Development of a research tool to investigate pedagogical affordances of engineering students’ experimental learning venues (*or how to audit the teaching styles supported by your laboratory spaces*)

Final report 2015

Swinburne University of Technology, lead institution

Curtin University, Queensland University of Technology, partner institution(s)

Dr George Banky, project leader

Mr Aaron Blicblau, Associate Professor Hari Vuthaluru, Dr Prasanna Egodawatta and Mr Martin Vcelka, team member(s)

Dr George Banky, Mr Aaron Blicblau, authors

Development of a research tool to investigate pedagogical affordances of engineering students’ experimental learning venues (or how to audit the teaching styles supported by your laboratory spaces)
Acknowledgements

The team wishes to acknowledge the support received from:

- Landell Archer and Troy Baker from *Studiocode Business Group*;
- colleagues Associate Professor Faisal Anwar (from Curtin University), Dr Hock Neoh, David Richards and David Yammouni (from Swinburne University of Technology);
- the *Science Technology Engineering and Mathematics Education (STEMed)* Group within the Faculty of Science, Engineering and Technology at Swinburne University of Technology.
## List of acronyms used

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curtin</td>
<td>Curtin University</td>
</tr>
<tr>
<td>CQU</td>
<td>Central Queensland University</td>
</tr>
<tr>
<td>STEM</td>
<td>Science, Technology, Engineering and Mathematics</td>
</tr>
<tr>
<td>OLT</td>
<td>Australian Government Office for Learning and Teaching</td>
</tr>
<tr>
<td>QUT</td>
<td>Queensland University of Technology</td>
</tr>
<tr>
<td>SUT</td>
<td>Swinburne University of Technology</td>
</tr>
<tr>
<td>UniMelb</td>
<td>The University of Melbourne</td>
</tr>
<tr>
<td>USyd</td>
<td>The University of Sydney</td>
</tr>
</tbody>
</table>
# Table of contents

Acknowledgements .................................................................................................................... 3

List of acronyms used ................................................................................................................ 4

Table of contents ....................................................................................................................... 5

Tables and figures ...................................................................................................................... 6

Executive summary .................................................................................................................... 7

Chapter 1: Project context ......................................................................................................... 9

   Chapter 1.1: Experimental Learning and Venue Affordance ............................................ 10

Chapter 2: Project approach .................................................................................................... 11

   Chapter 2.1: Small Group Experiments ................................................................. 11

   Chapter 2.2: Large Group Experiments ................................................................. 11

   Chapter 2.3: The Practiced Pedagogy ........................................................................ 12

   Chapter 2.4: Methodology ......................................................................................... 12

Chapter 3: Project findings ...................................................................................................... 16

   Chapter 3.1: Results of student activity patterns in face-to-face laboratory experimental learning at multiple sites in engineering .............................................................. 16

   Chapter 3.2: A tool to explore the affordances of experimental learning environments... 24

Chapter 4: Discussion ............................................................................................................... 26

Chapter 5: Dissemination of outcomes ................................................................................... 28

Chapter 6: Conclusions ............................................................................................................ 29

Appendix A: Certification ......................................................................................................... 30

Appendix B: References ........................................................................................................... 31

Appendix C: Impact of outcomes to the sector ....................................................................... 33

Appendix D: Promotional materials for masterclass/workshop presentations ...................... 34

Appendix E: Publications .......................................................................................................... 36

Development of a research tool to investigate pedagogical affordances of engineering students’ experimental learning venues (or how to audit the teaching styles supported by your laboratory spaces)
Tables and figures

Table

Table 1: Kikan-shido activity definitions (O’Keefe, Xu, & Clarke, 2006, p. 77) ........................ 14

Figures

Figure 1: Schematic flowchart showing the methodology used to identify affordances ............................ 13
Figure 2: Student kikan-shido patterns from recordings of face-to-face laboratory sessions ............................. 17
Figure 3: Student kikan-shido patterns from recordings of face-to-face laboratory sessions (continued) ........................................... 18
Figure 4: Student kikan-shido patterns from recordings of face-to-face laboratory sessions (continued) ........................................... 19
Figure 5: Summary of identified student kikan-shido events in the recorded videos. .............................. 20
Figure 6: Demonstrator (tutor) kikan-shido patterns from recordings of face-to-face laboratory sessions. ................................................................................................................................................................................. 21
Figure 7: Demonstrator (tutor) kikan-shido patterns from recordings of face-to-face laboratory sessions (continued). ................................................................................................................................................................................. 22
Figure 8: Summary of identified demonstrator (tutor) kikan-shido events in the recorded videos from Curtin and QUT ................................................................................................................................................................................. 23
Figure 9: Summary of identified demonstrator (tutor) kikan-shido events in the recorded videos from SUT ................................................................................................................................................................................. 24
Figure 10: Mapping kikan-shido events, as described in Table 1, to venue communication affordances ................................................................................................................................................................................. 25
Executive summary

Experimental learning, traditionally conducted in on-campus laboratory venues, is the cornerstone of science and engineering education. To satisfy online student and accreditation requirements, the common practice has been to offer equivalent remote or simulated laboratory experiments in lieu of the ones delivered, face-to-face, on campus. The current implementations of both remote and simulated laboratories tend to be specified with a focus on technical characteristics, instead of pedagogical requirements. This work attempts to redress this situation by developing a framework for the investigation of teaching and learning delivery in existing and proposed experimental educational environments.

For the tertiary education sector involved with technical or scientific training, a research tool capable of assessing the affordances of laboratory venues is an important aid during the planning, designing and evaluating stages of face-to-face and online environments that facilitate student experimentation. In our context the term “affordance” is used to describe how a venue impacts on the delivery of student learning and demonstrator teaching within it. The creation of quality experimental learning venues has been identified as one of the distance-education providers’ greatest challenges.

