Introduction of Graduate Capabilities Through ‘Teamworker’ and Extended Project in Infomechatronics

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ABSTRACT

Accreditation of engineering courses requires the incorporation of not only technical content but also generic capabilities development in the course structure. Among the many requirements are:

- Ability to communicate effectively, with engineering teams and the community at large
- Ability to function effectively as an individual and in multi-disciplinary teams, as a team leader as well as an effective team member.

Queensland University of Technology (QUT) is committed to the integration of generic capabilities with the technical content. QUT has listed seven graduate capabilities to be incorporated in every course. Communication and collaborative working are among these seven graduate capabilities.

The infomechatronics course is an engineering program integrating mechanical, electrical and information technology. This course is an Engineers Australia accredited course. There are several subjects that specifically include graduate capabilities within the course. One of the subjects that include team work and communication skills is Mechatronics Systems Design. This unit uses extended laboratory work as a means to facilitate team work and communication skills. This paper outlines the structure of this subject and the use of ‘TeamWorker’, a web based facility developed at QUT, in developing team work and communication skills with students’ response in this development.

Keywords: Graduate capabilities, teamwork, communication skills.

1. INTRODUCTION

Engineering education in the past (pre 1980’s) placed emphasis on science and engineering fundamentals resulting in graduates with a high technical capability [1]. It was left to the industry to mold them into the broader role of engineering professionals. Professional institutions in many countries, including Australia, undertook a review of engineering education and consequently several changes were made to the engineering curriculum. The Institution of Engineers Australia (now called Engineers Australia, EA), Council of Engineering Deans and the Academy of Technological Sciences and Engineering with financial support from the Australian Government undertook a review of engineering education and concluded that [2], in addition to technical competency, graduates should have:

- the ability to communicate effectively, not only with engineers but also with the community
- the ability to function effectively as an individual and in multi-disciplinary and multicultural teams, with the capacity to be a leader or manager as well as an effective team member
member

- an understanding of the social, cultural, global and environmental responsibilities of the professional engineer, and the need for sustainable development
- an understanding of and commitment to professional and ethical responsibilities
- the expectation and capacity to undertake life-long learning

The recommendations of this review were then incorporated in the accreditation requirements of engineering courses by Engineers Australia. Thus, engineering schools around Australia are increasingly incorporating the graduate capabilities, as mentioned above, in their degree programs. Queensland University of Technology is no exception. The engineering courses within the Faculty of Built Environment and Engineering have included the new objectives into the core of the disciplines. This paper outlines how some of these objectives specifically working in teams are integrated into a unit (In US terminology a course) and how the development of these objectives are facilitated using a web based facility called TeamWorker. The paper will also discuss the reaction of the students to the introduction of these objectives in the unit.

2. BACKGROUND

It is well known that our skill level moves from novice to expert as we gain experience reflect upon our experiences and modify our future behavior based on the reflection. The various stages of moving from novice to expert [2] are novice, advanced beginner, competent, proficient and expert. The characteristics of each of these stages are shown in the table 1.

<table>
<thead>
<tr>
<th>STAGE</th>
<th>CHARACTERISTICS</th>
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<tr>
<td>Novice</td>
<td>No experience</td>
</tr>
<tr>
<td></td>
<td>Sticks strictly to rules</td>
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<td></td>
<td>Unable to decide which tasks most relevant</td>
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<td>Advanced beginner</td>
<td>Low level unsupervised performance</td>
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<td></td>
<td>Belief in single solution</td>
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<td></td>
<td>Ask for answers</td>
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<td></td>
<td>Unwilling to explore problems</td>
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<tr>
<td>Competent</td>
<td>Can analyse complex problems</td>
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<tr>
<td></td>
<td>Uses conscious, thoughtful, analytic reflection</td>
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<tr>
<td></td>
<td>Conscious planning</td>
</tr>
<tr>
<td></td>
<td>Lacks speed and flexibility of higher levels</td>
</tr>
<tr>
<td>Proficient</td>
<td>Intuitive response to “big picture” Uses experience of ‘typical’ events</td>
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<tr>
<td></td>
<td>Considers fewer options than competent person</td>
</tr>
<tr>
<td>Expert</td>
<td>Acts “by instinct”</td>
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<tr>
<td></td>
<td>Is unaware of rules</td>
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It is apparent that in an undergraduate degree program that the skill level developed in any aspect cannot be at the expert level. However, it is expected that the engineering graduates
exhibit a competent/proficient stage in their technical capabilities. Until recently the other graduate capabilities such as team skills, communication skills etc neither formed part of the curriculum nor was assessed. It was assumed that over the four years of study that the students will acquire some of these skills.

