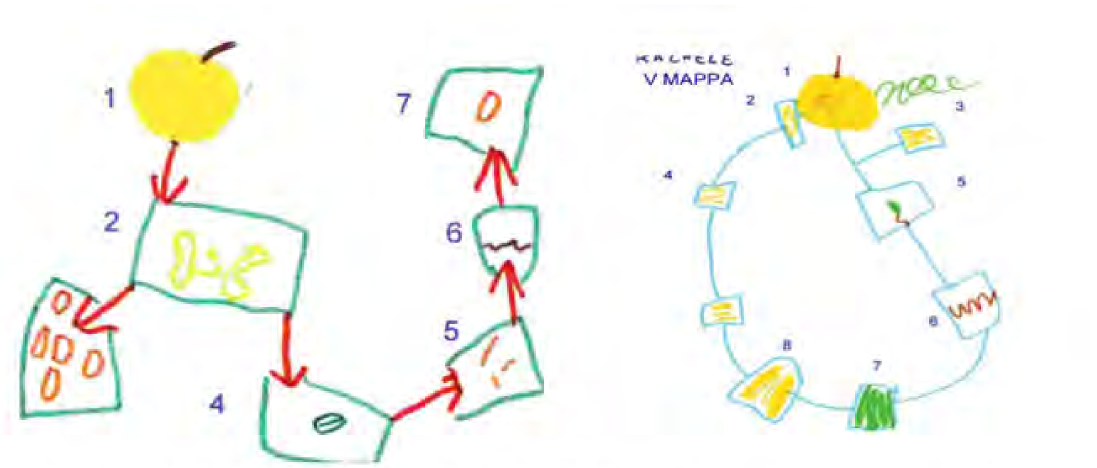
These examples show what Brown and DeLoache (1978 in Bransford, Brown & Cocking 1999) define as metacognition in the context of young children: the ability to self-regulate one's learning which is essential in the organisation of any piece of knowledge.

The work of Mérida (2002) and Mancinelli et al. (2004) also support the benefits of using mapping approaches that enable children to rehearse the skills of knowledge retention and self-regulation:

- Once an understanding of Mérida's mapping approach was achieved, the ability to use rehearsal strategies solved the issue of idea representation.

With practice, says Mérida (2002), her 5-year old students became better and better at self-regulating the activities involved in map building: drawing a concept with abstract symbols, drawing and colour-coding connecting lines relating these symbols, and representing hierarchical levels with ordinal numbers and boxes of different sizes.

- The symbol-based maps give evidence of their children's ability to use these cognitive skills, although Mancinelli and colleagues (2004) do not explicitly discuss such abilities in their report. The building of those maps required mastering the following activities (see Figure 9.3): planning how to represent an idea with a drawing, using knowledge retention to remember the essential parts of a pumpkin, and then, deciding the sequence in which the drawings should be connected to show the lifecycle of a pumpkin. This process was represented relating drawn conceptual ideas with connecting lines.



Two examples of pumpkin concept maps (each child built his/her map)

1. Entire pumpkin; 2. Broken pumpkin; 3. Seeds; 4. Leaf; 5. Pumpkin threads; 6. Soil; 7. Seed to plant.
1. Entire pumpkin; 2. Broken pumpkin; 3. Seeds; 4. Pumpkin threads; 5. Leaf; 6. Soil to plant seeds; 7. Color of leaf; 8. Color of seed.

Figure 9.5 – mapping structures created by two different 5-year olds about the pumpkin (Mancinelli et al, 2004, p 4)

The examples presented further support the claim that preschool concept mapping instruction can only be effective if the students map with tools supporting the use of known skills. Only under these conditions are children are fully capable to use the cognitive skills required for concept mapping.

Attention span

The average of 44 minutes, which the three children of case study one voluntarily spent in the mapping activity, challenges some views on young children's attention span (see chapter 7). While some experts say that young children cannot maintain attention on one particular activity (Piernot et al. 1995). Others, such as a forum teacher (FOD 2004a), state that at this age children's attention span is of 15-minute intervals. The teacher/director of case study one found children's steady concentration unsurprising. She had seen her children concentrate for long periods of time in activities that were of interest to them. Therefore, it can be claimed that the BDP features in the case of these children promoted concentration and reduced attention loss.

Knowledge sharing: active inquiry and meaning negotiation

Coffey *et al.* (2003) lists a device, group learning, and the learner her/himself as factors that promote knowledge organisation, active inquiry, and meaning negotiation in concept mapping. In chapter 2, these interactions were reported as essential to promote learning during the building of a concept map. Concept mapping, Coffey et al. continues, is greatly enhanced when these factors are present in the activity, as the nature of the learner's mental interactions with the subject being mapped is not passive.

Individually, with peers, or with teacher facilitation, children mapped concepts and propositions they knew about 'chicken eggs' or 'big cats' with the BDP features. The nature of the mental interactions that occurred while mapping (e.g. identification of a conceptual similarities and a missing concept) were not passive. Knowledge was organised with several mapping structures, as explained earlier in this chapter and this process promoted active inquiry and meaning negotiation. Knowledge organisation did not always revolve around the teacher; on the contrary, children could work autonomously, and some helped their peers (see chapter 8).

Autonomous object and content manipulation increased meaning negotiation, which was evident in the knowledge represented in the maps and in the comments made during the building process. One teacher described these interactions as characteristic of active learning by commenting that '…it wasn't my interpreting of their words, it was their words…' She also said that '…there was more active participation on their part rather than me, them sitting talking and me writing' (chapter 8).

The principle of active learning requires that the classroom have a stimulating environment, offering children many choices, provoking them to engage in many activities, and opportunities to represent their ideas in different media (Fraser & Gestwicki 2002). The children of case study two found the mapping activity stimulating because the BDP features offered them choices at labelling and manipulating knowledge. Instead of 'them sitting talking and me writing' as described by teacher-B (chapter 8), children were actively involved in meaning making, autonomously created something new, and constructed meanings product of intellectual processing, which are crucial requirements to learning (Smith & MacGregor 1992).

High levels of engagement were also seen in case study one when children autonomously operated BDP features and worked in topics they knew (Gomez, 2006). Motivation can be equated to 'wanting to learn', one of the conditions of Ausubel's theory of meaningful learning, which is also present when Novak's concept map are used according to the theory (see chapter 2). With motivation, people are 'most likely to learn something effectively when they experience success or progress that they regard as worthwhile and significantly challenging'(Crooks 2002).

When teacher facilitation changed to supporting children's own labelling process, the class dynamic changed and teacher became a partner. Teacher-B commented that teacher-student partnerships are 'very much the preschool mentality' and another characteristic of active learning (see chapter 8 for quoted comment). Teacher-student collaboration was evident when the BDP features and conceptual content were explained or reviewed one-to-one, at the child's individual request or the teacher's decision. Some children asked for conceptual help during representation e.g. 'How can I draw a lion's tail' and few others in operating voice-recorders. Mérida (2002) has also reported facilitating children during peer conversations on concept representation. In these occasions, teachers have acted less as expert transmitters of knowledge to students and more as expert designers of intellectual experiences for students -- as coaches … of a more emergent learning process (Belenky, Clinchy, Goldberg, & Tarule, 1985; Schön, 1983, 1987; Whipple, 1987 in Smith & MacGregor 1992, p. 11).

When children did not know how to make knowledge explicit with the BDP knowledge organisation, meaning negotiation and active inquiry were close to passive. When this situation occurred, the educational activity became teacher-led, and children's intrinsic motivation and focus lessened. It also changed the dynamic of the activity, and the results achieved. Also reported by the teachers of the five experiences (chapter 2), such situations occurred in both studies. In study one, the limited drawings skills of 'N' and 'C' slowed down the process of representation to a point that I could not demonstrate the rest of the activity. Instead I heavily mediated the drawing of the ideas, which limited their creative output. However, the transcripts showed that these children knew more about chicken eggs than what they drew.

A critical issue to resolve in preschool concept mapping is how to promote children's active inquiry and meaning negotiation at different stages of a concept mapping activities. Only when children have been instructed to build self-created symbol-based maps, such as in my case studies (chapters 7 and 8) and the experiences reports of Mérida (2002) and Mancinelli and colleagues (2004), aspects of collaborative learning, meaning negotiation, and active participation become noticeably higher. These uncommon mapping experiences allowed the emergence of children's individuality at drawing representation and activity understanding. The results of this research in terms of collaborative learning are discussed in Gomez (In press).

Unexpected outcomes

Children with special needs

As anticipated in the expanded design requirements (chapter 5), the inclusive characteristics of the BDP facilitated teachers and children to work together, and lessened training time. It was unexpected that this requirement would also benefit children with mild special needs. Two examples illustrate:

- 'N', the 4.6-year old, had a mild speech problem, which the teacher/director of case study one brought to my attention. In our interactions, the child and I had difficulties understanding each other: the child kept correcting the way I pronounced his name and other words. I thought that my English accent created the communication difficulties until the teacher clarified the child's problem to me.

- I was not aware I was working with an autistic child, until one of the teachers of case study two brought this to my attention during the activity with the Leopards. The child, supported by the assigned aid, finished a verbally-labelled symbol. The characteristic of the BDP that stood out for the teachers of this child was the ability to revisit the work done at own discretion and of peers. They explained that repetition is important for helping autistic children to achieve goals. The voice-recorders enabled this child to autonomously rehearse this skill by pushing the buttons at own will and without direct teacher assistance.

Another unexpected outcome was a 6-year old of case study two using written language for the first time during the activity. Teacher-A was thrilled with this behaviour (see quote, chapter 8).

The teachers of case study two have suggested using the BDP with autistic children or with 4-year olds, while experts at professional meetings (see chapter 5) have asked if the BDP could be used for teaching phonics or with older children with special needs. These suggestions and questions are worthy of further investigation.

So far the unexpected outcomes show that the BDP promotes autonomous participation and the characteristics of an inclusive classroom. The case studies' teachers experienced a way to design collaborative activities that integrated children at different levels of development: pre-literates, emergent writers and children with special needs (Gomez In press).

Non-typical tools

Voice-recorders are not found in current educational materials for this age group. Teacher-A and teacher-B said that the BDP was unique, in their experience, as a tool for supporting peer action and peer teaching when sharing thoughts. While they sometimes use tape records these are different due to the affordances and constraints of this device when compared to the voice-recorders used in this study.

Designer involvement

Teachers usually design their classroom materials or buy them from trusted educational providers. The teacher/director in study one expressed loving the idea of having a Designer in the classroom to assist her with material development. Teacher-B in study two was impressed by the tool design, as she thought it needed a teacher to design effective educational materials (Gomez 2007). Teacher-B's comment was:

> We set up our activities that way... The activities that we do we try to set up so there can be peer interaction, peer teaching and things like. But not anything that's a tool like this that has been made… by someone else. It is usually made by us [laugh] You created something that can be used, I think, with preschool, but I am thinking, you know, middle school... you can use this from K through college. It is a great tool.

The BDP method has been shown to be effective for designing practical educational resources that are ready for immediate use in the classroom. The favourable design comments confirmed the expert design advice, which was used in the prototype development. This advice included to study child development (Brouwer-Janse et al.