The seed project draws on the expertise of staff at three Australian universities: Swinburne University of Technology, Curtin University and Queensland University of Technology. The aim was to explore the use of an innovative tool (employing analysis of video recorded data) to identify the occurrences of kikan-shido (a Japanese term meaning ‘between desks instruction’) in order to produce student and demonstrator activity patterns. The approach facilitated the investigation, in a comparative framework, the pedagogy that is practiced in face-to-face laboratories, in order to validate its usefulness as a tool to ultimately reveal the pedagogical affordances in all types of experimental education delivery platforms.

For the laboratory venues investigated, the results obtained reflected the affordances that were available to support the experimenters as well as their supervision by the demonstrators. This information provides a base-line for the affordances that are necessary to conduct the same experiments in other venues, thereby ensuring that students will have the opportunity to receive the same delivery of education irrespective of when or how this is accomplished.

The project outputs included:

- a tool/framework to explore the affordances of experimental learning environments;
- details of video recording equipment that was used for data collection;
- e-Resources (or tutecasts) depicting the application of the resultant framework;
- summaries of the data analysed and examples of subsequent interpretation;
- conference papers, workshops, master classes and a journal article; and
- a website with the project’s outputs and outcomes.
The framework will be useful for evaluating existing and proposed experimental learning spaces. In 2015 the framework was used to evaluate online real-time supervision (via immersive wearable technologies) of experimenting Swinburne University of Technology students¹.

Chapter 1: Project context

The recent growth of the digital economy and the rapid development of internet communication technologies have promised improved online education and training (Bell, Bush, Nicholson, O’Brien, & Tran, 2002). Furthermore, extra pressures exist on education providers to be globally competitive in their tertiary education offerings by improving the quality of their internet-based delivery with the incorporation of new technologies. These improvements are particularly targeted to support students in remote communities and disabled students anywhere (Lang, 2012). Moreover, these steps are seen by some as attempts to preserve the institutions’ income levels by evolving “their businesses in new and exciting ways” (Davies, 2012). In any case, technology-driven innovations in education must be founded on evidence-based curriculum design.

Attempts to address the engineering skills shortage in Australia by increasing graduate numbers (Back et al., 2012), while dealing with budgeting pressures with academic staff cutbacks, have challenged the higher education institutions to migrate a number of their courses to online platforms. This includes courses in STEM education that involve experimental learning in laboratory venues (Nickerson, Corter, Esche, & Chassapis, 2007). In order to ensure that graduates are exposed to ‘real-world’ situations and attain the necessary professional skill-sets (as mandated by course accreditation bodies such as Engineers Australia2 for all engineering degrees in Australia), face-to-face laboratory experimentation with real equipment has been an integral component of engineering education worldwide (Lowe, Murray, Li, & Lindsay, 2008; Sarukkalige, Lindsay, & Anwar, 2010). To satisfy accreditation requirements, the common practice has been to offer off-campus students equivalent remote and/or simulated laboratory experiments in lieu of the ones delivered on-campus in brick-and-mortar venues (Nedic, Nafalski, Ozdemir, & Machotka, 2011). The current implementations of these remote and simulated laboratories tend to be specified with a focus on technical characteristics, whilst ignoring many of the pedagogical requirements. The research described in this report attempts to redress this situation by investigating the venue affordances for facilitating quality teaching and learning in different experimental educational environments.

In 2013, the successful submission for an Australian Government Office for Learning and Teaching (OLT) seed project funded the development and verification of a research tool, in the form of a framework that aimed to identify student activities in existing experimental learning environments, such as face-to-face and online/remote engineering laboratories, where students have access to real and/or simulated equipment. The research team comprised of staff from three Australian universities: Swinburne University of Technology, Curtin University and Queensland University of Technology; and received in-kind support from The Labshare Institute. Also, members of a reference group of eminent education researchers from Central Queensland University, The University of Melbourne and The University of Sydney were available for on-going advice.

---

Chapter 1.1: Experimental Learning and Venue Affordance

The provision of quality experimental learning venues has been identified as one of the distance-education providers' greatest challenges (Arbaugh & Benbunan-Fich, 2005; Sivakumar, Robertson, Artimy, & Aslam, 2005). For the tertiary education sector providing technical or scientific training, a framework helping to identify venue affordances will be beneficial during the planning, designing and evaluating stages of face-to-face and online (or cyber) environments that facilitate student experimentation.

The term “affordance” is used to describe how an object, or an environment, impacts on the actions of its user(s) and is attributed to Gibson (1977). Norman (1990) argued that while affordances facilitate use, constraints impede potential uses. Hence, affordances must be context specific. This framework focused only on identifying pedagogical (or learning and teaching) affordances of experimental learning venues for engineering undergraduate courses. Venue affordances facilitate, for example, the communication, monitoring, and instruction modes available; therefore the pedagogy that may be practiced by the participants.

With the availability of new communication technologies the delivery of tertiary education is rapidly changing to facilitate the global demand for flexible quality learning. The two commonly accepted differences for the delivery of experimental learning in remote laboratories have been identified as less opportunities for student collaboration and demonstrator supervision (Nedic et al., 2011).

In engineering, as in all the STEM disciplines, laboratory work targets four broad educational objectives: conceptual understanding, design skills, social skills and professional skills (Lang, 2012). Some studies involving small numbers of students have found no significant differences in educational outcomes between face-to-face and cyber laboratories (Nickerson et al., 2007; Ogot, Elliott, & Glumac, 2003; Sonnenwald, Whitton, & Magloughlin, 2003). Whereas, other studies have identified statistically significant differences in the learning outcomes of those students who are exposed to different modes of laboratory experimentation that ultimately “could change the effectiveness of [their] education” (Nickerson et al., 2007, p.710). The investigation of venue affordances in each of the aforementioned delivery contexts should assist with reaching a better understanding of the possible causes for this phenomenon of apparently conflicting conclusions.

