Engaging Students for Active Learning: Structuring a Project Subject for First Year Engineering Students

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Abstract: This paper reports on how an engineering project subject was structured in line with engagement theory to provide more active learning for students to achieve the stated objectives. The design and development steps of five real world oriented projects were structured into three major phases. Students were engaged in the roles of a manager, constructor, and tester/documenter in a team in rotation that resemble the real industrial world. Relevant pedagogical theories supporting this approach were discussed. Based on an evaluative survey, this paper also presents students' feedback on the effectiveness of learning this project-based subject.

Keywords: Project-based learning, engagement theory, structured approach, generic attributes, learning environment, learning experience.

Introduction

There is a greater emphasis on the introduction of project based learning across all years in the teaching of engineering courses on a worldwide basis. In the first year of the course this is a more difficult task due to the students’ limited or even non-existent technical knowledge. Further, both the Institution of Engineers Australia Professional Engineering Program Accreditation document (IEAust, 1997) and the Swinburne University graduate attributes (Swinburne, 2002) encourage the introduction of this type of content delivery method in order to ensure the desired student outcomes.

The subject HET1005 – Engineering Projects was developed to address the above attributes in the first year of the Bachelor of Engineering (Electronic Engineering & Computer Systems) course with the expectation that students after completing this subject should have:

- had experience in the work of a professional engineer in a representative context, and shared in the experience of other students engaged in projects, leading to a more inclusive understanding of the engineering profession.
- an appreciation of the social context of engineering work.
- conducted at least one small engineering design project from conception to final product.
• constructed a richer understanding of fundamental concepts through active engagement with these concepts in an application to “real world” problems.
• developed problem identification and solution skills.
• further developed skills in working as part of a team.
• gained skills in accessing, interpreting and using information from a range of sources.
• improved skills in a range of communication modes.
• developed time management and organisational skills.
• developed physical skills appropriate to the project type.
• reflected on personal strengths and weaknesses, and developed a better understanding of themselves as learners and individuals.

Theoretical bases of the approach

The design of the approach to teaching this subject is based on the following educational principles:

Engaging student learning

The basic concept of engagement theory argues that, in order to motivate students, they must be meaningfully engaged in learning activities through interaction with others. Kearsley and Shneiderman (1999) suggest that students will be engaged in their learning if they are involved in active cognitive processes that involve creating, problem-solving, reasoning, decision-making and evaluation. Students will not be strongly motivated if the activities they are required to undertake only involve them in acquiring facts and accessing information. We used an approach aimed at facilitating student-centred flexible learning, in order to motivate students to learn both individually and collaboratively.

According to Anderson (2002), for engagement to occur, students not only have to work interactively with the content, but also need to work with their ‘own reasoning’ and ‘perspective’. The aim is to develop and contribute personal insights that further enrich the understanding they and their peers acquired from class instruction or other forms of learning. Consequently, engaged students are able to make important contributions to the meaning and value of what is studied.

Project-based learning

Meaningful project work engages students to be creative, inquisitive, and collaborative. Project work is an ideal context in which to apply engagement theory. It requires students to be actively engaged in meaningful learning by sharing ideas about project activities and then to further develop what they have learnt about a topic into a product. As noted by Saiedian (1998), an early participation and exposure to group projects would also help students to understand that written and oral communication, interpersonal skills, and the ability to analyse results are important competencies of a professional in the real world. Group project work provides learning experiences whereby students not only develop skills through doing, but are also involved in deep approaches to acquire knowledge. Project work promotes student autonomy in such a way that students have to be responsible for their own learning and consequently will develop lifelong learning skills.

Project-based learning also introduces some of the practical issues that face product development teams in industry. One of the five major benefits of group project suggested by Mello (1993) is that students become more prepared for the real world. A student in a team will be able to gain an overall understanding of roles in a product development team that is
difficult to obtain without the support of a group. Group projects are becoming an essential part of teaching and learning in most of engineering courses because of their relevance to industry.

Design of the learning environment

The structured approach

For project-based teaching to succeed, appropriate planning is very important. In order to achieve the expected learning outcomes considerable care has to be taken to insure that the class project is structured in such a manner that students, working together, acquire valuable knowledge and develop in them the graduate attributes demanded. For this to happen five “real world” projects were identified and well defined, each covering an important discipline in Electrical Engineering. Specifications for these projects are summarized in Table 1. Students were told why they are learning the particular disciplines and how these disciplines relate to each other. The aim was to let students understand the purposes of their project work and the cognitive processes involved.

<table>
<thead>
<tr>
<th>Project Number [Dick Smith Code]</th>
<th>Project Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project 1 (P1) [K1329 VELLEMAN Water Alarm Kit]</td>
<td>The SnowWhite Washing Machine Company is experimenting with electronic controls for their latest range of heavy-duty washing machines to be called the Grumpy. Your design team has been given the task of designing a “water alarm” module for this new product range.</td>
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<tr>
<td>Project 2 (P2) [K1334 VELLEMAN Sound Level Meter Kit]</td>
<td>The legal firm of Bumstead &amp; Co (specialists in class action claims) has devised a marketing plan to inform people attending “rave parties” of the possible hearing damage that may be caused by the high noise levels within such venues. Your design team has been given the task of designing a “sound level meter” module that may be handed to potential clients for the purpose of obtaining evidence.</td>
</tr>
<tr>
<td>Project 3 (P3) [K2631 DS Wireless Microphone Kit]</td>
<td>The online startup venture, Junkfoodtogo.com wants to establish an inhouse mobile communication network for its staff of 2000 “online personal shoppers” at its purpose built warehouse complex. Your design team has been given the task of designing a self contained “Microphone – Transmitter Module” that may be used in such an application.</td>
</tr>
<tr>
<td>Project 4 (P4) [K3533 DS Clifford the Cricket Kit]</td>
<td>The business plan of the internet startup, Howgreenwasmyvalley.com, calls for the commercialisation of a range of electronic insects or e-bugs. The company hopes to obtain the support of the Green Community and list on the stock exchange as soon as any of its products become available. Your design team has been given the task of designing its flagship product an “electronic cricket” which is the first member of its teenygreeny range.</td>
</tr>
<tr>
<td>Project 5 (P5) [K1254 DS Formula-1 Car Kit]</td>
<td>The next PetitPrix is scheduled for Melbourne (probably along the corridors of the SE building at Swinburne University of Technology). Your design team has been given the task of preparing an entry vehicle for this forthcoming event.</td>
</tr>
</tbody>
</table>

Table 1: Project Specifications

Completing projects that relate to real world situations require different teaching and learning strategies. It can be daunting, if not frightening, to students who have no industrial working experience and little or no technical foundations, to expect them to solve problems connected to the outside world. For students who have work experience, it can be a little easier, as they can relate a project to a work situation that is familiar to them. To achieve this, all potential projects were screened to ensure that they are appropriate for the subject matter involved and that the scope of work is feasible within the students’ knowledge base and available timeframe.
Teaching and learning details
The subject is timetabled for 36 contact hours per student in the second semester of their eight-semester long course. At this early stage of their academic path, since the technical knowledge of these first year students is assumed to be minimal, asking them to design a solution to an engineering problem from first principles would result in frustration for most. Therefore, as a compromise, after the students are guided through the research steps, we issue them with an appropriate commercial kit to carry out the project work.

The option of kits rather than loose components was selected in order to minimise any associated administrative work. Further, the kits were selected with the following criteria in mind:

- low voltage based systems (for safety);
- hardware rather than software solutions (for better understanding of circuit behaviour);
- discrete and/or SSI devices (for maximum exposure to classic components).

This approach attempts to expose all of the students to valuable hands-on activities, and accommodates, in the later stages of the project cycle, extension work for some of the more capable students.

Figure 1: Project Teaching and Learning Arrangement
The teaching and learning structure of this subject is made up of three Phases, as illustrated in Figure 1 above.

Phase 1 – Introduction cum Practice
The first three contact hours are spent on discussing the engineering design process, as well as giving students the opportunity to practise using a soldering iron.
Phase 2 – Project Design and Development

In Phase 2 the students are given five small commercially available project kits, each one selected to highlight the discipline of electronics, instrumentation, communication, microcontrollers and/or machines. Table 1 shows the specifications of these projects.

Under staff supervision and guidance, the projects are completed in six contact hour cycles (a total of thirty hours) during which the students carry out some research, construction, testing, documentation and then discuss component operation (a macroscopic view), commercialisation and possible improvements to the design. One of the remaining contact hours is spent enhancing students’ professional knowledge by focussing on discussing professional issues such as IP protection, entrepreneurship, the role of professional societies and venture capitalists.

Phase 3 – Group Competition

During the final two contact hours the students are given the opportunity to fine tune their last project (a model F1 racing car) and then race it against others in the MiniPrix held along the corridors of one of the on-campus buildings.

Group activity
To facilitate the students’ learning of teaming skills and to monitor the ongoing quality of team processes, as suggested by Lewis et al (1998), the students are divided into groups of three. For each project, the roles of manager, constructor and tester/documenter are rotated so that each student spends approximately the same effort in the last two roles. This is possible because the complexities of each of the chosen projects are of a different level. Each student is required to keep a detailed logbook that is assessed at the end of the semester. Each group must deliver a seminar presentation and a formal report on one of the projects that was randomly assigned by the staff member.

Have the expected learning outcomes been achieved?

In order to gain some understanding of whether the learning objectives have been achieved, a survey was used (with Ethics Committee permission) in order to solicit students’ feedback on various aspects of the teaching and learning process. Students’ final scores were also reviewed in order to gauge the success of the Subject.

Student Feedback
The survey questionnaire consisted of Likert statements and open-ended questions on factors of ‘Objectives and Educational Value’, ‘Structure of Subject’, ‘Facility and Resources’, and ‘Assessment of Subject’. The survey was administered to all 25 students enrolled in the subject after they delivered their respective seminar presentations. Table 2 below summarizes the responses obtained.
Students in general agreed that this subject has provided them with learning experiences that facilitated them to achieve the stipulated objectives. They felt that they have developed in themselves some of the graduate attributes required to enter the world of professional engineers. Students also agreed the subject was well structured in that they have been provided with sufficient guidance in the design and development of the projects and engaged in various meaningful group activities. The survey results also revealed that students were satisfied with the facility and resources available to them in completing their projects. With regard to the assessment process, students agreed that they have been given a fair chance to demonstrate what they have learned in a balanced manner emphasising both the process and product.

**Student Performance**

Students were assessed in both the process of solving the problems posed in the projects and the outcome. Students had to submit a logbook and project reports for assessment of the process. In order to assess the outcome, groups were required to make presentations on their project work to the class, during which the students were given the opportunity to assess their peers as well. Assessment weightings allocated to each of the components were logbook – 40%, formal report – 30%, seminar presentation – 20% and peer assessment – 10%.
Figure 2: Consolidated Class Results

It can be seen from Figure 2 that the students, in general, achieved good results with a mean score of 71.

Conclusion

The idea of using a structured approach in project-based teaching in order to engage students in their learning has been very successful in this case. Students’ feedback and their actual performance indicated that the learning experiences created were successful in engaging students in meaningful group activities, in order to achieve the stipulated objectives. We believe the success of project-based teaching, in the first year of Engineering courses, relies on the academic acknowledging the possible limitations in the students’ technical knowledge by selecting projects that expose the student to simple basics (such as discrete components discussed functionally rather than operationally) instead of more technically appropriate but also more complex alternatives (for example, VLSI and LSI based solutions such as microcontrollers or other custom chips that can only be treated either in too much detail or as “black boxes”). Further, the academic must ensure that the students understand not only the tasks they are to undertake, but also the purposes for such activities. Finally, from an administrative viewpoint the subject was found to be scalable as long as the staff-student ratio was maintained.

References


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