1997), find out the 'true' needs of users (Norman 1999), and consult informants on teacher availability and classroom limitations.

Future Work

In the case studies, I analysed the interactions of children and teachers with the BDP from an interaction design perspective. However, the circumstances, age of the children and the children's actual response to the exercise presented could have myriad explanations such as from developmental and educational perspectives. For example one perspective that has been done is by Casatta-Widera (2008a) who presented in her doctoral work, interactions of a group of 5- to 6-year olds and their teachers with my BDP. As intended in this research, she adapted the BDP for preschool concept mapping to the circumstances of her own research and analysed children's and teacher's interactions with this tool from a developmental psychology perspective. Further investigation should look into teacher's bias about direct instruction, play and instruction, children and memory.

While this thesis suggests that the BDP for preschool concept mapping has had the effect of some children producing concept maps that meet Novak's criteria, further research needs to be undertaken to provide empirical evidence. That is, clinical trials need to be undertaken to evaluate the level and generalisability of the BDP outcomes.

Conclusions

The purpose of this research was to investigate the claim that preschool children will be able to make knowledge explicit with Novak's concept maps if provided with a tool that allows them to label symbolic representations with verbal inputs. This type of concept mapping tool will promote children's autonomy during concept manipulation and facilitate teacher mediation. To investigate this claim and using the Bridging Design Prototype (BDP) method, a functional prototype was developed that teachers agreed to incorporate into classroom activities. The BDP method is original to the research and grounded on user-centred design and constructivist learning principles.

The BDP for preschool concept mapping allowed me to observe members of two preschool communities in their natural setting, the classroom, performing concept mapping related activities. The modest results of the case studies, discussed in the first part of this chapter, cannot be generalised. However, they are promising considering the participant children interacted with the BDP for only one session, for less than an hour, and with very little instruction. In this section, the concluding remarks of this doctoral research are presented, addressing claims and issues introduced in chapter 1.

Promoted autonomy and multiliteracy, facilitated instruction

The BDP features (see Table 4.2) promoted authoring and multiliteracy at making knowledge explicit because its structuring features scaffolded children's control over every aspect of the map building and their ability to choose how they wanted to represent concepts or propositions. Having control over building activities and being able to choose how to label knowledge (e.g. use voice, drawing and/or emergent writing): 1) enhanced self-idea exploration and explicit representation of conceptual and propositional meanings, 2) increased levels of engagement, peer-to-peer collaborative interactions, and transformed teacher facilitation into a partnership. A child's level of autonomy increased or lessened during map building in accordance with their prior knowledge, ability to operate devices, and teacher direct mediation.

Under the constraining conditions of the case studies, the BDP performed well and met the design criteria related to teachers' needs (see chapter 5), such as it required little training, was easily integrated into classroom activities and not demanding of teachers' time, was flexible to adaptation, and allowed children at different developmental stages to work on the same activity (pre-literates, emergent writers and an autistic child) (Gomez In press).

Characteristics of Novak's concept maps

The results of the case studies showed that the participant children could perform concept mapping-related activities with or without teacher assistance: 4.6-year olds and beyond could label symbols, 5-year olds and beyond could label symbols, organise labelled symbols with arrows, and if instructed, demonstrate the potential of these children to structure labelled symbols using hierarchy.

We do not yet know if the BDP facilitates instruction of Novak concept maps in preschool, as this could not be evaluated. However, we know that BDP features facilitated:

- The representation of the constitutive elements of Novak concept maps, (concepts, propositions, linking phrases, connecting lines) and that due to BDP design, these elements can be easily manipulated.

- The instruction of concept mapping-related skills. Some children demonstrated the ability to add conceptual or propositional meanings to symbols with verbal inputs. Verbal labelling of symbols facilitated the manipulation, sharing, and organisation of knowledge that was represented in the form of concepts and propositions. On at least one occasion the verbal labelling of symbols was shown to facilitate knowledge retention. Novak's concept maps promote meaningful learning because they facilitate knowledge retention, sharing and preservation. Two of these characteristics were present in the children interactions with the BDP.

Incorporation of voice-recorders into the BDP in order to enable symbol labelling and inclusion of linking phrases was pivotal to children negotiating meanings alone, with a teacher, and/or with peers. Originally Novak's concept maps did not include linking phrases (Novak & Gowin 1984) which were only later added to enhance understanding (Novak & Cañas 2006b). In Novak's earlier maps knowledge mapping occurred as the concepts were hierarchically organised, but the relationships among mapped concepts were only made explicit with the incorporation of linking phrases. A comparison can be drawn: the experience reports of Mérida (2002) and Mancinelli et al. (2004) have shown that symbol-based maps enabled their students to organise knowledge with self-generated drawings. Knowledge mapping is also occurring with these teacher approaches (chapter 2), but a child's understanding of a topic is either partially explicit or inexplicit and depends of the mastery of drawing representation skills.

The maps created by the children with the BDP in the case studies (chapters 7 and 8) showed that verbally-labelled drawings make knowledge explicit, despite the poor quality of a child's drawings. Therefore, it can be claimed that inclusion of linking phrases (as part of or separate to a proposition) with written or verbal language is needed for enhancing autonomy, participation, active inquiry, and meaning negotiation in preschool concept mapping. All of these are important activities (or interactions) resulting from using the elements of Novak's concept maps in the representation of organised knowledge.

Capable of concept mapping

Introduced in chapter 1 section 'background', the research outcomes provide support for Novak's claim '…young children learn quickly how to make good concept maps…' (Novak 1998, p. 31). The case studies have shown that the 22 preschool children, aged 4.6 years and beyond, who participated in the case studies are developmentally ready to make concept maps, and that with practice, their relevant mapping-related skills can be improved. However, such ability depends on effective teacher instruction and suitable tools. The following accounts show that the key capabilities relevant for concept mapping were present in the observed interactions of the children with the BDP:

- **People think with concepts:** children in this age group think with concepts and propositions (knowledge), and communicate this knowledge fluently with spoken language (see Table 7.1, Table 7.3, and Table 7.5), and (when instructed) with symbols (see Figure 2.1 and Figure 2.3), verbally-labelled symbols (see Figure 7.2 and Figure 7.6), as well as verbally-labelled symbols and/or written language (see Figure 8.1 and Figure 8.5) .

- **Children and adults use similar processes for learning:** the 5- to 6-year olds of case study one, teacher-A of case study two, and the 5-year-old students of Mérida (2002) all employed similar knowledge structures or patterns for representing organised knowledge, see Figure 9.3. The verbally-labelled symbols and the verbally-labelled pattern showed how children assimilate concepts into their cognitive structure. Evidence of this assimilation process includes: 1) the language used (such as correctness or quality of vocabulary), 2) image matching voice-recorded meaning, and 3) use of idiosyncratic or formal language.

- **The conditions of meaningful learning** were present. The BDP features allowed children to represent prior knowledge, use familiar representational languages, and motivated them to spend time in the mapping activities despite developmental challenges. These conditions were especially evident in the mapping activity of the 5.6-year old of case study one (see chapter 7), who voluntarily participated in the activity during free-play time for around 70 minutes. Also see section 'concept mapping-related characteristics' of this chapter for a discussion on these conditions in relation to the research outcomes.

- **Using and interpreting symbols:** these children show the human capacity to use and represent symbols donated by the culture or learnt via schooling. However, instruction is needed for helping them to use 'hierarchy' (see subheading 'use of hierarchy' in this chapter). Hierarchy is an abstract symbolic representation that is not systematically instructed in preschool. In this thesis (chapters 2 and 8, and discussion section of chapter 9), some examples have been presented and discussed which provide insights for the development of instructional programmes about the concept of 'hierarchy' in preschool.

Recognition of visual information is a human capacity required in concept mapping. Verbally-labelled symbols (audiovisual image) enabled children to independently establish conceptual similarities between maps, an error in a pattern organisation. With teacher facilitation, these symbols enabled children to: 1) identify similarities between propositions, 2) see misconceptions, 3) a missing concept, as well as 4) organise concepts in clusters. (See discussion of research results supporting this claim in section 'mapping knowledge of this chapter.)

The preschool experts' beliefs reported in chapter 2 are also supported by the outcomes of this research. Concept maps have the potential to become as powerful as drawings and clinical interviews in disclosing what children know with their own vocabulary and multiliteracy skills. Together with the supporting comments of the teachers of the case studies (see section 'facilitated instruction?'), these results show that children can be taught to use concept maps systematically, similar to the way they currently are instructed in the use of art techniques (Edwards, Gandini & Forman 1998), observational drawing (Brooks 2004), and webs of knowledge (Helm & Katz 2001).

Preschool concept mapping

This research has shown the value of investigating issues in preschool concept mapping from a design perspective. Incorporating the BDP in the classroom showed how concept mapping could be made age-appropriate. It also presented a window for understanding preschool mapping issues and provided insights into how these could be addressed. These mapping issues were heavy teacher mediation during the map building due to unlabelled symbols or absence of linking phrases, long hours of instruction due to unsuitable mapping tools, and difficulty in understanding the concept of hierarchy or making conceptual relationships with arrow-head connecting lines.

In my view, the design approach taken to investigating these issues produced results that show that preschool children's inability to make Novak's concepts maps is primarily knowledge, not developmentally, related. The literature has shown that in a variety of preschool programmes children are capable of performing beyond developmental limitations, if provided with appropriate instruction (Brooks 2004; Cadwell 2003; *Construction kits made of atoms and bits - CAB project* n.d.; Edwards, Gandini & Forman 1998; Hill 2004).

Considered as a whole, my doctoral research, the research and teacher experiences in preschool concept mapping (chapter2), the literature reviews, and the forums cited in this thesis, together show that children's cognitive skills for concept mapping can be developed, but that the curriculum, teacher biases, and lack of effective instruction and tools are important obstacles.

An educationally sound and effective implementation of Novak's concept maps has yet to be developed for the preschool classroom. Developing and testing prototypes similar to the BDP would be a useful way of stimulating productive discussions. Such work could lead to the implementation of a tool that facilitates the rehearsal of concept mapping-related skills, and if successful its eventual dissemination as part of the universal preschool curriculum (Gomez 2006). My research to date has contributed to the area of early childhood research and practice by providing evidence which shows that equipping children with suitable interaction elements helps them to overcome representational and developmental limitations when concept mapping. The interaction features of the BDP allowed: 1) teachers to make map adaptations while avoiding the pitfalls of previous approaches, which in many cases transformed an otherwise autonomous and meaningful activity into a heavily directed rote-learning task; 2) experts to investigate the significance and effectiveness of concept mapping in the classroom.

A child's inability to make maps as stated by Novak can be catalogued as knowledge visualisation issue. We should remember that the concept map template was initially the visual interface solution to a design problem: how to represent and manipulate the content of audiotaped transcripts of interviews tracing changes in children's understanding of science concepts. The concept map facilitated researchers to track conceptual changes over time (Novak & Cañas 2006a). See a quote explaining he invention of concept maps in chapter 1– in the section 'a visual representation of three aspects of Ausubel's theory.