Information on venue affordances will enable multi-campus universities to ensure that their students’ experimental virtual learning environments will also be of the similar quality when associated laboratory test rigs are shared online. This information is clearly needed by the multi-campus partnering institutions. SUT offers identical undergraduate coursework at its domestic and international campuses, as does Curtin at its campuses, while QUT is a multi-campus state-wide university. Furthermore, institutions that participate in the Open University3 will be in a position to benchmark those online accredited professional courses that mandate laboratory experimentation. The ability to benchmark the pedagogical affordances in existing and future remote engineering laboratories may be used to fine tune both face-to-face and online facilities to improve learning outcomes.

http://www.openuniversity.edu.au

3 Development of a research tool to investigate pedagogical affordances of engineering students’ experimental learning venues (or how to audit the teaching styles supported by your laboratory spaces)
Chapter 2: Project approach

For this OLT seed grant, the partner institutions provided the participants, the laboratory experiments and the various data collection venues. The original proposal intended to collect data in both face-to-face and remote laboratory experimentation venues. However, unresolved technical difficulties with the required rig at Curtin (it was to be accessed online by QUT students via the LabShare Institute’s Internet portal), resulted in a six-month long delay of unresolved issues and the eventual replacement of this experiment with similar face-to-face experiments for both Curtin and QUT students.

After submitting and gaining ethics approval from each of the partner institutions, video recordings of student activities were created using “action camera glasses” worn by randomly selected students who attended the experiments identified as suitable by the research team members. In order to further assist with identifying the recorded participant activities a wide-angle video of the venue was also created with a fixed camera, on an elevated tripod, in a corner of the room. Since, available technologies are rapidly changing and improving, the video recording devices used (and described on the associated websites listed in the footnotes) are included to highlight their functional rather than technical value. Over 50 hours of video glass recordings and a further 10 hours of fixed camera recordings were de-identified and analysed by the research assistant, whose “independence” was mandated in the granted ethics approvals.

The engineering disciplines, the laboratory layouts, the experiments and the practiced pedagogy were different for each of the partner institution’s contributions, as outlined in the following sections.

Chapter 2.1: Small Group Experiments

At SUT the students self-selected into groups of two, with eight to ten such groups and two academic demonstrators per session. In their groups of two, the learners were asked to design, simulate and test a specified transistor-based amplifier circuit and then repeat the process using real components. In their post-experiment group-written reports they were asked to compare and discuss the performance of each realisation.

Chapter 2.2: Large Group Experiments

At QUT the students, in groups of ten, performed two experiments on fluid behaviour in two water tanks. The demonstrators guided them in the operation and use of the respective flow equipment. Under on-going supervision, the learners had to complete the prescribed experiments, record instrument readings, and then perform calculations in order to consolidate their understanding of the relevant theorems.

---

4 http://www.labshare.edu.au
5 SUHREC Project 2013/258
At Curtin the students, in one group of no more than ten, were asked to communally experiment on a rig. Values such as flow velocities and amounts of water were read from instruments by nominated students, who were rotated in taking measurements and all attendees, before the finish of the session, participated in the subsequent discussions with their supervisor on how to interpret the collected data.

**Chapter 2.3: The Practiced Pedagogy**

The experimental learning recorded for this OLT seed grant covered the spectrum from student-centred learning (SUT) to demonstrator-centred learning (Curtin) with a blended version somewhere in-between (QUT).

**Chapter 2.4: Methodology**

Figure 1 graphically summarises the data collection and analysis procedure adopted by the researchers. The described approach is significant because the data collection framework and the associated analysis tools have never been applied in this context.

The underlying methodology is based on the assumption that if: **affordances impact on activity then activity patterns reflect on a venue’s affordances, hence on learning outcomes.** Some affordances may cause learning outcomes that might not be acceptable to engineering course accreditation bodies such as Engineers Australia, perhaps resulting in the professional course(s) not being reaccredited and ultimately not being offered.

The foundation of the framework is the analysis of video data to identify the occurrences of “kikan-shido” events which are detailed in Table 1. The more familiar “over-the-shoulder learning and teaching (OTST/L)” pedagogy that is observed in experimental learning venues is a subset of kikan-shido. Kikan-shido patterns have been used in experiential learning contexts to identify cultural differences; for example in Year 7 and 8 mathematics classes (Clarke, 2002). Banky (Banky, 2007) confirmed the presence of kikan-shido events in a tertiary context, their use to investigate experimental venue affordances in engineering experimental learning is therefore innovative.

The processing of the collected data utilised a three-layered interpretive model for media-rich research into social interaction, attributed to Wortham and Derry (2006). This model ensures a traceable path from the analysed data, through any intervening depiction(s), back to the recorded data. One of the benefits of this technique is an implied link between the various data forms and the raw data. Additionally, video recordings of the sessions resulted in permanent records that permitted a researcher and/or any other expert(s) and/or interested parties to repeatedly review the affordances depicted in the video recordings, facilitating coding or recoding anytime (Fraenkel & Wallen, 2006).