Since the review of engineering education, more and more engineering courses are being designed to allow students to acquire some team related skills [3]. Shuman et.al. [3] reported that there are many forms of team related skills are included in the curriculum. These range from simple decision making exercises to project management exercises in authentic settings. They also reported on practices adopted by several universities. They suggested two guiding principles for the selection of activities for incorporating team skills in any program: fidelity and complexity. Fidelity refers to the authenticity of the situation presented to the students and complexity is defined by two factors: task dependencies and cognitive factor. Several universities in US have adopted a modular approach [3] to support team activities. The United Kingdom has gone through the same changes and the Higher Education Academy [4,5] has generated several resources to help universities in how to integrate team skills in their curriculum with several case studies. Likewise, in Australia, engineering schools have designed the engineering curriculum incorporating the graduate capabilities. Mildren et.al [6] have introduced team work as a teaching and learning paradigm in engineering and used teams to cooperate in their learning and to develop capabilities for self-directed learning. Johnston and McGregor [7] argued that it is the responsibility of the engineering academics to provide the environment for the development of team skills. They suggested that group projects and assignments can provide an effective context for developing team skills. Jolly and Radcliff [2], have explored strategies for developing reflexive habits and concluded that given the opportunity, the students do reflect on the work done, but not using the insight gained in reflection to modify future plans. This applies to both individual and group work. In all the literature, emphasis is placed on integrating the team skills and other graduate capabilities into the curriculum and teaching them as part of a unit.

There is very little literature on the assessment of team skills development. Shuman et.al. [3] indicated that formal assessment of team work skills is difficult to set and suggesting a portfolio approach over the entire engineering program with formative feedback.

3. DESCRIPTION OF THE COURSE AND UNIT

Infomechatronics is among the several engineering courses (programs) run at the School of Engineering Systems of the Queensland University of Technology. Infomechatronics course is a collaboration across the disciplines: Mechanical and Manufacturing Engineering, Electrical Engineering and Information technology. Students follow basic units in all three disciplines in the first 2½ - 3 years of study and learn applications and do their (Thesis) project in the final 1½ - 1 year. All students are expected to do an industry based project spending 3 – 4 days in the industry over a 4 – 5 months period. Many of the units in the later part of the course are project oriented or with design type assignments. One such unit in the fourth year of the course is Mechatronics Systems Design. This unit is aimed at unifying the three disciplines and is mainly project oriented. This unit provides students with an understanding of design and interpretation of hydraulic and pneumatic circuits, basic understanding of the design of mechatronics systems and PLC programming for the control of manufacturing systems with the emphasis on hands on practice. The unit consists of about 10 – 12 hours of lectures and tutorials where the concepts are introduced followed by 40 – 50 hours of laboratory exercise. Laboratory exercise consists of three components: understanding of pneumatic and hydraulic systems, operation of a flexible manufacturing cell as a mechatronics system and setting up and programming the operation of a production system. The pneumatic
and hydraulic components laboratory is of the traditional type, where the students spend about three hours looking at various elements of a pneumatic/hydraulic circuit and analyse the operation of various components. The flexible manufacturing system exercise is also an extended laboratory where the student is to develop an integrated product development and manufacture concept through programming the flexible manufacturing cell. The third exercise is the development of a production system. An example of a production system is shown in Figure 1.

![Figure 1: A Modular production System](image)

Students in groups of four or five will assemble the modular system to perform a manufacturing process from a given specification. They will then test the mechanical functionality of the system and develop a control strategy to automate the system using a programmable logic controller (PLC). Wiring, programming and testing is done by the group. This may take about 4 – 6 weeks. The students will then present a description of the system to their peers as well as to any invited staff demonstrate the system and answer any questions. The group will also present a report outlining the work done.