Investigating users in their natural setting

My research to date has contributed to Interaction Design by showing how user-centred, participatory and inclusive design methods can be adjusted for investigating user communities in their natural settings. The BDP method has been demonstrated to be an effective and a practical way to investigate theoretical ideas in real settings at a low cost to users and to the researcher. It provides a good example of how to investigate the performance of interactions, activities or tasks in difficult-to-access and technologically disinclined communities.

The prototype performed well under very restrictive preschool conditions, demonstrating that the BDP method (chapter 3) was an appropriate inquiry approach. It helped to identify the gaps between theory and practice in relation to children's concept mapping (chapter 4), and the design requirements appropriate to address these gaps. This led consequently to the development of a functional prototype built on the prior knowledge of the user community. Incorporating the BDP for preschool concept mapping into classroom activities:

- Allowed investigation of the research issues and claims
- Showed what the children were or were not able to do with it as well as revealed unexpected interactions
- Easily adjusted to the communities' needs
- Provided insight into the reasons for the limited use of concept mapping in preschool classrooms at present. Teachers biases were made evident through the use of the BDP and their comments about the children's interactions with it
- Challenged (and in some cases changed) the views of teachers as to the age-specific capabilities of children
- Identified areas of learning not currently addressed in the preschool curriculum that are important for concept mapping instruction, such as teaching of the concept of hierarchy, using abstract symbols such as arrows, or separating propositions into concepts and linking phrases.

My research outcomes lead me to assert that BDPs can be a useful strategy in gaining access to a user community, provide exposure to context that can lead to a more realistic user profile, reveal other users, biases, and identify innovative ideas useful in the product development process. One other important quality of BDPs is that they are functional and can continue to be employed if the community desires this after the research has concluded. Using the BDP it is possible to apply in the preschool classroom, Norman's (1999) suggestion on the value of observing users performing tasks relevant to the product to be designed.

Designing from the users' viewpoint enabled the designer to develop a product that really communicated with the preschool community. The tool created was open-ended, enhanced hands-on experiences, and reflected the theory of child development and strategies for stimulating thinking (Gomez 2006).

The BDP for preschool concept mapping is sufficiently intriguing and attractive that teachers who have been exposed to it to want to try it, even though concept mapping as a learning strategy is still not employed in Australian educational institutions at a preschool level. Work needs to be done to convince Australian early childhood educators of the benefit of such an approach. For those countries and teachers in the rest of the world who are already using concept mapping, this research has produced a tool that overcomes one of the most significant barriers: that of enabling preschool children to make symbolic knowledge explicit, include linking phrases, and abstract concepts. The work of Cassata-Widera (2008a; 2008b) is a practical example of just described.

In my opinion, the BDP method is an emergent prototyping method to design and investigate interactions that could possibly lessen transgenerational divides and digital divides in a variety of societal problems. One application that I can immediately see is that the BDP method could be used for designing technology systems that lessen the instruction curve for learning how to operate a device. The BDP for preschool concept mapping showed such characteristics in the case studies.

Research limitations as strengths

Descriptions of future work, or of work which was not undertaken, may often be viewed as limitations in the context of research. With design research projects however this is not necessarily the case. Here they were seen as opportunities for learning about the user community and the issues surrounding preschool concept mapping.

Given my topic, the biggest research limitation was not being able to instruct Novak's concept mapping. This reflected an educational gap in the culture of early childhood education. Tools such as the one developed for this research can help overcome those gaps.

Limitations of the studies included that they were not suitably controlled, and that systematic gathering of data was not possible. Reasons for this were lack of research assistance, limited technical resources, and adjustment of research schedules due to teaching activities and classroom routines. For example, with regard to research assistance, case study one required considerable preparation and role taking. I assumed two roles, those of teacher and observer, which made onsite data collection quite difficult. To overcome this problem I relied heavily on my audio-recordings to make the research verifiable. In case study two I planned to correct some of the observation-related issues identified in case study one, but again this was not possible because sudden changes in teacher schedules which pushed the activity forward a week disrupting my preparation schedule. Observations in case study two were easier but still difficult, as I was not only taking observations but also assisting teachers. Because of the described situations, data gathering was difficult. I found that one video camera was not sufficient to record all the interactions of individual and group activities. In any future classroom studies I would plan to address these types of issues.

However, these aspects of limited planning, limited interactions with the teachers, and little control over the activity undertaken, provided an unexpected opportunity for me, the researcher and designer, to experience the reality of the users' context and to evaluate the BDP performance under such stress. Interaction designers should become accustomed to this kind of setting: where challenges, difficulties and unplanned situations will occur. Including this PhD my design career has covered almost 14 years. This project was the first time that I have been actually able to directly evaluate my designs with the users. Designers in professional employment hardly ever get the opportunity to interact with the users during prototyping. Knowledge about the user is usually passed down from executive management and testers. The literature on user-centred, participatory and inclusive design calls for companies to enable designers to get closer to their users (Keates & Clarkson 2003; Norman 1999; Schuler & Namioka 1993). Due to this call and when the designer is part of a big team, the industry is changing for the good of the user. However, in my view very little is happening at the level of the small design firm, which typically cannot afford to practice extensive user-centred design research.

My BDP method is a way for designers working in small firms to respond to this need. As described in chapter 3, if it is not possible to work with the user-community during the prototyping stage, there are approaches for creating user-centred prototypes that users may find acceptable for incorporation into their activities. For investigating relevant interactions, designers can learn about the users' needs from relevant literature, talking to key informants, and when possible, testing the ideas with sections of the target group. The results of my research show that these can be valid ways to get closer to the users.

Breakthroughs

Interactions with the BDP helped refine the user community profile, clarify concept mapping issues, and recognise unexpected innovations. Breakthroughs were identified that will greatly benefit this product's further development. They not only suggested relevance to the design of effective knowledge representation tools, but also to the design of technologies for applying inclusive education concepts to the preschool classroom.

Voice-input

Educational devices that harness children's speech for learning are not usually found in preschool. This research has opened the door for developing products that build on this idea. This study has shown that voice input/output promotes autonomy and peer-to-peer interactions. Children could easily 'off-load' or put their thoughts, or knowledge, down for representation, communication and sharing.

Mapping with verbal symbols

As discussed earlier, concept mapping occurred when children and teachers revisit verbal labels representing their knowledge. The BDP encourages and supports this activity, as occurs with Novak's concept maps and other visual techniques.

Understanding of computer technology

The case studies provided some useful information about how these preschool teachers perceived computer technology and for understanding why it was not possible to incorporate a computer-based BDP in the classroom (chapter 5).

Teacher/director of case study one dislikes computers in the classroom, and when asked why, stated that her students played enough computer games at home, and preschool should offer hands-on and philosophising experiences. Teachers of case study two did have computers in the classroom and encouraged children to use them during free-choice time. However, student interactions with them were organised around specific activities (Gomez 2007).The director said that if an activity could be done with a different resource, computers would not be used.

Despite their low engagement with computer technologies, the studies' teachers quickly embraced the idea of using the voice-recorders with their students, which shows that they had a limited understanding of technology embodiment. One reason for these teachers embracing the voice-recording technology can be that while desktop computers were considered 'harming' or limiting to the students, self-contained and tangible small computer devices were not, perhaps because they looked like tangible objects that belonged in the classroom. Research on tangible computerised objects for educational play has had a big push in the last decade (chapter 5), but its educational relevance to the preschool classroom has only been of recent interest.

In my view, preschool teachers may embrace computer technologies that easily integrate into their classroom activities and facilitate their young students, including those with special needs, to rehearse high cognitive skills such as those required for concept mapping (Gomez 2007)

Overall, the results of this doctoral work are positive with regard to preschool children's ability to undertake autonomous knowledge representation with concept mapping. Through this research, an effective child-friendly alternative to Novak's concept map template has been designed and tested. The research outcomes show that it facilitates interactions that put children in charge of a mapping process that makes their own knowledge explicit.

As shown by my case studies and the case study of Casatta-Widera (2008a), this alternative tool is ready to be applied in preschool classrooms interested in developing instruction for concept mapping and investigating the relevance of this learning tool to the areas of child memory, development and instruction, and early literacy. The outcomes of these exploratory case studies show that it's worth investing time in these types of inquiries.

The usefulness of the designed alternative tool in terms of teaching is that teachers, through evaluating children's mapping productions, may be able to make judgments in regard to conceptions and misconceptions of preliterate and emergent writing students. In terms of limitations, it is not known yet whether an instructional programme can be designed to allow children to represent the hypothetical map of Figure 1.3. So far we know students can represent sections of it if teacher facilitation is effective.

In addition, this research has identified breakthroughs in relation to tangible technologies for the preschool classroom that promote inclusive interactions among children of different developmental capacities. Ongoing refinement and continued development of the BDP should occur, in the context of activities which connect with preschools interested in incorporating concept mapping.

Summary

This chapter has discussed the results of case studies, and presented research conclusions and future work.

The significance of this doctoral research is underpinned by the different situations that the case study participants saw for the BDP in the classroom. Using this tool in teacher-led and free play activities revealed issues preventing the successful incorporation of concept mapping in the preschool classroom.

The design of the BDP features brought child autonomy during map building when they were instructed on how to operate them. Their ability to perform mapping-related activities shows that automation, direct manipulation, easy to use, and adaptability to any classroom setting are essential aspects of a child-friendly alternative to Novak's concept maps.

The representation of knowledge with Novak’s concept map template was not instructed. However, the constitutive elements of this template, concepts, linking phrases, arrow-connecting lines, were present in the mapping structures that were built by children and teachers, alone or in company. The alternative mapping structures enabled students to represent synthesis of thinking processes. They showed patterns of information that facilitated evaluation of knowledge that children had organised with verbally-labelled symbols and/or arrows.

Concept mapping-related characteristics (knowledge retention, self-regulation, and sharing) and the conditions of meaningful learning (prior knowledge, familiar languages, and wanting to learn) were only present when children autonomously represented elements of the map. Teacher facilitation and instruction was also transformed into a partnership under the described conditions.

The BDP features facilitated preliterate and emergent writers to perform mapping activities normally only perform by teachers, showing that the issues in preschool concept mapping are related to lack of effective tools and instruction, and not to a child’s stage of development, as it has been reported in the literature.

Bibliography

Africano, D, Berg, S, Lindbergh, K, Lundholm, P, Nilbrink, F & Persson, A 2004, 'Designing tangible interfaces for children's collaboration', *Proceedings: CHI'04 Extended Abstracts on Human Factors in Computing Systems,* ACM Press Vienna, Austria, pp. 853 - 868, http://doi.acm.org/10.1145/985921.985945

Alí-Arroyo, E 2004, 'Desarrollo de mapas conceptuales con niños de kinder y primer grado', *Proceedings: First International Conference on Concept Mapping,* Universidad Publica de Navarra, Pamplona, Spain, http://www.cmc.ihmc.us/papers/cmc2004-038.pdf, viewed 15 November 2004.

Anning, A & Edwards, A 1999, *Promoting children's learning from birth to five: developing the new early years professional,* Open University Press, Buckingham, Philadelphia.