---

8 a Japanese term meaning ‘between desks instruction’ (Clarke, 2006)
Development of a research tool to investigate pedagogical affordances of engineering students' experimental learning venues (or how to audit the teaching styles supported by your laboratory spaces)

Figure 1: Schematic flowchart showing the methodology used to identify affordances.
Table 1: Kikan-shido activity definitions (O’Keefe, Xu, & Clarke, 2006, p. 77)

<table>
<thead>
<tr>
<th>M1</th>
<th>Selecting Work</th>
<th>Students are chosen to share their work, methods or thinking with the whole class. This may occur immediately or later in the lesson.</th>
</tr>
</thead>
<tbody>
<tr>
<td>M2</td>
<td>Monitoring Progress</td>
<td>Teacher walks around the classroom observing student progress of on-task activity.</td>
</tr>
<tr>
<td>M3</td>
<td>Questioning Student</td>
<td>An expression of inquiry that invites or calls for a reply from a student that may or may not be related to the current on-task activity.</td>
</tr>
<tr>
<td>M4</td>
<td>Monitoring Homework Completion</td>
<td>While students are engaged in on-task activity, the teacher observes the completion of homework and may note student achievement or understanding of subject matter.</td>
</tr>
<tr>
<td>G1</td>
<td>Encouraging Student</td>
<td>Activity pursued by the teacher intended to motivate, provide support and feedback to individuals or groups of students.</td>
</tr>
<tr>
<td>G2</td>
<td>Giving Instruction / Advice at Desk</td>
<td>Teacher scaffolds the development of students’ understanding by providing information, instruction or advice, focusing on the development of a concept that addresses meaning, reasoning, relationships and connections among ideas or representations, or the demonstration of a procedure.</td>
</tr>
<tr>
<td>G3</td>
<td>Guiding Through Questioning</td>
<td>A series of specific teacher questions intended to scaffold the development of student understanding of a procedure or concept during the on-task activity.</td>
</tr>
<tr>
<td>G4</td>
<td>Re-directing Student</td>
<td>Activities pursued by the teacher to regulate the behaviour of student(s) who are perceived not to be paying attention to the current activity, and to support students’ ongoing engagement during the lesson.</td>
</tr>
<tr>
<td>G5</td>
<td>Answering a Question</td>
<td>Information given by the teacher when requested by a student.</td>
</tr>
<tr>
<td>G6</td>
<td>Giving Advice at Board</td>
<td>Instruction or advice given while an individual or group of students work at the board. The instruction or advice may be intended for those students working at the board or may be intended for the whole class.</td>
</tr>
<tr>
<td>G7</td>
<td>Guiding Whole Class</td>
<td>Teacher walks around the classroom and provides information, instruction or advice intended for the whole class.</td>
</tr>
<tr>
<td>O1</td>
<td>Handout Materials</td>
<td>Teacher walks around the classroom distributing materials related to on-task activity.</td>
</tr>
<tr>
<td>O2</td>
<td>Collect Materials</td>
<td>Teacher walks around the classroom and collects materials from students.</td>
</tr>
<tr>
<td>O3</td>
<td>Arranging Room</td>
<td>Teacher repositions furniture to enable independent, paired, group or board work.</td>
</tr>
<tr>
<td>S1</td>
<td>School Related</td>
<td>Teacher engages in conversation related to school activities or curriculum.</td>
</tr>
<tr>
<td>S2</td>
<td>Non-School Related</td>
<td>Teacher engages in conversations of a social nature not related to the subject matter or on-task activity.</td>
</tr>
</tbody>
</table>
The identification of data in the video recordings was undertaken with the aid of *Studiocode*® (a commercial video analysis software) that is available from Studiocode Business Group⁹. As described by Clarke (Clarke, 2001), the software facilitates the annotation of the recorded material, thus creating a permanent record for quality assurance. In order to ensure internal code-recode reliability, the team adopted Miles and Huberman’s (1994) recommendations that a portion of each recording was independently coded on at least two occasions several days apart.

The analyses of the video recordings were used to obtain an indication of the relevant venue affordances by identifying the *kikan-shido* activities (as detailed in Table 1) between:

- student and student (or peer-to-peer); and
- student and demonstrator (or tutor).

---

Chapter 3: Project findings

Chapter 3.1: Results of student activity patterns in face-to-face laboratory experimental learning at multiple sites in engineering

The data collected from all participating institutions for both student and staff activity video recordings were de-identified and summarised in the following ways:

- histograms of time taken for each kikan-shido event in seconds and as a percentage of the length of each recording;
- a binary indicator if a kikan-shido event occurred during the recording.

A visual inspection of the histograms showed that a time- or percentage-based summary did not indicate the affordances of the venues, but rather reflected the type of laboratory experiment and/or student learning preferences and/or staff teaching styles. The aim of this project was not concerned with any of these later issues. Hence this data analysis was not pursued.

The research team concluded that a binary tabulation of the identified events did indeed reflect on the affordances of the investigated venues. Therefore, the analysis results simply documented if a kikan-shido event occurred during the recorded sessions. The events, which were not identified, were also logged by default. Each set of video glasses worn by a student collected data for two participants. For the students, the original set of sixteen kikan-shido events (shown in Table 1) were expanded to thirty-two, thus enabling the identification of both student-student and student-demonstrator interactions for the visible participants. During the analysis, the identification of an event was noted numerically with the number “1”, while subsequent identifications of the same event for that recording were ignored. Studiocode® was used to keep track of this part of the process, thereby facilitating the verification of the outcomes with the “code-recode” technique attributed to Miles and Huberman (1994).

The results obtained for each student recording are shown in Figure 2, Figure 3 and Figure 4, and the summaries of the number of recordings that contain each kikan-shido event are shown in Figure 5. Similarly, the results obtained for each demonstrator recording are shown in Figure 6 and Figure 7, whilst the summaries of the number of recordings that contain each kikan-shido event are shown in Figure 8 and Figure 9. The colour coding scheme assists with visual analysis of the results. Visual inspections of Figure 2, Figure 3, Figure 4, Figure 6 and Figure 7 highlight the incidence of identified kikan-shido events within the three observed laboratories¹⁰, and across all the observed laboratory sessions¹¹.

¹⁰ Each row of thirty-two, in Figure 2, Figure 3 and Figure 4, and each row of sixteen, in Figure 6 and Figure 7, is a different laboratory exercise in a different venue at one of the participating institutions.