4. INCORPORATION OF TEAMWORKER

Since the laboratory work takes about 4 – 6 weeks and there are several tasks that need to be planned and executed, it was decided to incorporate some team work skills as part of the exercise. It was opportune that a web based system called TeamWorker was developed to manage team work by a member of the staff in 2002/2003 as part of his teaching fellowship [8]. It was decided to try TeamWorker as part of the mechatronics systems design. The TeamWorker provides a comprehensive team management tool with the following facilities for the students:

- Mandatory registration with the system
- A mandatory self evaluation exercise to sensitise students to their own skills in team work.
- Quick access to team members and staff via e-mail or phone
- Advice and guidance on how successful teams work and a step by step process for conflict resolution
- A peer evaluation, self-reflection and team reflection facility
- Ability to submit team’s goals and plans as well as meeting minutes
- Ability to view the records or evaluations entered by fellow team members
- Quick access to activity deadlines and planned meetings
- A chat room allowing online meeting if required.
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Similarly TeamWorker allows the staff to do the following:

- Allocate students to teams in a variety of ways
- Set up activities for the teams and their members
- Inspect any or all entries which the students have made into TeamWorker
- Quickly generate status report

A short introduction to TeamWorker was given at the beginning of the semester (well before the students were due to start their laboratory exercise). This included a short introduction to how to run meetings, record minutes, how to deal with loafers and conflict. The students were then asked to register and given a deadline to do so. The following activities were set up for the students as individuals and as a team to perform during the semester.

- Register and complete self-evaluation
- Set up a meeting and write out the plan
- Conduct and write minutes of the meeting
- Evaluate individually how the team is functioning
- Evaluate the role & behavior of other team members (for staff view only)
- Evaluate the role & behavior of other team members (for members to view)

5 DISCUSSION AND EVALUATION

There are two motives for setting up this laboratory exercise. First is to provide an authentic industry like project and the other is to develop team management skills. This exercise provides the student with an open ended problem with some missing information. Students are given only the likely outcome from the exercise and have to find out how to achieve this. This requires planning and careful execution. Thus, team management is an important aspect of the exercise. In the past, it was left to the students to understand the team dynamics and manage the team. Invariably, it was found that there was conflict and students struggle to complete the exercise as well as manage the team. The introduction of TeamWorker with a structured approach to team management, made it easier for the students to complete the exercises without the problems encountered by the past students. The students were given full control of the exercise. An example of the key details of a team’s plan at the beginning of the exercises is shown in figure 2.

Figure 2: Sample planning entry into TeamWorker
Author observed that the groups worked as one and there were some lively discussions during the exercises. In a conventional laboratory exercise there is very little discussion among the students due to time constraints. Some of the comments made by the students during an informal feedback session on the exercise are very encouraging about the authenticity of the exercise.

“I have learnt a lot by doing this experiment”
“This assignment gave me confidence in working with tools and to program the PLC”
“This experiment, unlike other lab classes, made me think how things are done in the industry”
“The assignment gave us control in planning and execution”

The introduction of TeamWorker also allowed students to comment on how they saw their role in the team as well as how others behaved in the team. Two of the reports are given in figure 3.

<table>
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<tr>
<th>STUDENT 1 (verbatim)</th>
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<tr>
<td>I attended all meetings, which was conducted each week. Ask team members comment about the task allocated to me and chose the best of it. Completed all task allocated to me. To discuss more with the members, punctual and more hardworking and put in more effort to be a better team member.</td>
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<tr>
<th>STUDENT 2 (verbatim)</th>
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<tr>
<td>I have quite enjoyed working with the members of this team. In the past I have dreaded group assignments since I always end up doing all work. This group was however very different. Personally, I am pleased with the way I managed myself with the team. Although I do not think the group is in trouble in terms of finishing the tasks in time, perhaps, I should have been more assertive in saying that we should move things along a bit. I do not think that anyone in the team has any problem with me and I think this has been reflected through their opinions. I would be more than happy to work with this team again and would like to think everyone else would feel this way too.</td>
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Since the introduction of TeamWorker, author never had to resolve any conflict between members of teams. The above statements and others indicate that TeamWorker has helped them in planning, reflecting how they worked in the team and solved any team related problems.

6. CONCLUSION

It is evident from the way the students conducted themselves during the exercise as well as from their reflections that the extended industry like laboratory exercises allowed them to solve open ended problems under environments similar to what they will encounter in industry. With full control of the laboratory exercise, students interacted with each other more than in any other situation in the university. The presentation and demonstration also helped them to improve their communication skills. Introduction of the web based online tool TeamWorker has helped the students to plan, reflect on their performance as a team member and to resolve any conflicts during the 4 – 6 week period of the exercise. The School intends to improve on the existing industry like exercises in the later part of their degree program.
REFERENCES

1. Institution of Engineers, Australia, Changing the Culture: Engineering Education into the Future, Institution of Engineers, Australia, 1996