Ausubel, DP 1968, *Educational psychology: a cognitive view,* Holt, Rinehart and Winston, Inc., New York.

Ausubel, DP, Novak, JD & Hanesian, H 1978, *Educational psychology: a cognitive view* 2nd edn., Holt, Rinehart and Winston, New York.

Badilla, S 2004, 'Experiencia pedagógica: mapas conceptuales en preescolar', *Proceedings: Memorias del V Congreso Nacional de Educadores. Programa Nacional de Informatica Educativa MEP-FOD (Preescolar, I y II Ciclos),* Septiembre 3 - 4 San Jose, Costa Rica, http://www.fod.ac.cr/Vcongreso/CronoPonencias.htm, viewed 15 October 2004

Benyon, D, Turner, P & Turner, S 2005, *Designing interactive systems: people, activities, contexts, technologies,* Addison-Wesley, Harlow.

Beyer, H & Holtzblatt, K c1998, *Contextual design: defining customer-centered systems,* Morgan Kaufmann, San Francisco, California.

Birbili, M 2006, 'Mapping knowledge: concept maps in early childhood education', *Early childhood research and practice*, vol. 8, no. 2, http://ecrp.uiuc.edu/v8n2/birbili.html

Bjorklund, DF 2000, *Children's thinking: developmental function and individual differences,* 3rd edn., Wadsworth, Australia.

Bjorklund, DF & Douglas, RN 1997, 'The development of memory strategies', in Cowan, N (ed) *The development of memory in childhood*, Psychology Press, Hove, East Sussex, UK, pp. 201-246.

Blackler, A, Popovic, V & Mahar, D 2003a, Designing for intuitive use of products. An Investigation, paper presented at the 6th Asian Design Conference, Tsukuba, Japan, viewed 2005, http://test.eprints.qut.edu.au/1441/1/Designing_for_intuitve_use_of_products.An_investigation.pdf.

Blackler, A, Popovic, V & Mahar, D 2003b, 'The nature of intuitive use of products: an experimental approach', *Design Studies*, vol. 24, no. 6, pp. 491-506.

Blackler, A, Popovic, V & Mahar, D 2004, 'Intuitive interaction with complex artefacts', *Proceedings: Futureground Design Research Society International Conference,* Melbourne, Australia, http://eprints.qut.edu.au/2065/1/intuitive_interaction_with_complex_artefacts_FutureGround.pdf

Boggino, N 1997, *Como elaborar mapas conceptuales en la escuela,* Ediciones Hommo Sapiens, Rosario.

Bransford, J, Brown, AL & Cocking, RR (eds), 1999, *How people learn: brain, mind, experience and school* National Academy Press, Washington, D.C.

Britton, LA & Wandersee, JH 1997, 'Cutting up text to make moveable, magnetic diagrams: a way of teaching and assessing biological processes', *The American Biology Teacher*, vol. 59, no. 5, May, pp. 288-291.

Brooks, M 2004, 'Drawing: the social construction of knowledge', *Australian Journal of Early Childhood*, vol. 29, no. 2, June 2004, pp. 41-49.

Bruner, JS 1988, 'The course of cognitive growth', in Sheldon, S (ed) *Cognitive development to adolescence: a reader*, Psychology Press, New York, pp. 33-60.

Bruner, JS 1997, *The culture of education,* Harvard University Press, Mass.

Buchanan, R 2005, 'Design as inquiry: the common future and current ground of design', in *Futureground Proceedings of the Design Research Society Conference 2004* Monash University, Melbourne, Australia, pp. 21.

Cadwell, LB 2003, *Bringing learning to life: the Reggio approach to early childhood education,* Teacher College Press, New York.

Cañas, AJ & Novak, JD (eds) 2006, 'Concept maps: theory, methodology, technology', *Proceedings: Second International Conference on Concept Mapping,* University of Costa Rica, San José, Costa Rica, http://cmc.ihmc.us/cmc2006/CMC2006Program.html

Cañas, AJ, Novak, JD & González, FM (eds) 2004, 'Concept maps: theory, methodology, technology', *Proceedings: First International Conference on Concept Mapping,* Universidad Publica de Navarra, Pamplona, Spain, http://cmc.ihmc.us/CMC2004Programa.html

Cañas, AJ, Reiska, P, Ahlberg, MK & Novak, JD (eds) 2008, 'Concept mapping: connecting educators', *Proceedings: Third International Conference on Concept Mapping,* Tallinn University, Estonia, http://cmc.ihmc.us/cmc2008/cmc2008Program.html

Case, D & Bauder, D 2001, Incorporating all individuals in Math & Science. Inclusive strategies using AT: Bringing AT into regular education curriculum, PowerPoint presentation, http://kysig.louisville.edu/handouts/EASTConf.ppt, viewed , October 2004.

Cassata, AE & French, L 2006, 'Using concept mapping to facilitate metacognitive control in preschool children', *Paper presented at the Second International Conference on Concept Mapping,* San Jose, Costa Rica, University of Costa Rica, pp. 598-605, http://cmc.ihmc.us/cmc2006Papers/cmc2006-p247.pdf

Cassata-Widera, AE 2008a, 'Concept mapping and early literacy: a promising crossroads', *Paper presented at the Third International Conference on Concept*

Mapping, Tallin, Estonia & Helsinki, Finland, September 22-25, Tallin University, pp.189-196, http://cmc.ihmc.us/cmc2008papers/cmc2008-p123.pdf

Cassata-Widera, AE 2008b, 'Fostering metacognitive control, skills in the kindergarten classroom using concept maps', *Poster presented at the Annual Meeting of the American Educational Research Association,* New York, NY.

Chi, MTH 1976, 'Short-term memory limitations in children: Capacity of processing deficits?' *Memory & Cognition*, vol. 4, no. 5, pp. 559-572.

Clements, DH 1997, *'Effective use of computers with young children',* non-refereed opinion paper sponsored by the National Science Foundation, Arlington, VA pp. 24, http://www.eric.ed.gov:80/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/80/15/f7/39.pdf

Coffey, JW, Carnot, MJ, Feltovich, PJ, Feltovich, J, Hoffman, RR, Cañas, AJ & Novak, JD 2003, *A Summary of Literature Pertaining to the Use of Concept Mapping Techniques and Technologies for Education and Performance Support,* IHMC - Institute for Human and Machine Cognition, Pensacola, FL, pp. 108, http://www.ihmc.us/users/acanas/Publications/ConceptMapLitReview/IHMC%20Literature%20Review%20on%20Concept%20Mapping.pdf

Construction kits made of atoms and bits - CAB project, n.d., http://web.archive.org/web/20040504061743/cab.itd.ge.cnr.it/cab/home.htm, viewed September 2004.

Cowan, N (ed) 1997a, *The development of memory in childhood*, Psychology Press, Hove, East Sussex, UK.

Cowan, N 1997b, 'The development of working memory', in Cowan, N (ed) *The development of memory in childhood*, Psychology Press, Hove, East Sussex, UK pp. 163-199.

Crooks, T 2002, Assessment, accountability and achievement - principles, possibilities and pitfalls, in *Keynote address to the annual conference of the New Zealand Association for Research Education,* Palmerston North, NZ.

Curtis, D & Carter, M 2000, *The art of awareness: how observation can transform your teaching,* Redleaf Press, St Paul, MN.

Curtis, D & Carter, M 2003, *Designs for living and learning: transforming early childhood environments* Redleaf Press, St. Paul, Minn.

Dorsey, DW, Campbell, GE, Foster, LL & Miles, DE 1999, 'Assessing knowledge structures: relations with experience and posttraining performance', *Human Performance*, vol. 12, no. 1, pp. 31-57.

Dwyer, J 2005, 'Beware the child glued to his handheld', http://www.smh.com.au/news/opinion/beware-the-child-glued-to-his-handheld/2005/08/04/1123125851928.html, viewed 5 August 2005.

ECT interview: computers and young Children, 1999, http://www2.scholastic.com/browse/article.jsp?id=3745649, viewed 13 July 2008, Edwards, A 2001, 'Qualitative designs and analysis', in MacNaughton, G, Rolfe, SA and Siraj-Blatchford, I (eds), *Doing early childhood research: international perspectives on theory and practice*, Alen & Unwin, Crows Nest, Australia, pp. 117-135.

Edwards, C, Gandini, L & Forman, G (eds) 1998, *The hundred languages of children: the Reggio Emilia approach--advanced reflections*, Ablex, Greenwich, Conn.

Elliott, A & Hall, N 1997, 'The impact of self-regulatory teaching strategies on "at-risk" preschoolers' mathematical learning in a computer-mediated environment', *Journal of Computing in Childhood Education* vol. 8, no. 2-3, pp. 187-198.

Figueiredo, M, Lopes, AS, Firmino, R & de Sousa, S 2004, 'Things we know about the cow: concept mapping in a preschool setting', *Paper presented at the First International Conference on Concept Mapping,* Universidad Pública de Navarra, Pamplona, Spain, http://cmc.ihmc.us/papers/cmc2004-038.pdf

Fisher, J 2002, *Starting from the child: teaching and learning from 3 to 8.,* 2nd edn., Open University Press, Buckingham [England], Phildelphia.

Fleer, M 1996, 'Early learning about Light: mapping preschool children's thinking about light before, during and after Involvement in a two week teaching program', *International Journal of Scientific Education*, vol. 18, no. 7, pp. 819-836.

Flyvbjerg, B 2006, 'Five misunderstandings about case-study research', *Qualitative Inquiry*, vol. 12, no. 2, April 2006, pp. 219-245.

FOD 2004a, *Foro en linea con Doña Eleonora Badilla-Saxe en preparacion del V Congreso Nacional de Educadores PRONIE ME-FOD, Preescolar, I y II Ciclos*, http://www.fod.ac.cr/Vcongreso/CronoPonencias.htm

FOD 2004b, *Foro en linea de las inquietudes iniciales de los tutores previas al foro con Doña Eleonora Badilla-Saxe*, http://www.fod.ac.cr/Vcongreso/ChatEleonora.htm, viewed 15 October 2004.

Foley, J n. d., 'Key concepts in ELT: scaffolding ', *ELT Journal*, vol. 48, no. 1, p. 2.

Fraser, S & Gestwicki, C 2002, *Authentic childhood: exploring Reggio Emilia in the classroom,* Delmar, Thomson Learning, Canada.

Giudici, C, Rinaldi, C & Krechevsky, M (eds) 2001, *Making learning visible: children as individuals and group learners*, Reggio Children S.r.l., Reggio Emilia, Italy.