¹¹ Each coloured cell represents the detection of an event.
Figure 2: Student *kikan-shido* patterns from recordings of face-to-face laboratory sessions

Development of a research tool to investigate pedagogical affordances of engineering students’ experimental learning venues (or how to audit the teaching styles supported by your laboratory spaces)
Development of a research tool to investigate pedagogical affordances of engineering students' experimental learning venues (or how to audit the teaching styles supported by your laboratory spaces)

Figure 3: Student *kikan-shido* patterns from recordings of face-to-face laboratory sessions (continued)
Figure 4: Student *kikan-shido* patterns from recordings of face-to-face laboratory sessions (continued)
### Figure 5: Summary of identified student *kikan-shido* events in the recorded videos.

<table>
<thead>
<tr>
<th>Curtin</th>
<th>Total</th>
<th>Weighted</th>
<th>QUT</th>
<th>Total</th>
<th>Weighted</th>
<th>SUT</th>
<th>Total</th>
<th>Weighted</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1-Encourage Student</td>
<td>0</td>
<td>0.00%</td>
<td>G1-Encourage Student</td>
<td>0</td>
<td>0.00%</td>
<td>G1-Encourage Student</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>G2-Giving Instruction</td>
<td>0</td>
<td>0.00%</td>
<td>G2-Giving Instruction</td>
<td>0</td>
<td>0.00%</td>
<td>G2-Giving Instruction</td>
<td>1</td>
<td>2.94%</td>
</tr>
<tr>
<td>G3-Guiding by Questioning</td>
<td>0</td>
<td>0.00%</td>
<td>G3-Guiding by Questioning</td>
<td>0</td>
<td>0.00%</td>
<td>G3-Guiding by Questioning</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>G4-Redirecting Student</td>
<td>0</td>
<td>0.00%</td>
<td>G4-Redirecting Student</td>
<td>1</td>
<td>2.78%</td>
<td>G4-Redirecting Student</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>G5-Answering Question</td>
<td>2</td>
<td>8.33%</td>
<td>G5-Answering Question</td>
<td>0</td>
<td>0.00%</td>
<td>G5-Answering Question</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>G6-Advice on Board</td>
<td>0</td>
<td>0.00%</td>
<td>G6-Advice on Board</td>
<td>0</td>
<td>0.00%</td>
<td>G6-Advice on Board</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>G7-Guide whole class</td>
<td>0</td>
<td>0.00%</td>
<td>G7-Guide whole class</td>
<td>0</td>
<td>0.00%</td>
<td>G7-Guide whole class</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>G51-Encourage Student</td>
<td>0</td>
<td>0.00%</td>
<td>G51-Encourage Student</td>
<td>0</td>
<td>0.00%</td>
<td>G51-Encourage Student</td>
<td>3</td>
<td>8.82%</td>
</tr>
<tr>
<td>G52-Giving Instruction</td>
<td>8</td>
<td>33.33%</td>
<td>G52-Giving Instruction</td>
<td>22</td>
<td>61.11%</td>
<td>G52-Giving Instruction</td>
<td>22</td>
<td>64.71%</td>
</tr>
<tr>
<td>G53-Guiding by Questioning</td>
<td>10</td>
<td>41.67%</td>
<td>G53-Guiding by Questioning</td>
<td>21</td>
<td>58.33%</td>
<td>G53-Guiding by Questioning</td>
<td>20</td>
<td>58.82%</td>
</tr>
<tr>
<td>G54-Redirecting Student</td>
<td>4</td>
<td>16.67%</td>
<td>G54-Redirecting Student</td>
<td>1</td>
<td>2.78%</td>
<td>G54-Redirecting Student</td>
<td>13</td>
<td>38.24%</td>
</tr>
<tr>
<td>G55-Answering Question</td>
<td>5</td>
<td>20.83%</td>
<td>G55-Answering Question</td>
<td>23</td>
<td>63.89%</td>
<td>G55-Answering Question</td>
<td>20</td>
<td>58.82%</td>
</tr>
<tr>
<td>G56-Advice on Board</td>
<td>0</td>
<td>0.00%</td>
<td>G56-Advice on Board</td>
<td>0</td>
<td>0.00%</td>
<td>G56-Advice on Board</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>G57-Guide whole class</td>
<td>3</td>
<td>12.50%</td>
<td>G57-Guide whole class</td>
<td>0</td>
<td>0.00%</td>
<td>G57-Guide whole class</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>M1-Selecting Work</td>
<td>0</td>
<td>0.00%</td>
<td>M1-Selecting Work</td>
<td>0</td>
<td>0.00%</td>
<td>M1-Selecting Work</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>M2-Monitor Progress</td>
<td>0</td>
<td>0.00%</td>
<td>M2-Monitor Progress</td>
<td>0</td>
<td>0.00%</td>
<td>M2-Monitor Progress</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>M3-Question Student</td>
<td>0</td>
<td>0.00%</td>
<td>M3-Question Student</td>
<td>0</td>
<td>0.00%</td>
<td>M3-Question Student</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>M4-Monitor Student</td>
<td>0</td>
<td>0.00%</td>
<td>M4-Monitor Student</td>
<td>0</td>
<td>0.00%</td>
<td>M4-Monitor Student</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>M51-Selecting Work</td>
<td>0</td>
<td>0.00%</td>
<td>M51-Selecting Work</td>
<td>0</td>
<td>0.00%</td>
<td>M51-Selecting Work</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>M52-Monitor Progress</td>
<td>1</td>
<td>4.17%</td>
<td>M52-Monitor Progress</td>
<td>0</td>
<td>0.00%</td>
<td>M52-Monitor Progress</td>
<td>2</td>
<td>5.88%</td>
</tr>
<tr>
<td>M53-Question Student</td>
<td>21</td>
<td>87.50%</td>
<td>M53-Question Student</td>
<td>22</td>
<td>61.11%</td>
<td>M53-Question Student</td>
<td>23</td>
<td>67.65%</td>
</tr>
<tr>
<td>M54-Monitor Student</td>
<td>0</td>
<td>0.00%</td>
<td>M54-Monitor Student</td>
<td>0</td>
<td>0.00%</td>
<td>M54-Monitor Student</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>O1-Handout Materials</td>
<td>0</td>
<td>0.00%</td>
<td>O1-Handout Materials</td>
<td>0</td>
<td>0.00%</td>
<td>O1-Handout Materials</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>O2-Collect Materials</td>
<td>0</td>
<td>0.00%</td>
<td>O2-Collect Materials</td>
<td>0</td>
<td>0.00%</td>
<td>O2-Collect Materials</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>O3-Arranging Room</td>
<td>0</td>
<td>0.00%</td>
<td>O3-Arranging Room</td>
<td>0</td>
<td>0.00%</td>
<td>O3-Arranging Room</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>O51-Handout Materials</td>
<td>0</td>
<td>0.00%</td>
<td>O51-Handout Materials</td>
<td>0</td>
<td>0.00%</td>
<td>O51-Handout Materials</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>O52-Collect Materials</td>
<td>0</td>
<td>0.00%</td>
<td>O52-Collect Materials</td>
<td>0</td>
<td>0.00%</td>
<td>O52-Collect Materials</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>O53-Arranging Room</td>
<td>0</td>
<td>0.00%</td>
<td>O53-Arranging Room</td>
<td>0</td>
<td>0.00%</td>
<td>O53-Arranging Room</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>S1-School Related</td>
<td>1</td>
<td>4.17%</td>
<td>S1-School Related</td>
<td>0</td>
<td>0.00%</td>
<td>S1-School Related</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>S2-Non-School Related</td>
<td>0</td>
<td>0.00%</td>
<td>S2-Non-School Related</td>
<td>0</td>
<td>0.00%</td>
<td>S2-Non-School Related</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>S51-School Related</td>
<td>18</td>
<td>75.00%</td>
<td>S51-School Related</td>
<td>22</td>
<td>61.11%</td>
<td>S51-School Related</td>
<td>5</td>
<td>14.71%</td>
</tr>
<tr>
<td>S52-Non-School Related</td>
<td>0</td>
<td>0.00%</td>
<td>S52-Non-School Related</td>
<td>4</td>
<td>11.11%</td>
<td>S52-Non-School Related</td>
<td>0</td>
<td>0.00%</td>
</tr>
</tbody>
</table>
Development of a research tool to investigate pedagogical affordances of engineering students’ experimental learning venues *(or how to audit the teaching styles supported by your laboratory spaces)*

Figure 6: Demonstrator (tutor) *kikan-shido* patterns from recordings of face-to-face laboratory sessions.
**Development of a research tool to investigate pedagogical affordances of engineering students’ experimental learning venues (or how to audit the teaching styles supported by your laboratory spaces)**

**Figure 7:** Demonstrator (tutor) kikan-shido patterns from recordings of face-to-face laboratory sessions (continued).
<table>
<thead>
<tr>
<th>CURTIN</th>
<th>(12)</th>
<th>Total</th>
<th>Weighted</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1-ENCOURAGE STUDENT</td>
<td>0</td>
<td>0.00%</td>
<td></td>
</tr>
<tr>
<td>G2-GIVING INSTRUCTION</td>
<td>3</td>
<td>25.00%</td>
<td></td>
</tr>
<tr>
<td>G3-GUIDING BY QUESTIONING</td>
<td>2</td>
<td>16.67%</td>
<td></td>
</tr>
<tr>
<td>G4-REDIRECTING STUDENT</td>
<td>8</td>
<td>66.67%</td>
<td></td>
</tr>
<tr>
<td>G5-ANSWERING QUESTION</td>
<td>8</td>
<td>66.67%</td>
<td></td>
</tr>
<tr>
<td>G6-ADVICE ON BOARD</td>
<td>6</td>
<td>50.00%</td>
<td></td>
</tr>
<tr>
<td>G7-GUIDE WHOLE CLASS</td>
<td>8</td>
<td>66.67%</td>
<td></td>
</tr>
<tr>
<td>M1-SELECTING WORK</td>
<td>0</td>
<td>0.00%</td>
<td></td>
</tr>
<tr>
<td>M2-MONITOR PROGRESS</td>
<td>0</td>
<td>0.00%</td>
<td></td>
</tr>
<tr>
<td>M3-QUESTION STUDENT</td>
<td>7</td>
<td>58.33%</td>
<td></td>
</tr>
<tr>
<td>M4-MONITOR STUDENT</td>
<td>0</td>
<td>0.00%</td>
<td></td>
</tr>
<tr>
<td>O1-HANDOUT MATERIALS</td>
<td>0</td>
<td>0.00%</td>
<td></td>
</tr>
<tr>
<td>O2-COLLECT MATERIALS</td>
<td>0</td>
<td>0.00%</td>
<td></td>
</tr>
<tr>
<td>O3-ARRANGING ROOM</td>
<td>6</td>
<td>50.00%</td>
<td></td>
</tr>
<tr>
<td>S1-SCHOOL RELATED</td>
<td>6</td>
<td>50.00%</td>
<td></td>
</tr>
<tr>
<td>S2-NON-SCHOOL RELATED</td>
<td>0</td>
<td>0.00%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>QUT</th>
<th>(18)</th>
<th>Total</th>
<th>Weighted</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1-ENCOURAGE STUDENT</td>
<td>0</td>
<td>0.00%</td>
<td></td>
</tr>
<tr>
<td>G2-GIVING INSTRUCTION</td>
<td>16</td>
<td>88.89%</td>
<td></td>
</tr>
<tr>
<td>G3-GUIDING BY QUESTIONING</td>
<td>15</td>
<td>83.33%</td>
<td></td>
</tr>
<tr>
<td>G4-REDIRECTING STUDENT</td>
<td>15</td>
<td>83.33%</td>
<td></td>
</tr>
<tr>
<td>G5-ANSWERING QUESTION</td>
<td>17</td>
<td>94.44%</td>
<td></td>
</tr>
<tr>
<td>G6-ADVICE ON BOARD</td>
<td>0</td>
<td>0.00%</td>
<td></td>
</tr>
<tr>
<td>G7-GUIDE WHOLE CLASS</td>
<td>16</td>
<td>88.89%</td>
<td></td>
</tr>
<tr>
<td>M1-SELECTING WORK</td>
<td>0</td>
<td>0.00%</td>
<td></td>
</tr>
<tr>
<td>M2-MONITOR PROGRESS</td>
<td>0</td>
<td>0.00%</td>
<td></td>
</tr>
<tr>
<td>M3-QUESTION STUDENT</td>
<td>1</td>
<td>5.56%</td>
<td></td>
</tr>
<tr>
<td>M4-MONITOR STUDENT</td>
<td>15</td>
<td>83.33%</td>
<td></td>
</tr>
<tr>
<td>O1-HANDOUT MATERIALS</td>
<td>16</td>
<td>88.89%</td>
<td></td>
</tr>
<tr>
<td>O2-COLLECT MATERIALS</td>
<td>0</td>
<td>0.00%</td>
<td></td>
</tr>
<tr>
<td>O3-ARRANGING ROOM</td>
<td>0</td>
<td>0.00%</td>
<td></td>
</tr>
<tr>
<td>S1-SCHOOL RELATED</td>
<td>0</td>
<td>0.00%</td>
<td></td>
</tr>
<tr>
<td>S2-NON-SCHOOL RELATED</td>
<td>0</td>
<td>0.00%</td>
<td></td>
</tr>
</tbody>
</table>