Gomez, G 2005a, 'Factors in designing concept mapping tool for 3-to-5 year olds', *Proceedings: University of Queensland Interaction Design Postgraduate Students Conference,* University of Queensland, Brisbane Australia, pp. 45-48, http://www.itee.uq.edu.au/%7Equid/proceedings-web.pdf

Gomez, G 2005b, 'Young children's use of a voice-input device to transform their symbolic maps into concept maps', *paper presented at the conference Our Children the Future 4 - OCTF 4,* July 16 - 19, Government of South Australia and DEST South Australia, Adelaide, Australia, http://www.octf.sa.edu.au/files/links/gome_1.doc

Gomez, G 2006, 'An authoring concept mapping kit for the early childhood classroom', *Proceedings: Second International Conference on Concept Mapping,* Cañas, San José, Costa Rica, University of Costa Rica, pp. 32-38, http://cmc.ihmc.us/cmc2006Papers/cmc2006-p200.pdf

Gomez, G 2007, 'A bridging design prototype for investigating concept mapping in the preschool community', *CHI '07 Extended Abstracts on Human Factors in Computing Systems,* San Jose, California, USA, April 28-May 3, ACM, pp. 174-1752, http://doi.acm.org/10.1145/1240866.1240894

Gomez, G , c2010, 'Enhancing autonomy, meaning negotiation, and active inquiry in preschool concept mapping', in Torres, PL and Marriott, RCV (eds), *Handbook of Research on Collaborative Learning using Concept Mapping,* Hershey, Information Science Reference, pp. 384-409.

Greene, TR 1994, 'What kindergartners know about class inclusion hierarchies', *Journal of Experimental Child Psychology* vol. 57, no. 1, pp. 72-88.

Guha, ML, Druin, A, Chipman, G, Fails, JA, Simms, S & Farber, A 2004, 'Mixing ideas: a new technique for working with young children as design partners', *Proceedings: 2004 conference on Interaction design and children: building a community,* ACM, Maryland, pp. 35 - 42, http://doi.acm.org/10.1145/1017833.1017838

Hakansson, J 1990, 'Lessons learned from kids: one developer's point of view', in Laurel, B and Mountford, JS (eds), *The art of human interface design*, Addison-Wesley, Reading, Mass, pp.123-130.

Healy, JM 1998, *Failure to connect: how computers affect our children's minds-for better and worse,* Simon & Schuster, New York.

Helm, JH & Katz, LG 2001, *Young investigators: the project approach in the early years,* Teachers College Press, New York.

Hill, S 2004, 'Hot diggity! findings from the children of the new millennium project', Paper presented at *Early Childhood Organisation Conference EDC,* March 6 2004, http://www.unisanet.unisa.edu.au/staff/SueHill/ECHPaper.pdf, viewed 2 August 2004.

Hoffmann, MHG 2007, 'Working paper no 24: Cognitive conditions of diagrammatic reasoning', *Working paper series,* Ivan Allen College, School of Public Policy, Georgia Institute of Technology, Atlanta, pp. 29. http://www.spp.gatech.edu/faculty/workingpapers/wp24.pdf, viewed 15 June 2007.

Hyerle, D 2000, *A field guide to using visual tools,* ASC Publications, Alexandria, Virginia, USA.

Interim report of the developmentally appropriate technology in early childhood (DATEC) project, cat. 2000, Multiple Partners, pp. 8, http://www.datec.org.uk/

IXDA-members 2007, What tools do you use for prototyping?, http://gamma.ixda.org/discuss.php?post=22050&search=prototyping, viewed November 2007.

Jeremijenko, N n.d., 'Dialogue with a monologue: voice chips and the products of abstract speech', http://www.topologicalmedialab.net/xinwei/classes/readings/Jeremijenko/VoiceChips.pdf, viewed 6 January 2006.

Jonassen, DH & Henning, P 1996, 'Mental models: knowledge in the head and knowledge in the world', paper presented at the *International Conference on Learning Sciences International Society of the Learning Sciences,* Evanston, Illinois, pp. 433-438.

Jones, A & Selby, C 1997, 'The use of computers for self-expression and communication', *Journal of Computing in Childhood Education* vol. 8 no. 2-3 pp. 199 - 214.

Keates, S & Clarkson, J 2003, *Countering design exclusion: an introduction to inclusive design,* Springer, London; New York.

Kolko, J 2007a, *Thoughts on interaction design,* Brown Bear, LLC., Austin, Texas.

Kolko, J 2007b, *Thoughts on interaction design,* Brown Bear, LLC., Savannah, Georgia.

Kozulin, A, Gindis, B, Ageyev, VS & Miller, SM (eds) 2003, *Vygotsky's educational theory in cultural context*, Cambridge University Press, New York.

MacNaughton, G, Rolfe, SA & Siraj-Blatchford, I (eds) 2001, *Doing early childhood research: international perspectives on theory and practice*, Alen & Unwin, Crows Nest, Australia.

Mancinelli, C, Gentili, M, Priori, G and Valitutti, G 2004, 'Concept maps in kindergarten', *Paper presented at the First International Conference on Concept Mapping,* Universidad Publica de Navarra, Pamplona, Spain. http://cmc.ihmc.us/papers/cmc2004-195.pdf, viewed 15 November 2004

Mancinelli, C 2006, 'Learn while having fun - conceptualization Itineraries in kindergarten - children experiences with C-maps in an italian school', *Proceedings: Second International Conference on Concept Mapping,* University of Costa Rica, pp. 343-350, http://cmc.ihmc.us/cmc2006Papers/cmc2006-p44.pdf

Mancinelli, C & Guaglione, G 2004, *Le esperienze dei bambini: Indagare nella zucca - Le parole della scienza nella scuola dell'infanzia*, http://85.47.105.117/ces/index.htm, viewed 6 August 2004.

McLane, JB & McNamee, GD 1990, *Early literacy* Harvard University Press, Cambridge, Massachusetts.

Mérida, R 2001-2002, 'Ayudando a organizar el pensamiento infantil: los mapas preconceptuales', *Kikiriki - Cooperación Educativa*, 62-63 (Double Issues), 18-09-2003, pp. 76-83.

Mérida, R 2002, 'Una nueva forma de trabajar en educación infantil: los mapas preconceptuales / a new Approach to preschool Education: conceptual maps', *Cultura y Educación*, vol. 14, no. 1, pp. 99-125.

Mettler, R, Bourgoing, Pd & Jeunesse, G 1990, *The egg,* Moonlight Publishing, London.

Millar, S 1997, *Reading by touch,* Routledge, London .

Millen, DR 2000, 'Rapid ethnography: time deepening strategies for HCI field research', *Proceedings: DIS'00 conference on Designing Interactive Systems: Processes,* *Practices, Methods, and Techniques,* New York City, New York, United States, ACM Press 280-286, http://doi.acm.org/10.1145/347642.347763

Mintzes, JJ, Wandersee, JH & Novak, JD (eds) 2005, *Teaching sciences for understanding: a human constructivist view*, Elsevier Academic Press, United States of America.

Nicolson, S & Shipstead, SG 1998, *Through the looking glass: observations in the early childhood classroom,* Second edition*,* Prentice Hall Inc, Upper Saddle River, New Jersey.

Norland, FH, Lawson, AG & Kahle, JB 1974, 'A study of levels of concrete and formal reasoning in disadvantaged junior and senior high school students', *Science education*, vol. 58, no. 4, Oct - Dec, pp. 569-575.

Norman, DA 1990, *The design of everyday things,* Basic Books, New York.

Norman, DA 1994, *Things that make us smart: defending human attributes in the age of the machine* Addison-Wesley Pub. Co., Reading, Mass.

Norman, DA 1999, *The invisible computer: why good products can fail, the personal computer is so complex, and information appliances are the solution,* MIT Press, Cambridge, Mass.

Novak, JD 1998, *Learning, creating and using knowledge: concept maps as facilitative tools in schools and corporations,* Lawrence Earlbaum Associates, Mahweh, NJ.

Novak, JD 2004, 'A science education research program that led to the development of the concept mapping tool and a new model for education', *Paper presented at the First International Conference on Concept Mapping,* Pamplona, Spain, September 14 - 17, pp. 11, http://cmc.ihmc.us/papers/cmc2004-286.pdf

Novak, JD n.d., *The theory underlying concept maps and how to construct them*, http://cmap.coginst.uwf.edu/info/printer.html, viewed 9 May 2004.

Novak, JD & Cañas, AJ 2003, *Hybrid concept map / procedure on building a concept map*, http://cmap.ihmc.us/Documentation/, viewed 9 May 2004.

Novak, JD & Cañas, AJ 2006a, 'The origins of the concept mapping tool and the continuing evolution of the tool', *Information and Visualization Journal*, vol. 5, no. 3, September, pp. 175-184.

Novak, JD & Cañas, AJ 2006b, *The theory underlying concept maps and how to construct them,* Florida Institute for Human and Machine Cognition, Pensacola, Florida pp. 31.

Novak, JD & Gowin, DB 1984, *Learning how to learn,* Cambridge University Press, New York.

Novak, JD & Wandersee, JH 1990, 'Perspectives on concept mapping', *Special issue of the Journal of Research in Science Teaching*, vol. 27, no. 10, pp. 927-1074.

O'Rourke, M & Harrison, C 2004, 'The introduction of new technologies: new possibilities for early childhood pedagogy', *Australian Journal of Early Childhood*, vol. 29, no. 2, June 2004, pp. 11-18.

OECD 2009, *Glossary of Statistical Terms - Research and Development*, http://stats.oecd.org/glossary/detail.asp?ID=2312, viewed 3 May, 2009.

Osgood, J 2006, 'Editorial. Rethinking 'Professionalism in the Early Years: perspectives from the United Kingdom', *Contemporary Issues in Early Childhood*, vol. 7, no. 1, March, pp. 1-4.

Owocki, G 1999, *Literacy through play,* Heinemann, Portsmouth, NH.

Pérez-Cabaní, ML 1994, *Ensenyament de l'ús diferencial d'estratègies d'aprenentatge: anàlisi de la incidència dels mapes conceptuals en l'aprenentatge d'estudiants universitaris,* Universitat Autónoma de Barcelona, España.

Pérez-Cabaní, ML 1995, 'Los mapas conceptuales', *Cuadernos de pedagogía*, vol. 237, no., pp. 16-21.

Pérez-Cabaní, ML 1999, 'Los mapas conceptuales en el parvulario: un proceso de toma de decisiones ', *Aula de Innovación Educativa*, vol. 78, no., pp. 54-57.

Pérez-Cabani, ML, Falgas, M, Nadal, A & Valenti, M 1992, 'Els mapes conceptuales: una estrategia d'aprenentatge al parvulari', *Revista Guix*, 181.

Pérez-Cabaní, ML & Tarradellas-Pifarrer, MR 1996, 'Los mapas conceptuales como procedimiento interdisciplinario', in Solé-i-Gallart, I and Monereo-Font, C (eds), *Asesoramiento Psicopedagógico: Una Perspectiva Profesional y Constructivista*, Alianza Editorial, España, pp. 425-440.

Piaget, J 1963, *The origins of intelligence in children,* The Norton Library, New York.

Piaget, J 1973, *To understand is to invent: the future of education,* Grossman, New York.

Piaget, J 1974, *The child and reality: problems of genetic psychology,* Muller, London.

Piaget, J & Inhelder, B 1977, *The psychology of the child,* Redwood Burn Limited Trowbridge & Esher, Great Britain.

Piernot, PP, Felciano, RM, Stancel, R, Marsh, J & Yvon, M 1995, 'Designing the PenPal: blending hardware and software in a user-interface for children', *Proceedings: CHI'95 conference on Human Factors in Computing Systems,* Denver, Colorado, United States, May 07 - 11, 1995, ACM Press/Addison-Wesley Publishing Co, pp. 511-518, http://doi.acm.org/10.1145/223904.223973

Pinker, S 1995, *The language instinct,* The Penguin Group London, England.

Preece, J, Rogers, Y & Sharp, H 2002, *Interaction design: beyond human-computer interaction,* J. Wiley & Sons, New York.

Quintana, C, Carra, A, Krajcik, J & Solloway, E 2002, 'Learner-centered design: reflections and new directions', in Carroll, JM (ed) *Human-Computer Interaction in the New Millenium*, Addison - Wesley, NY, pp. 605-626.

Raskin, J 2000, *The humane interface: new directions for designing interactive systems,* Addison-Wesley, Reading, Mass, Harlow.

Reference list in CmapTools website, 2003, http://cmap.ihmc.us/Publications/ReferenceList.php, viewed 18 July 2004.

Rolfe, SA 2001, 'Direct observation', in MacNaughton, G, Rolfe, SA and Siraj-Blatchford, I (eds), in *Doing early childhood research: international perspectives on theory and practice*, Alen & Unwin, Crows Nest, Australia, pp. 224-239.

Ryan, S 2008, 'Action or reaction!: reflecting on Sally Lubeck's wisdom to reinvent the field of early education', *Journal of Early Childhood Research,* vol. 6, no. 1, pp. 69-74.

Saffer, D 2007, *Designing for interaction: creating smart applications and clever devices,* New Riders, Berkeley, California.

Sánchez, J, Alarcón, P & Flores, H 2006, 'Diseño centrado en el usuario de una herramienta para que usuarios no videntes construyan mapas conceptuales ', *Proceedings: Second International Conference on Concept Mapping,* Cañas, San José, Costa Rica, University of Costa Rica, pp. 177-184, http://cmc.ihmc.us/cmc2006Papers/cmc2006-p186.pdf

Sanders, EBN & Williams, CT 2001, 'Harnessing people's creativity: ideation and expression through visual communication', in Langford, D and McDonagh, D (eds) *Focus groups: supporting effective product development,* Taylor and Francis, New York.

Schaffer, HR 1996, 'Joint involvement episodes as contexts for development', in Daniels, H (ed) *An introduction to Vygotsky*, Routdledge, London, pp. 251-280.

Schuler, D & Namioka, A (eds) 1993, *Participatory design: principles and practices*, Lawrence Erlbaum Associates Inc, Hillsdale, New Jersey.

Schuman, L 1993, 'Foreword ', in Schuler, D and Namioka, A (eds), *Participatory Design: Principles and Practices*, Lawrence Erlbaum Association, Hillsdale, New Jersey, pp. vii-xii.

Seng, S-H 1998, 'Enhancing learning: computers and early childhood education', *paper presented at the Educational Research Association Conference Singapore,* Nov 23-25, pp. 14, http://www.eric.ed.gov:80/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/80/17/9d/8f.pdf

Siraj-Blatchford, I & Siraj-Blatchford, J 2001, 'An ethnographic approach to researching young children's learning', in MacNaughton, G, Rolfe, SA and Siraj-Blatchford, I (eds), *Doing early childhood research: international perspectives on theory and practice*, Alen & Unwin, Crows Nest, Australia, pp. 193-207.

Smith, BL & MacGregor, J 1992, 'What is collaborative learning?' in Goodsell, AS, Maher, MR, Tinto, V, Smith, BL and MacGregor, J (eds), *Collaborative learning: a sourcebook for higher education*, National center on postsecondary teaching, learning, and assessment University Park, PA, pp. 10-30.

Spinuzzi, C 2002, 'A Scandinavian challenge, US response: methodological assumptions in a Scandinavian and US prototyping approaches, in *SIGDOC 2002 Proceeding,* ACM Press, New York, pp. 208-215, http://doi.acm.org/10.1145/584955.584986

Subrahmanyam, K, Kraut, RE, Greenfield, PM & Gross, EF 2000, in *The Future of Children*, Vol. 10, pp. 123-143.

Torres, PL & Marriott, RCV (eds) c2010, *Handbook of research on collaborative learning using concept mapping*, Information Science Reference, Hershey

Unesco 2005, *Towards knowledge societies,* United Nations Educational, Scientific, and Cultural Organization, France. http://unesdoc.unesco.org/images/0014/001418/141843e.pdf

Vygockij, LS 1996, *Thought and Language,* MIT Press. Cambridge, MA US.

Vygotsky, L 1962, *Thought and Language*, MIT Press, Cambridge, MA US.

Vygotsky, L 1978a, 'Interactions between learning and development', in Gauvin, M and Cole, M (eds), *Readings on the development of children* Scientific American Books, New York, pp. 34-40.

Vygotsky, L 1978b, 'The role of play in development', in *Mind and Society*, Harvard University Press, Cambridge, MA, pp. 92-104.

Vygotsky, LS, Vygotsky, L, Hanfmann, E & Vakar, G 1962, 'Thought and Word', in *Thought and language.*, MIT Press, Cambridge, MA US, pp. 119-153.

Wandersee, JH 1990, 'Concept mapping and the cartography of cognition', *Journal of research in science teaching*, vol. 27, no.10, pp. 923-936.

Wood, D, Bruner, JS & Ross, G 1976, 'The role of tutoring in problem solving', *Journal of Child Psychology & Psychiatry & Allied Disciplines*, vol. 17, no. 2, January 4, pp. 89-100.

Wyeth, P & Purchase, HC 2002, 'Tangible programming elements for young children', *Proceedings: CHI'02 Extended Abstracts on Human Factors in Computer Systems,* Minneapolis, MA, United States, pp. 774-775, http://doi.acm.org/10.1145/506443.506591

Appendix A - Ethics documents for participants of case study one

Form of disclosure and informed consent for parents – page 1/2

FORM OF DISCLOSURE AND INFORMED CONSENT
(Final Version to be printed on University letterhead)

University:	Swinburne University of Technology
Department:	National Institute for Design Research - NIDR, Faculty of Design
Project Title:	Design of Concept Mapping Tool for Children with Literacy Skills in Development
Investigator(s):	Dr. Deirdre Barron – Principal Supervisor Designer Gloria Gomez - Research Student
Degree:	PhD of Design

I am a graphic designer. As part of my doctoral studies I am developing a tool that if successful will be used by caregivers to support the learning of children under the age of 5.
I am trialing a concept mapping kit appropriate to children who are either pre-literate or developing literacy skills. It is anticipated that the children will develop conceptual and memory skills by organizing and interpreting knowledge in the form of concept maps.

The children will be asked to make concept maps about "Farm Animals". The activity would involve the use of picture cards and "voice chip recorders". The voice recorders are used for recording sound onto the pictures. Each card and voice recorder has magnetic strips attached to it. The children will place the cards and voice recorders onto a write and wipe magnetic board by following a few rules. They will organize the cards and voice recorders with templates. The templates show the path for constructing simple concept maps and conceptual relationships.

By participating in the activity, the children may learn to make simple concept maps about "Farm Animals" and recognize conceptual relationships between two or more concepts (e.g. ducks and chickens lay eggs). They may also learn to differentiate words that can be represented with drawings, letters or spoken language (e.g. pig) from words that can only be represented with letters and spoken language (e.g. is, like). Figure 1 shows a child making a concept map about "Farm Animals".

The activity will be performed at school and presented as a game. The rules will be explained to the children but won't be reinforced. If they decide to stop the activity no pressure will be put on the children at all. The activity may present an opportunity for the children to evaluate their prior knowledge about "Farm Animals" and/or learn new conceptual relationships about them. The test will also help the designer to understand the interactions between 1) the children and the activity elements 2) children and caregivers, 3) child to child and 4) children, caregivers and their surroundings.

I will take notes, tape-record children's comments during the activity and also take still photos of what is produced. I will not take photos of the children's faces or any other distinguishing feature. I will also avoid the reference to topics that can bring up personal issues. I will discuss the activity with you (teacher or parents/guardian) in advance; however it is important you (teacher or parents/guardian) are available at all times.

The information gathered during the session will inform the design of concept mapping activities that would be produced in the future. I am willing to explain the project further to you (teacher or parents/guardian) for you to make an informed decision concerning participation, intrusiveness and complexity of the study. I also understand you may take the time necessary to think about it before agreeing to participate.

The participation in the project is voluntary. You (teacher or parents/guardian) may withdraw consent to participate and discontinue participation at any time until the data are processed. You may also withdraw any unprocessed data previously supplied. The withdrawing from the research will not jeopardize the relationship with the researchers.

Figure 1

The study results will be used for different academic purposes (such as thesis, project online community, refereed journals and conferences). The data collected will be kept in a locked cabinet and retained by the Research Coordinator, Faculty of Design – Swinburne University of Technology, for a period of five years from the gathering of the data. When the time is due, the data will be destroyed in accordance with Swinburne University of Technology privacy regulations http://www.swin.edu.au/corporate/registrar/ppd/files/humres.htm.

Please contact the following persons if you required any further information.

Enquiries regarding research project:

- Designer Gloria Gomez, PhD Candidate, ggomez@groupwise.swin.edu.au, ph. (03) 95104353, mob. 0415635778
- Dr. Deirdre Barron, Research Supervisor, Research Coordinator NIDR, Prahran campus, the Swinburne University of Technology, 144 High Street, Prahran VIC 3181, dbarron@swin.edu.au, ph. (03) 92146091

Enquiries regarding problems with ethics:

- Prof. Allan Whitfield, Director of NIDR, Prahran campus, the Swinburne University of Technology, 144 High Street, Prahran VIC 3181, awhitfield@swin.edu.au, ph (03) 92146882, mob. 0416174855
- Prof. Kerry Pratt, Pro Vice Chancellor Research, the Swinburne University of Technology, kpratt@swin.edu.au, ph. (03) 92145009

Consent form for parents of participant children

SWINBURNE UNIVERSITY OF TECHNOLOGY
(Final Version to be printed on University letterhead)

National Institute of Design

Consent form for persons participating in research projects

Designing of a Concept Mapping Tool for Children with Literacy Skills in Development

Name of participant parent or guardian: ______

Name of investigator(s): Dr. Deirdre Barron and PhD candidate Gloria Gomez

1. I consent to participate in the project named above, the particulars of which - including details of set of concept mapping activities organized to use with 3-5 year olds under institution supervision have been explained to me. A written copy of the information has been given to me to keep.

2. I authorize the researcher or his or her assistant to use with me the set of concept mapping activities organized to use with 3-5 year olds under institution supervision referred to under (1) above.

3. I acknowledge that:

(a) The possible effects of the set of concept mapping activities organized to use with 3-5 year olds under institution supervision have been explained to me to my satisfaction;

(b) I have been informed that I am free to withdraw from the project at any time without explanation or prejudice and to withdraw any unprocessed data previously supplied;

(c) The project is for the purpose of research

(d) I have been informed that the confidentiality of the information I provide will be safeguarded subject to any legal requirements.

4. I have been informed that the sessions will be audio taped and transcript copies will be returned to me for verification upon my request. I understand the name of my child will not be revealed in any publication arising from the research.

Child Name: ______

Signature ______ Date ______
(Parent/Guardian)

Consent form for preschool director

SWINBURNE UNIVERSITY OF TECHNOLOGY
(Final Version to be printed on University letterhead)

National Institute of Design

Consent form for persons participating in research projects

Designing of a Concept Mapping Tool for Children with Literacy Skills in Development

Name of participant: [redacted]

Name of investigator(s): Dr. Deirdre Barron and PhD candidate Gloria Gomez

1. I consent to participate in the project named above, the particulars of which - including details of set of concept mapping activities organized to use with 3-5 year olds under institution supervision have been explained to me. A written copy of the information has been given to me to keep.

2. I authorize the researcher or his or her assistant to use with me the set of concept mapping activities organized to use with 3-5 year olds under institution supervision referred to under (1) above.

3. I acknowledge that:

(a) The possible effects of the set of concept mapping activities organized to use with 3-5 year olds under institution supervision have been explained to me to my satisfaction;

(b) I have been informed that I am free to withdraw from the project at any time without explanation or prejudice and to withdraw any unprocessed data previously supplied;

(c) The project is for the purpose of research

(d) I have been informed that the confidentiality of the information I provide will be safeguarded subject to any legal requirements.

4. I have been informed that the sessions will be audio taped and transcript copies will be returned to me for verification upon my request. I understand the name of the participant children under my care will not be revealed in any publication arising from the research.

Name:

Signature   Date

(Director of [redacted] Preschool)

Appendix B - Ethics documents for participants of case study two

Forms required at Carnegie Mellon University

IRB required certificate

National Cancer Institute
U.S. National Institutes of Health | www.cancer.gov

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Human Participant Protections Education for Research Teams

Completion Certificate

This is to certify that

Gloria Gomez

has completed the **Human Participants Protection Education for Research Teams** online course, sponsored by the National Institutes of Health (NIH), on 03/27/2006.

This course included the following:

- key historical events and current issues that impact guidelines and legislation on human participant protection in research.
- ethical principles and guidelines that should assist in resolving the ethical issues inherent in the conduct of research with human participants.
- the use of key ethical principles and federal regulations to protect human participants at various stages in the research process.
- a description of guidelines for the protection of special populations in research.
- a definition of informed consent and components necessary for a valid consent.
- a description of the role of the IRB in the research process.
- the roles, responsibilities, and interactions of federal agencies, institutions, and researchers in conducting research with human participants.

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FIRSTGOV

Application for IRB review – page 1/3

Carnegie Mellon University

For CMU's IRB Office Use:
Date Received: ______________
CMU Assigned IRB No. ______________
IRB Review Type: ______________

APPLICATION FOR IRB REVIEW OF RESEARCH INVOLVING HUMAN SUBJECTS

Research Project Title: Development of a Concept Mapping Tool for Children with Developing Learning Skills (This is PhD research undertaken at the Faculty of Design, Swinburne University of Technology, Australia)

Anticipated Start Date: March, 2006
Anticipated End Date: December, 2006
Source of Funding (Sponsor): Internal: ______________
External: Visiting Research Scholar Scholarship Funding

Principal Investigator (PI): Gloria Gomez
PI Title/Degree: PhD in Design Candidate (Research Visitor)
PI's Department: School of Design (Sponsor)
PI's Phone: 412-2686155
PI's E-mail: ggomez@andrew.cmu.edu
PI's Building & Room No: MMC, 2nd floor, Smilie Lab

If student, please complete:
Faculty Advisor: Dr Deidre Barron
Department: Faculty of Design, Swinburne University, Australia
Phone: +613-92146091 Building/Room #: ______________
E-mail: dbarron@swin.edu.au

CMU's Co-Investigators:
(1) Dr Sharon Carver, Director of the Children's School
(2) ______________
(3) ______________
(4) ______________
(5) ______________

Concise Statement of Proposed Research with Details of Human Use Aspect

Describe within the space below, in layman's terms, what is to be done so that a realistic estimate of the risks to the subject and the benefits of the project can be assessed.

The inclusion of females and members of minority groups and their sub-populations must be addressed in the development of the research design appropriate to the scientific objectives of the study. The research plan should describe the composition of the proposed study population in terms of gender and racial/ethnic group. Provide a rationale for selection of such subjects. Your proposal should contain a description of the proposed outreach programs for recruiting females and minorities as participants.

This project is investigating the development of a concept mapping tool for preschool children. Concept maps are tools for representing organized knowledge. Two or more concepts are enclosed in a square or circle, and connected to each other to form conceptual relationships (propositions) by a linking phrase. A line is used to connect the concepts and the linking phrase together. Concepts are labeled with words and symbols (Novak 1998). Novak theorized that young children are able to make good concepts and are very good at it because they haven't been exposed to rote learning yet. The development of an age-appropriate tool is required to be able to test Novak's claims. Studies reveal young children are able to represent meanings using enactive, iconic and symbolic representations (Brunner 1968 in Brooks & Dowley 1990), as well as to organize knowledge if the material (task) is explained and presented to them in a stimulating environment and supported by their teachers or caregivers (Bjorklund & Douglas in Cowan 1997).

A prototype Concept Mapping Kit has been developed based on the literature review. The Kit is comprised by materials familiar to the preschool classroom (magnetic board, construction paper, magnets, Velcro strips, markers, etc) and incorporates a new one, voice-recorders. They are small voice-input devices for recording voice and/or sound. It is important to test this tool with children in order to see if they are actually able to organize simple forms of knowledge using concept maps.

The Kindergarten teachers of the Children's School will lead, plan and guide the mapping activity and transform the Kit components to suit the needs of the children. The research involves observation, audio recording and/or videotaping of these interactions.

We need to know 1) if children are able to make conceptual relationships (two or more concepts and a linking phrase) using a general concept and a more specific one; 2) if they understand the rules involved in pursuing the task (differentiate concepts and linking phrases); 3) If they find the process of concept mapping engaging; 4) If they are able to speak out the reasons why they connected certain concepts and linking phrase to make a proposition; 5) If two or more children make different types of propositions using the same set of concepts and linking phrases.

CMU IRB REVIEW APPLICATION

1. Regarding the human subjects involved in the proposed study:

   (a) What is the age range of the subjects? 5/6 years of age (If subjects are minors, assent forms may be required.)

   (b) How many subjects are needed for this study? The 5/6 years class of the Children's School

   (c) Of the subjects studied, what will be the ratio of males to females? 9 female, 13 male

   (d) Of the subjects studied, what percentage will be from minority groups? 4/22

   (e) Are the subjects capable of understanding the nature of the study and the consenting process? YES [X] NO [

   (f) What is the population source of the subjects to be studied? Carnegie Mellon's Children's School

   (g) Indicate how subject recruitment will be performed: (Check appropriate boxes)
   [ ] CMU directory listing
   [ ] Existing in Investigator's files
   [ ] Email or web-based solicitations (Please elaborate)
   [ ] External advertising (radio, TV, publications, postings)
   [ ] List of subjects from previous student recruitment efforts
   [X] Other: CMU Kindergarten class

2. Will any of the following classes of vulnerable subjects be involved in the proposed study?

	YES	NO	Comments
Students or Minors	[X]	[ ]	
Subjects with Compromised Mental Status	[ ]	[X]	
Hospitalized or Institutionalized Subjects	[ ]	[X]	
Pregnant Women	[ ]	[X]	
Fetuses	[ ]	[X]	
Prisoners	[ ]	[X]	
Subjects requiring certificate of confidentiality	[ ]	[X]	

	YES	NO
3. If a clinical study, will a placebo or placebo procedure be used in this study?	[ ]	[X]
4. Will the subjects receive intangible benefit from the study? Learning a new way of representing concepts	[X]	[ ]
(a) Are the subjects paid (monetarily) for entering the study? If yes, what is the amount and source of the funds? $____ (Amount) ____ (Source)	[ ]	[X]
(b) Are other inducements planned to recruit subjects? If yes, describe other inducements planned:	[ ]	[X]

Application for IRB review – page 3/3

		YES	NO	Comments
5.	Is subject's confidentiality/anonymity in the project protected? Video transcripts will replace children's names with pseudonyms. All the data will be coded by subject ID number not name.	[X]	[ ]	
6.	Are consent forms to be used? Parents have already signed blanket consent forms for observation / research at the Children's School.	[ ]	[X]	
7.	Are provisions for subject's medical care available in the event of a personal (physical or mental) injury resulting solely from subject's participation in the research?	[ ]	[ ]	

8. Indicate degree of research's physical risk to subject: X Minimal ___Greater than Minimal ___High

9. Indicate degree of research's psychological risk to subject: X Minimal ___Greater than Minimal ___High

Minimal Risk: A risk is minimal where the probability and magnitude of harm or discomfort anticipated in the proposed research are not greater, in and of themselves, than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests.

Greater than Minimal Risk: A risk is greater than minimal where the probability and magnitude of harm or discomfort anticipated in the proposed research are greater than those ordinarily encountered in daily life or during t performance of routine physical or psychological examinations or tests.

High Risk: A risk is high when a moderate-to-high probability of serious adverse effects might occur as a result of participation in a research study.

10. Do you or any individual who is associated with or responsible for the design, the conduct, or the reporting of this research have an economic or financial interest in or act as an officer or a director for any outside entity whose interests could reasonably appear to be affected by this research project? YES [ ]* NO [X]

(*If yes, please provide detailed information to permit the IRB to determine if such involvement should be disclosed potential research subjects.)

The Investigator(s) must also report any Adverse Event to the IRB or its Officers after its occurrence within ten working days.

I am familiar with and agree to comply with the CMU's policies on the responsible conduct of research.

____________	03/17/2006	____________	03/17/2006
Principal Investigator	Date	Co-Investigator (1)	Date
Dr Deirdre Barron (Swinburne Uni)	03/17/2006	____________	______
Co- Investigator (2)	Date	Co-Investigator (3)	Date
____________	______	____________	______
Co- Investigator (4)	Date	Co-Investigator (5)	Date

Above signatures may be obtained after submission to IRB for review, but completed signatures are needed before final approval can be granted (faxed copies accepted).

Please submit each of the following with this IRB Review Application form (electronic submission preferred):

1. A draft or an abstract of the proposal.
2. A clear definition of how the subjects will be utilized, how the experimental treatment will be administered or the methodology.
3. A copy of the "informed" consent form(s) that the subjects or parent or guardian will be required to sign.
4. A description of how confidentiality/anonymity will be protected.
5. The name(s) and address(es) of official(s) authorizing access to any subjects in cooperating institutions not affiliated with CMU.
6. A description of the risks and benefits to the subjects.
7. A copy of any recruitment document (include advertisement flyers/invitation letters/invitation emails) to be used.
8. A copy of your on-line training certificate (http://cme.nci.nih.gov/).

For assistance or answers to questions, call CMU's Research Compliance Administration at 81901

IRB supporting materials – page 1/3

Gloria Gomez IRB - Supporting Materials

1. Abstract of the proposal

As part of my doctoral studies I developed a tool that if successful will be used by teachers to support the learning of preschoolers. I am pilot testing a concept mapping kit appropriate to children who are either pre-literate or developing literacy skills. It is anticipated that the children will develop conceptual and memory skills by organizing and interpreting knowledge in the form of concept maps.

The children will be asked to make concept maps about topics the teachers consider appropriate. The activity would involve the use of post-its, construction paper, markers crayons or color pencils and "voice chip recorders". The voice recorders are used for recording sound onto the drawings the children make. Each card and voice recorder has magnetic strips attached to it. The children will place the cards and voice recorders onto a write and wipe magnetic board by following a few rules provided by the teachers.

Figure 1

By participating in the activity, the children may learn to make simple concept maps and recognize conceptual relationships between two or more concepts (e.g. ducks and chickens lay eggs). They may also learn to differentiate words that can be represented with drawings, letters or spoken language (e.g. pig) from words that can only be represented with letters and spoken language (e.g. is, like). Figure 1 shows a child making a concept map about "Farm Animals".

2. A clear definition of how the subjects will be utilized, how the experimental treatment will be administered or the methodology

The teachers of the Children's School will introduce the Kit to use with the children for evaluation purposes. They will make adaptations based on their educational goals and decide when and how to use it. The children will interact with the Kit for the purpose of mapping concepts regarding a topic. The teachers will also choose the topic to concept map based on their curriculum and planned activities.

The Kit is comprised by materials familiar to the preschool classroom such as construction-paper cards, markers, Velcro, post-its, magnetised-foam arrows and incorporates a voice-input device called voice recorders. The children will use this device to add verbal meanings to the symbolic representations they make with the other materials.

My method of data collection will be direct observation. I won't interact with the children at all. I will observe how the teachers and the children use the Kit to evaluate if the insertion of this tool facilitates the negotiation of meanings among them and if allows the children to make conceptual relationships on the topic presented.

I will take notes and use a tape-recorder, a camera, and/or a video recorder. I would like to have different kinds of records of the process of making the concept maps. If visual recollection is approved children's faces won't be photographed or recorded. The individual identity of the children participating won't be revealed as part of the research. The Children's School video recording policy requires me to analyse the data at the School. The videos stay with them at all times.

3. A copy of the "informed" consent form(s) that the subjects or parent or guardian will be required to sign

The students at CMU's Children's School have blanket permission as a condition to enrollment. The consent form is already on file with the IRB, so no further consent is necessary.

4. A description of how confidentiality/anonymity will be protected

The Children's School would keep the confidentiality of the data gathered. The research student, Gloria Gomez, and her supervisor, Dr Deirdre Barron, from Swinburne University of Technology will also keep copies for research purposes.

The participants will be de-identified. Names of children participating in the research won't be revealed. If photographed or recorded, children's faces won't be shown, names won't be mentioned in the publications, thesis, and conference presentations.

Following the completion of the study, the Research Coordinator at National Institute for Design Research - Swinburne University of Technology will retain copies of the data in a locked cabinet for period of five years from the gathering of the information. After that, the material will be destroyed. The Children's School at CMU will also keep the originals of the data collected and dispose of them as it has been stated in their protocols.

5. The name(s)and address(es) of official(s) authorizing access to any subjects in cooperating institutions not affiliated with CMU.

IRB supporting materials – page 3/3

Not applicable to this study

6. A description of the risks and benefits to the subjects

Risks:

- Even though it is unlikely, the children may develop stress during the activity as a result of not understanding the task at hand. The teachers will take care of this if such situation presents, in the same manner as they would with any classroom activity.
- It would be risky if children's faces are photographed, but we are not going to do that.
- If my presence in the room becomes stressful for the children, I will follow teachers' instructions on how to proceed, e.g., leave the room. This is unlikely because the children are used to being observed at the Children's school

Benefits to Participants:
We expect to ground all our assumptions about the way the concept mapping tool should be designed to enable children to represent meanings using a learning tool that allows voice-input to disclose meaning.

General Benefits:
Concept maps are being recognized in other areas as effective tools to empower people's organization and critical thinking skills. At present, there is a small but growing community of early childhood educators around the world who believe this tool can enhance the development young children's organization, memory and metacognitive skills in a meaningful way.

7. A copy of any recruitment document (include advertisement flyers/invitation letters/invitation emails) to be used

Not applicable to this study

8. A copy of your on-line training certificate (http://cme.nci.nih.gov/)

My NIH on-line training certificate was completed on March 27th, 2006 and it has been enclosed to this application.

Forms required at Swinburne University of Technology

Form of disclosure and informed consent – page 1/3

FORM OF DISCLOSURE AND INFORMED CONSENT
(Final Version to be printed on University letterhead)

University:	Swinburne University of Technology, Australia
Department:	National Institute for Design Research - NIDR, Faculty of Design
Project Title:	Design of Concept Mapping Tool for Children with Literacy Skills in Development
Investigator(s):	Dr. Deirdre Barron – Principal Supervisor Designer Gloria Gomez - Postgraduate Student
Degree:	PhD of Design

I am a Graphic Designer. As part of my doctoral studies I am developing a tool that if successful will be used by teachers to support the learning of preschool children.
I am trialing an Authoring Concept Mapping Kit appropriate to children who are either pre-literate or developing literacy skills. It is anticipated that the children will develop conceptual and memory skills by organizing and interpreting knowledge in the form of concept maps.

Figure 1

By participating in the activity, the children may learn to make simple concept maps and recognize conceptual relationships between two or more concepts (e.g. ducks and chickens lay eggs). They may also learn to differentiate words that can be represented with drawings, letters or spoken language (e.g. pig) from words that can only be represented with letters and spoken language (e.g. is, like). Figure 1 shows a child making a concept map about "Farm Animals".

The teachers of Carnegie Mellon University (CMU)'s Children's School will introduce the Kit to use with the children for evaluation purposes. They will make adaptations based on their educational goals and decide when and how to use it. The children will interact with the Kit for the purpose of mapping concepts regarding a topic. The teachers will also choose the topic to concept map based on their curriculum and planned activities.

Form of disclosure and informed consent – page 2/3

The Kit is comprised by materials familiar to the preschool classroom such as construction-paper cards, markers, Velcro, post-its, magnetised-foam arrows and incorporates a voice-input device called voice recorders. The children will use this device to add verbal meanings to the symbolic representations they make with the other materials.

My method of data collection will be direct observation. I won't interact with the children unless requested by the teacher. I will observe how the teachers and the children use the Kit to evaluate if the insertion of this tool facilitates the negotiation of meanings among them and if allows the children to make conceptual relationships explicit on the topic presented.

I will take notes and use a tape-recorder, a camera, and/or a video-recorder.[1] The participants will be de-identified. Names of children participating in the research won't be revealed. If photographed or recorded, children's faces won't be shown, names won't be mentioned in the publications, thesis, and conference presentations. The Children's School video-recording policy requires me to analyze the data at the School. The videos stay with them at all times and lent to me upon request.

The information gathered during the sessions will inform the development of prototypes and the design of concept mapping activities that would be produced in the future. I am willing to explain the project further to you (the director of the Children's School) for you to make an informed decision concerning participation, intrusiveness and complexity of the study. I also understand you may take the time necessary to think about it before agreeing to participate.

The participation in the project is voluntary. You (the Director of The Children's School) may withdraw consent to participate and discontinue participation at any time until the data are processed. You may also withdraw any unprocessed data previously supplied. The withdrawing from the research will not jeopardize the relationship with the researchers.

The study results will be used for different academic purposes (such as thesis, project online community, refereed journals and conferences). But it is noted that this only will occur if CMU's Institutional Research Boards approves my application for dissemination. If approval is declined the information gathered will be used for further product development only.

Originals (in the form of photos, audio-recordings and video-recordings) of the data collected will be kept at Children's School. Copies of the same data will be kept in a locked cabinet and retained by the Research Coordinator, Faculty of Design – Swinburne University of Technology, for a period of five years from the gathering of the data. When the time is due, the data will be destroyed in accordance with Swinburne University of Technology privacy regulations http://ppd.swin.edu.au/humres/Privacy.htm

Please contact the following persons if you required any further information.

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[1] The Children's School at Carnegie Mellon University is a School Laboratory, where the students have blanket permission as a condition to enrollment. The parent consent form is already on file with the CMU's Institutional Research Board (IRB), so no further consent from them is necessary. The form covers any type of research data collection at the School and covers note taking, audio and/or video recording of the sessions.

Form of disclosure and informed consent – page 3/3

Enquiries regarding research project:

- Designer Gloria Gomez, PhD Candidate, ggomez@groupwise.swin.edu.au, ph. +613-95104353, mob. +613-415635778 (at Swinburne University - Australia), ggomez@andrew.cmu.edu ph. 412-2686165 (at Carnegie Mellon - in US)
- Dr. Deirdre Barron, Research Supervisor, Research Coordinator NIDR, Prahran campus, the Swinburne University of Technology, 144 High Street, Prahran VIC 3181, Australia dbarron@swin.edu.au, ph. +613-92146091

Enquiries regarding problems with ethics:

- Prof. Allan Whitfield, Director of NIDR, Prahran campus, the Swinburne University of Technology, 144 High Street, Prahran VIC 3181, Australia awhitfield@swin.edu.au, ph +613- 92146882, mob. +613-416174855
- Prof. Kerry Pratt, Pro Vice Chancellor Research, the Swinburne University of Technology, kpratt@swin.edu.au, ph. +613-92145009

Appendix C – List of Publications

Gomez, G, c2010, ‘Enhancing Autonomy, Meaning Negotiation and Active Inquiry in Preschool Concept Mapping’, in Torres, PL and Marriott, RCV (eds), *Handbook of Research on Collaborative Learning using Concept Mapping*, Hershey, Information Science Reference, pp. 384-409.

Gomez, G. 2007, ‘A Bridging Design Prototype for Investigating Concept Mapping in the Preschool Community’, in *CHI '07 Extended Abstracts on Human Factors in Computing Systems,* San Jose, California, USA, April 28-May 3, ACM, pp. 174-1752, http://doi.acm.org/10.1145/1240866.1240894

Gomez, G. 2006, ‘An Authoring Concept Mapping Kit for the Preschool Classroom,’ Proceedings: Second International Conference on Concept Mapping, Cañas, San José, Costa Rica, University of Costa Rica, pp. 32-38, http://cmc.ihmc.us/cmc2006Papers/cmc2006-p200.pdf

Gomez, G. 2005b, ‘Young Children’s use of a Voice-Input Device to Transform Their Symbolic Maps into Concept Maps’, *Paper presented at the Conference Our Children the Future 4 - OCTF 4,* July 16 - 19, Government of South Australia and DEST South Australia, Adelaide, Australia, http://www.octf.sa.edu.au/files/links/gome_1.doc

Gomez, G. 2005a, ‘Factors in Designing Concept Mapping Tool for 3-to-5 Year Olds’, *Proceedings: University of Queensland Interaction Design Postgraduate Students Conference,* University of Queensland, Brisbane Australia, pp. 45-48, http://www.itee.uq.edu.au/%7Equid/proceedings-web.pdf