Figure 8: Summary of identified demonstrator (tutor) *kikan-shido* events in the recorded videos from Curtin and QUT.
The numerical columns in Figure 5, Figure 8 and Figure 9 quantify the identified event occurrence as well as highlighting (with the “Weighted” value) the importance of ensuring that venue affordances will support as many of the identified kikan-shido events as possible.

In cases where the experiment is to be delivered in other settings, a rank, reflecting the importance of facilitating affordance(s), may be assigned in the descending order of the corresponding “Weighted” values.

Investigation of data analysis efficiency (by comparing “1hr versus 20min of each recording” for the 1hr recorded laboratories) established that the chance of observing an event during the 1hr analysis only increases, on the average, by 37 per cent for a 300 per cent increase in time and effort taken to complete it.

Chapter 3.2: A tool to explore the affordances of experimental learning environments

The tool, in the form of a framework, encompasses the collection and subsequent analysis of video recordings, of student and demonstrator communication, for kikan-shido events during experimental learning activities.

12 “Weighted” values were calculated as a percentage of the number of videos where it was identified.
To implement this tool the following steps should be taken in the order indicated:

- using audio and video recording equipment collect the data;
- use Studiocode® to document the subsequent analysis process; and
- map the identified kikan-shido events, as shown in Figure 10, to directly reflect the affordances of the venue under investigation.

<table>
<thead>
<tr>
<th></th>
<th>One → One</th>
<th>One → Many</th>
<th>Many → One</th>
<th>Many → Many</th>
</tr>
</thead>
</table>

*Figure 10: Mapping kikan-shido events, as described in Table 1, to venue communication affordances*
Chapter 4: Discussion

The framework applied in this investigation ensured “repeatability” of both data collection and subsequent analysis – a highly desirable feature, in case verifications of the analysis were attempted by other researcher(s) and/or any other expert(s) and/or interested parties.

The identification of student-student and student-demonstrator kikan-shido events highlighted the venue’s affordances as far as those events were concerned. We can only establish “that something is positively the case, never the reverse” (Greenfield, 2014; p.30). Events that were not identified may indicate a potential shortfall in venue affordances (by not supporting those events), or that there was no need for these in the context of the experimental learning, or both. Therefore, it is not possible to conclude absolutely that no other venue affordances are required “any more than … anyone could prove definitively, to use an age-old example, that there is not a teapot in orbit around Mars” (Greenfield, 2014; p.30).

In order to mimic the pedagogy that could be practiced during a laboratory experiment, the communication affordances (which are required for face-to-face and online delivery) have been mapped, in Figure 10, to all the kikan-shido events that may occur. This mapping identifies the communication affordances that are necessary to facilitate each event. It then follows that the real-time online implementation of the three communication affordances (namely audible, visual and gesturing) can fully facilitate the mimicking of face-to-face experimental pedagogy for off-campus students.

Furthermore, the data collected using video recordings were free from any participants’ personal bias. Other researchers have identified such bias to be present in many instances, for example:

- student/staff experience surveys (Bodner, Wade, Watson, & Kamberov, 2013; Corter, Esche, Chassapis, Ma, & Nickerson, 2011; Lang, 2012);
- focus groups (Jarmon, Traphagan, Mayrath, & Trivedi, 2009);
- participants’ reflective journals (Jarmon et al., 2009; Lang, 2012);
- formal laboratory reports (Lang, 2012); and
- marks obtained for pre-event and post-event testing (Nickerson et al., 2007).

It is worth noting that the last two listed data collection techniques, implemented by Lang (2012) and Nickerson et al. (2007), provide extremely narrow ranges of data variation with unreliable accuracy, hence being extremely poor indicators of the participants’ kikan-shido activities; consequently the venue’s affordances.

As observed from the percentage values in the “Weighted” columns of Figure 5, Figure 8 and Figure 9, some kikan-shido events were detectable for nearly all participants - in many cases across a range of different laboratory experiments. The higher the value of this percentage, the greater is the need to ensure that the affordance of a chosen face-to-face or cyber venue, in which the experiment is to be performed, facilitates such kikan-shido events.
Statistically the chance of observing any event increases with the length of time for which the video is analysed. Upon investigation of the chance of observing an event in 1 hour recordings, it was found, that the chance of observing these in a “mid-20 minutes” period of the same recordings\(^\text{13}\) was not linearly worse. This finding may be an argument for “more and shorter video analysis” when funds are extremely tight. Unfortunately, for events that were not identified, such calculations are not possible.

Resulting from the hands-on nature of the outcome, the research team deemed it more appropriate to develop e-Resources illustrating the application of the framework, rather than presenting the outcomes in webinars. These, identified as tutecasts, are available on the project’s web site\(^\text{14}\).

Finally, it is worth noting that Studiocode\(^\circ\) did provide the ideal utility to put into practice the three-layered interpretive model for media-rich research into social interaction (Wortham & Derry, 2006), thereby ensuring that a trail existed for the identification of kikan-shido events in the videos, for the binary technique of determining if an event was identified or not, Studiocode\(^\circ\) may not to be essential. Conversely, when the analyses require the time period for each kikan-shido event Studiocode\(^\circ\) is highly recommended.

---

\(^{13}\) The “middle 20minutes” was selected on the assumption that during this period any “start” and “stop” events would be minimal.

Chapter 5: Dissemination of outcomes

Outcome dissemination was achieved with the project website incorporating:

- tutorial videos, known as tutecasts, depicting the application of the resultant framework for use by the sector and delivering the project’s details to the wider community;

- details of conference workshops and master classes (see Appendix D), at the Australasian Association of Engineering Educators (AAEE) annual conferences in 2013\textsuperscript{15} and 2014\textsuperscript{16};

- conference papers (see Appendix E); and

- a journal article (see Appendix E).

\textsuperscript{15} http://hdl.handle.net/1959.3/381594
\textsuperscript{16} http://hdl.handle.net/1959.3/391263
Chapter 6: Conclusions

The proposed framework, based on the analysis of video recordings of participant activities for *kikan-shido* events\(^\text{17}\), was found to be a valuable tool. This framework has been found useful for deducing the affordances of experimental learning venues, such as student laboratories. It can also be used to safeguard the quality of students' experimental teaching and learning in any context by ensuring that the affordances needed to facilitate the identified *kikan-shido* events are present. Furthermore, another application of the framework is to ensure that proposed or existing online courses mimic, as closely possible, the outcomes of the on-campus delivered equivalents.

Following the completion of this seed grant, in 2015, this framework will be deployed to explore real-time online supervised laboratory experimentation utilising wearable technologies (see Appendix C for details).

\(^{17}\) As described by Clarke (2004), for his study of eighteen, year-eight mathematics classrooms, in order to compare the classroom practices in five countries around the world.
Appendix A: Certification

Certification by Deputy Vice-Chancellor (or equivalent)

I certify that all parts of the final report for this OLT seed grant provide an accurate representation of the implementation, impact and findings of the project, and that the report is of publishable quality.

[Signature]

Professor Jennelle Kyd
Senior Deputy Vice-Chancellor and Provost
Swinburne University of Technology
Date: March 27, 2015
Appendix B: References


Sarukkalige, R., Lindsay, E.D., & Anwar, A.H.M.F. (2010, December 5-8, 2010). Laboratory demonstrators’ perceptions of the remote laboratory implementation of a fluid mechanics laboratory. Paper presented at the 21st Annual Conference for the Australasian Association for Engineering Education, Sydney, N.S.W.


Appendix C: Impact of outcomes to the sector

Using the outcomes of this research, an investigation of the affordances of real-time online supervised real equipment experimentation has been funded by Swinburne University18.

18 Since Google ceased the development of their GoogleGlass (Smith, 2015), this investigation will use the Meta Spaceglasses ([https://www.getmeta.com/products](https://www.getmeta.com/products)).

Development of a research tool to investigate pedagogical affordances of engineering students’ experimental learning venues (or how to audit the teaching styles supported by your laboratory spaces)
Appendix D: Promotional materials for masterclass/workshop presentations

2013

Workshop 2C: I do and I understand: practiced pedagogy during experimental learning by engineering students.

Experimental learning, traditionally conducted in on-campus laboratory venues, is the cornerstone of science and engineering education.

In this workshop we will discuss, and then apply, established techniques to investigate the teaching and learning experiences within an experimental learning environment.

Come along and participate by sharing your experiences with the interactions between all the participants during experimental/porporional learning with real and virtual equipment in both face-to-face and remote laboratories.

Day: Tuesday December 10, 2013.
Time: 3:30pm to 5:00pm.

Project Team:
Dr George Banky (Project Leader), Mr Aaron Blicbland, A/Professor Hari Vuthaluru, Dr Prasanna Egodawatta

Partner Institutions:

Support for this workshop has been provided by the Australian Government Office for Learning and Teaching. The views in this workshop do not necessarily reflect the views of the Australian Government Office for Learning and Teaching.

2013 Australasian Association for Engineering Education (AAEE) Annual Conference
8th – 11th December 2013
Experimental learning, traditionally conducted in on-campus laboratory venues, is the cornerstone of science and engineering education.

In this workshop we will discuss, and then apply, the outcomes of an OLT funded Seed Project that investigated the teaching and learning experiences with experimental learning environments.

Come along and take part by identifying the observable interactions between participants during experimental learning using real and virtual equipment in face-to-face laboratories, thus benchmarking existing or planned online delivery venues.

**Day:** Monday December 8, 2014.

**Time:** 3:30pm to 5:00pm.

**Project Team:**
Dr George Banky (Project Leader), Aaron Blicbliou, Dr Prasanna Egodawatta, AV Professor Hari Vuthaluru and Martin Voelka

**Partner Institutions:**
Curtin University, QUT

Support for this workshop has been provided by the Australian Government Office for Learning and Teaching. The views in this workshop do not necessarily reflect the views of the Australian Government Office for Learning and Teaching.

Appendix E: Publications

Conference Papers:


Journal Articles:


Video Tutorials (Tutecasts):


Website: