Staff competencies/capabilities required and challenges faced when delivering project based learning courses

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CONTEXT

Project based learning (PBL) courses are becoming more popular in engineering programmes but, when implementing this new style of teaching, it can be difficult to anticipate what competencies/capabilities are needed by staff delivering these courses and what challenges they will face. In 2012 Massey University implemented a 'project spine' that consists of a series of PBL courses throughout the Bachelor of Engineering and Bachelor of Food Technology programmes. Since the implementation of the project spine 5 years ago, staff have gained useful practical insights into the delivery of PBL courses.

PURPOSE

The purpose of this research was to collect insights from staff involved in the delivery of PBL courses with a particular focus on understanding what competencies and capabilities staff view as being important, and to identify unique challenges staff have faced when delivering PBL courses and determine areas for further improvement.

APPROACH

All staff involved in delivering project spine courses (including co-ordinators, teachers and supervisors) were invited to participate in an initial online survey. This consisted of a series of questions to determine the importance of a range of different competencies/capabilities on a Likert scale. The questions were related to relevant graduate competencies and the expected benefits of PBL reported in literature. Staff were then asked what challenges they had faced when delivering PBL courses. It was anticipated that the mode of teaching and issues with student teams would be key challenges, based on previous experience as well as the issues reported in literature, so additional open-ended questions were asked on these topics. These were analysed using Affinity Diagrams to provide common themes.

RESULTS

The staff competencies/capabilities which were rated as most important were a willingness to learn as well as teaching experience, while those that rated lowest were industry experience and an understanding of teaching theory. It is interesting to note that teaching experience was seen as one of the most important attributes while an understanding of teaching theory was one of the least important given the change in teaching style required in adopting PBL. The most common challenges with PBL were related to group assessment, the different way of teaching, as well as course organisation and administration. The majority of staff reported that they 'sometimes' experienced problems with student teams and that these tended to be due to a single student either not putting in the effort or not being as capable as the other team members. The most common solution to these issues was via discussion/mediation.

CONCLUSIONS

The two key areas which require further improvement are the allocation of marks to individuals for group work, and the challenges international students face in PBL courses, and managing the solutions consistently across the programmes. The staff perspectives reported here will be valuable for other institutions implementing PBL courses within their engineering programmes.

KEYWORDS

Project based learning; professional development; staff competencies; staff capabilities

Introduction

Several international studies have found that today's engineering graduates require a broader perspective in terms of social, environmental and economic issues, lack teamwork and communication skills and, that while they have a good knowledge basis, they lack the ability to apply their knowledge in a practical way (Mills and Treagust, 2003; Nair *et al.*, 2009; Male *et al.*, 2010). One technique to enhance these skills is the use of project based learning (PBL). PBL typically involves small groups of students working together under the supervision of staff on a long term project (i.e. one semester or more) (Mills and Treagust, 2003). This approach to teaching encourages the students to be more active in their learning and promotes critical and proactive thinking (Hadim and Esche, 2002), all of which are key skills needed in graduate engineers (Goodyer and Anderson, 2011).

Following a substantial review (Goodyer and Anderson, 2011), Massey University implemented a 'project spine' that consists of a series of PBL courses throughout the four-year Bachelor of Engineering and Bachelor of Food Technology programmes in 2012. The project spine consists of one PBL course per semester for each of the first two years and one PBL double semester course for each of the third and fourth years (representing 25% of the programme). These courses focus on developing professional skills required by engineers, which includes communication skills, team work, project management, and the practical application of theory learnt in theoretical courses. In the project spine, projects narrow in focus from global perspectives in Year 1 to major specific Capstone projects in Year 4 (the final year), with increasing autonomy in management of the projects by the students themselves, and increasing level of ability in professional skills (Figure 1 of Tunnicliffe and Brown, 2017). The projects are common to all majors in Years 1 and 2, but are increasingly major specific in Years 3 and 4.The PBL style of teaching is quite different from traditional courses. Typically, a team of staff are involved in the delivery of these courses. The different roles involved are coordinators, teachers and supervisors, where staff may have more than one role in the course. Coordinators plan the course curriculum and administer the course. Teachers will present content that is outside of subject courses needed for the project. Supervisors meet weekly with teams to check progress, advise on direction, and monitor the teams for issues. All staff can be involved in assessment. Typically there are about 4-5 staff involved in a particular course.

Cohort sizes are about 150 (Engineering and Food Technology) across two campuses, students ranging in age from late teens to early twenties but also including some mature students. Staff coordinate, teach or supervise on their home campus, with some intercampus teaching and there is an overall coordinator for the course. Typically teams have four students (range is 3-5). Project courses take place on a single day of six hours in the students' timetable, called the 'project day'. This day is used for any content delivery, assessment, supervision and project work and no other courses are scheduled for this day. Students are also expected to spend an equivalent time outside the project day working on the project. Moodle websites are used for project information, notes and assignment submission. The first year courses have been described previously by Dahm and Anderson (2013) and Shekar and Tunnicliffe (2017). Courses evaluations are completed by students at least every two years and courses are reviewed across campuses annually.

The curriculum redesign focused on PBL as this was an effective method of implementing the CDIO syllabus (Goodyer and Anderson, 2011). Broadly the projects take place over an extended time period (a semester or double semester), they require the application of knowledge from their subject courses (in the current or previous semesters), and the project team has to manage their time, roles in the project and resources to deliver the completed artefact (e.g. design or model), features that differentiate Project Based Learning from Problem Based Learning (Mills and Treagust, 2003, Palmer and Hall, 2011). However it might be argued that Year 1 in particular has characteristics of Project-Assisted Learning or

Problem Based Learning as there is greater direction and content delivery from staff than in later years (Palmer and Hall, 2011, Mills and Treagust, 2003).

The majority of research focuses on the theory rather than the practical realities of PBL courses. Very few studies have examined what competencies and capabilities are required by staff in order to effectively deliver these PBL courses even though staff are known to be incredibly important to ensure the success of these courses (Hung, 2011). During the five years since the implementation of the project spine, Massey University staff have gained useful practical insights into the delivery of PBL courses. The purpose of this research is to capture this information to inform others of this knowledge and to identify key areas that could be further improved.

Methodology

All staff involved in the delivery of the project based courses (co-ordinators, teachers and supervisors) were invited to participate in an anonymous online survey. This research was reviewed and approved by the Massey University Human Ethics Committee, Application SOB 17/15. The survey was administered by an independent person and all identifying information was removed before the researchers were given access to the data. This initial survey was used to gain insight of issues that the staff delivering these courses might have, or capabilities that might be perceived by staff to be missing, and needed further investigation. The results are intended to direct further research, using focus groups and individual interviews, on the important findings from this survey to further develop PBL at Massey University and, improve the Engineering and Food Technology programmes.

The survey first asked the staff to rate the importance of the following competencies/capabilities in terms of their importance, in order to effectively deliver project based spine courses: industry experience, experience managing projects, experience managing people and teams, an ability to counsel and mentor, and technical knowledge specific to the project content/context. The graduate attributes of the Washington Accord (IEA, 2013) pertaining to Professional Skills such as "9 Individual and Team Work", "10 Communication", "11 Project Management and Finance", and pertaining to the design of artefacts such as "1 Engineering Knowledge." and "3 Design/Development of Solutions" are characteristic of project based learning (Mills and Treagust, 2003, Palmer and Hall, 2011). These are common learning outcomes for project courses, and therefore the survey should look at knowledge and experience in professional skills (project/people management and teamwork, technical knowledge of the project context). The projects are intended to reflect industry (Goodyer and Anderson, 2011), therefore, the opinion of staff was sought to see if this was important. Staff also rated teaching experience, an understanding of teaching theory, a willingness to learn and, a willingness to innovate. It was considered that teaching experience and teaching theory should be considered as the project-based courses reflect a change to a learning centred approach in course delivery, and previous research had suggested that quality teaching would occur with a change in staff conceptions about teaching (Kember and Kwan, 2000). This suggested staff have to learn and innovate to deliver the courses, and reflects attribute 12 (lifelong learning) of the Washington Accord (IEA, 2013).

Finally staff rated the need for a common mind-set within a particular course; and a common mind-set within the entire project spine, as student surveys show, for example, that differences in staff expectations of what is to be delivered in the project cause confusion for the students.

These competencies/capabilities were rated on a five point Likert scale with the options very important, important, moderately important, slightly important and not important available for selection. Staff were also asked for any additional competencies/capabilities that they felt were important.

The survey also asked staff what the key challenges are that they have faced when delivering project based courses. It was anticipated that common issues would include: the different mode of teaching since most staff also delivered traditional content-based courses, and issues with student teams, which was based on the authors' experience and previous work (Dahm and Anderson, 2013, Lima *et al.* 2007). Additional open-ended questions were asked in these areas.

Staff were asked their preferred mode of teaching as different project based courses are delivered in different ways. The options given were: all staff (teaching and supervisors) present throughout the project day, separate teaching and supervision sessions, other (please explain) and no preference.

The survey then focused on student teams as issues with student teams are well known (Dutson et al, 1997, Hansen, 2006). Initially staff were asked how often they have experienced issues with student teams working effectively in project based learning courses. This was answered on a five point Likert scale with the options always, very often, sometimes, rarely, never. Two open ended questions were then asked:

- What often causes issues within student teams?

- How do you resolve issues within student teams?

Finally with regards to student teams, the staff were asked if they used a team contact for the courses they were involved with.

Based on the responses from the participants, the literature was reviewed in order to compare these finding to others reported. There were a total of 40 potential participants and 20 responses were received giving a response rate of 50%. Of the participants who completed the survey, 55% reported that they were involved in course coordination, 90% involved in teaching and 65% involved in project supervision. Staff demographics were not sought to remove the possibility of identifying staff given the small sample size within one institution.

Results and discussion

Important competencies/capabilities

Staff evaluated a range of different competencies/capabilities in terms of their importance in order to deliver the project based spine courses effectively. A summary of these results is given in Figure 1, ranked from most important to least important. An analysis of the Likert scale questions was conducted. The responses were scored 1-5 (1 not important, 5 being very important) for each question and averaged. The average scores ranged from 4.25 (a willingness to learn and teaching experience) to 2.95 (an understanding of teaching theory).

The most important competencies were a willingness to learn and teaching experience, both receiving the same overall scores. It is interesting to note that while teaching experience rates as one of the most important competencies, an understanding of teaching theory is rated as least important. This is seen as important as it has been reported that fundamental changes in teaching quality and learning are unlikely to happen without teachers changing their conception of teaching (Kember and Kwan, 2000) in a course where teachers become the facilitator (Frank *et al.*, 2003) and one of the aims for the redesigned degree was better engagement for students (Tunnicliffe and Brown, 2017). Industry experience (average score of 3.90) and experience managing people and projects (3.85) are seen as moderately important, which is positive since the project courses are industry based and developing the students' teamwork and project management skills, but mildly negative since they are not very important given what the projects are supposed to achieve.
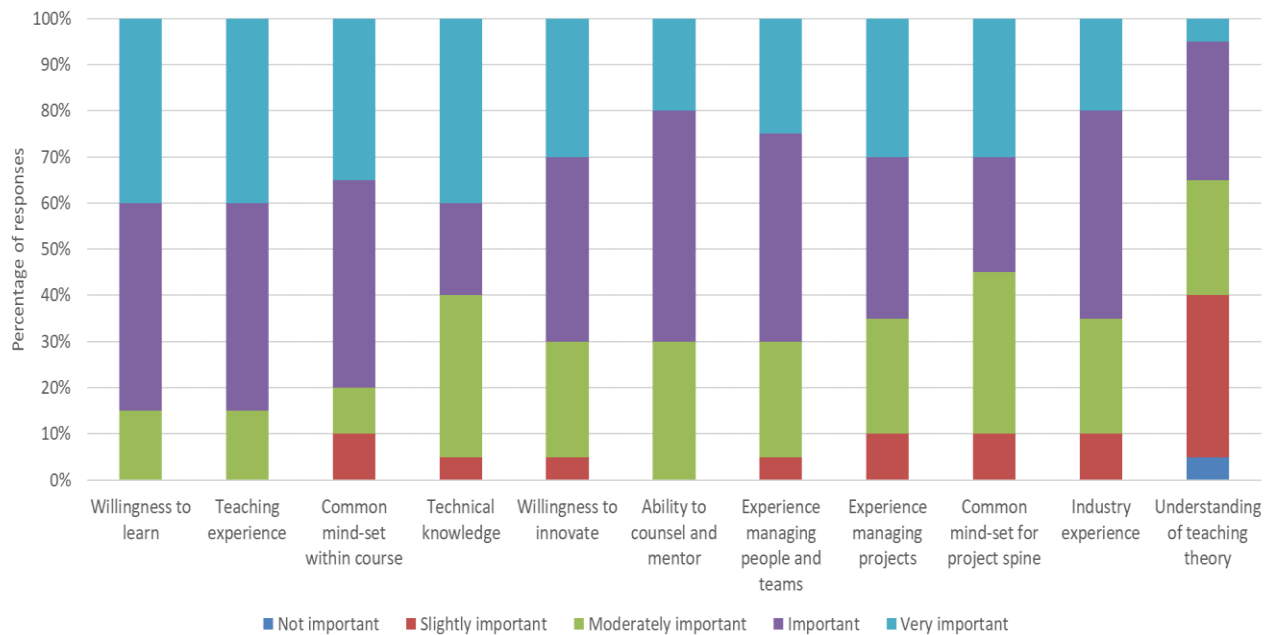
Figure 1: Staff evaluation of the importance of competencies/capabilities for effective delivery of project based courses.

Having a common mind-set within a particular course rated very highly. However staff did not view a common mind-set over the entire project spine as being important. From a student perspective however, this is important to ensure that the skills these courses aim to develop are presented and assessed in a unified way.

Additional competencies/capabilities were also identified in the three areas of motivating/enthusiastic, ability to work with others and flexibility. While the ability to work with others might be linked to 'experience managing people and teams' it appears that the participants saw this as a separate competency as it accounted for 55% of the answers given.

Key challenges when delivering project based courses

Staff were asked the question: What are the key challenges that you have faced when delivering project based spine courses? Using an Affinity diagram analysis each answer was grouped with similar responses and the overall themes together with the frequency of their occurrence are shown in Table 1. They are discussed further below.

Table 1: Key challenges staff have faced when delivering project based courses

Theme	Frequency of response
Group assessment	25%
Different way of teaching	22%
Course organisation/administration	19%
Managing staff	16%
Issues with student teams	13%
Physical resources	6%

Group assessment

As shown in Table 1 challenges with group assessment were identified as the most frequent challenge faced by staff. Assessment is often identified as an issue in the literature (for example Helle *et al.*, 2006, Lima *et al.*, 2007).

Challenges identified by staff within this theme tended to relate to the challenge of assigning individual marks and peer assessment. For example "marking group reports and allocating marks to individual students" and "peer assessments – who to handle mark allocation as we can be biased". Some courses adopt a web-based peer assessment (Dahm and Anderson, 2013) but this is not used consistently. This is seen as a potential area which needs further improvement, and is a consistent subject of student feedback in course surveys.

Different way of teaching and course organisation

Staff were asked their preferred mode of teaching and the results are shown in Table 2. The 'project day' could be comprised of a mixture of teaching, workshops, project work, meetings with supervisors and assessments. A range of different modes of teaching have been adopted by different courses. For some courses all staff (both teachers and supervisors) attend all classes. The advantage of this mode of teaching is that all staff are familiar with the course content and any instructions given to the students. However this does means that these courses do have a high staff workload compared to a traditionally taught course. Other courses have adopted a split day mode where part of the day will be allocated to teaching and project activities while the rest of the day the supervisors attend and they have project meetings with the students. This mode has a reduced staff workload but there is the potential for confusion due to the students receiving different advice from teaching staff and supervisors. With this mode of teaching clear communication between teaching staff and supervisors is vital.

Table 2: Staff preferences for the mode of teaching

Mode of teaching	Percentage of responses
All staff (teachers and supervisors) present throughout the day	28%
Separate teaching and supervision sessions	44%
A mixture of modes	11%
No preference	17%

Results show that the staff prefer to have separate teaching and supervision sessions compared to all staff being present throughout the day (Table 2). It is thought that because many staff are involved in multiple project based learning courses then the need to dedicate an entire day to each course is probably seen as an issue in terms of managing their workloads, which is consistent with other reported research (for example, Alves *et al.*, 2016). Staff had already identified the high workload involved in course management and administration as a key challenge of these project based courses (Table 1). Helle *et al.* (2006), in reviewing many published papers on the implementation of project based learning, reported that the course organisation and administration is often reported as a challenge. Support for administration tends to be underestimated when PBL is implemented (Hung, 2011). The benefits of adopting PBL despite the increased workload can be seen in the increased confidence that students have when assessing their ability in Professional skills (Tunnicliffe and Brown, 2017).

Challenges with student teams

Issues with student teams are often cited in the literature as a challenge associated with project based learning courses (for example Hansen, 2006). Therefore staff were asked how often they had experienced issues with student teams. Results are shown in Figure 2. A wide distribution of answers was given with the most frequent answers being "sometimes" and "very often."
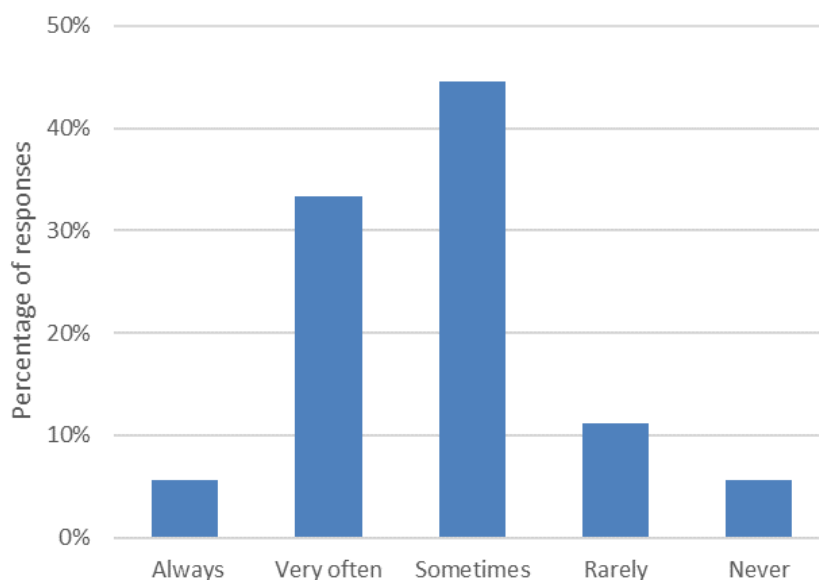

Figure 2: Frequency that staff have experienced issues with student teams in project based courses

Challenges with teams are inevitable as they are known to move through a range of stages which Tuckman (1965) described as forming, storming, norming, and performing. In the 'storming' stage discussions can become heated as individuals within the team establish their roles and positions of importance. This can lead to conflict. Hitchcock and Anderson (1997) describe dysfunctional teams as those that get 'stuck' in this stage of conflict.

One tool that has been suggested in order to manage student teams is the team contract (Seidel and Godfrey, 2005). This has been adopted by some PBL courses and is set up at the start of the semester by the student teams. It is developed by the team and gives detail of their goals and what they want to accomplish; expectations of team members; policies and procedures; and consequences. Staff were asked whether they used the contract. It was found that 47% of staff had adopted the contract in all courses they were involved with, 29% were not using the contract and 24% were using the contract in some of the courses they were involved in. The team contract is used consistently for the first two years of the programme but thereafter its use varies or is not needed by groups.

Staff were asked to identify what they believed the underlying causes of student team issues were. These responses were grouped by theme and the frequency of these comments is given in Table 3.

Table 3: Causes of team issues according to staff

Theme	Percentage of responses
Student not pulling their weight	32%
Weak student	24%

Theme	Percentage of responses
Cultural differences	14%
Issues with group organisation	14%
Personality clashes	11%
Dominant student	5%

The most common responses were regarding an uneven amount of work being completed by group members either due to students not pulling their weight or a weak student who was not as capable as the rest of the team (Table 3). This is consistent with other research (e.g. Lima *et al.*, 2007, Palmer and Hall, 2011). The distribution of these issues by year was not determined. Supervisor meetings, progress meetings and a 'Team Health' check list can help identify issues. Peer Assessment is applied to group marks but it is not effective in helping identify the team issues when used only at the end of the course.

Staff reported that cultural issues led to problems within student teams. In particular the English language level and the tendency for the international students to be shy were identified. International students face many hurdles compared to domestic students. These might include English as a second language (Andrade, 2006; Lethwaite, 1996; Barrett and Huba, 1994), a need for cultural adjustment (Wan *et al.*, 2000), a limited amount of ongoing interactions with domestic students (Knight, 1997) and a need to adjust to local teaching and learning styles (Ladd and Ruby, 1999; Stewart, 2007). These challenges can lead to limited participation within the classroom (Tompson and Tompson, 1996). Project based learning can escalate these problems as international students need to work in groups with domestic students. Therefore international students need to work in teams together so that they get the extra support required (Dahm and Anderson, 2013). Ensuring that this done consistently is an area where further improvement is required.

Staff were then asked how they resolved issues within student teams and a summary of the main themes is given in Table 4.

Table 4: Methods used by staff to resolve team issues

Theme	Percentage of responses
Discussion and mediation	71%
Monitoring and early intervention	17%
No solution found	8%
Move student to another group	4%

The vast majority of staff found that discussion and mediation with the team helps to resolve any issues (Table 4). This included individual and group discussions, refering to the team contract, revising plans, and outlining consequences for poor performance. Careful monitoring and early intervention was also found to be useful. Staff suggested that it is important to "identify issues early and make the team confront them".

Only a small number of responses indicated that they had not found a suitable solution. One example given also related to the challenge with international students saying that

> *"I have not found a solution for cultural differences. I have let students resolve issues themselves or grouped students so that it is not a problem."*

Another staff member had found a solution to this stating that

> *"I explain to domestic students that while international students may have limited English and took time to feel confident expressing themselves, they had other skills e.g. maths and could therefore become useful members of the team."*

Conclusions

In this research a staff viewpoint is given regarding the delivery of project based learning courses. In terms of key staff competencies/capabilities needed in order to deliver project based learning courses effectively, a willingness to learn and teaching experience were seen as most important. Of the competencies/capabilities listed, an understanding of teaching theory was viewed as least important. Staff also suggested additional competencies/capabilities and the most common suggestion was the ability to work with others. Given that projects are 'industry-based' the greater importance of teaching experience over project experience can be investigated, as does the greater importance of teaching experience over an understanding of teaching theory, given the change in the way course needs to be delivered using PBL, and the requirement to produce graduates that meet the Washington Accord attributes with respect to professional skills.

In terms of unique challenges with PBL courses, group assessment, the different style of teaching and course organisation and administration were the most common themes. Challenges with student teams did occur on a regular basis but the majority of staff found that discussion and mediation often worked effectively to resolve these issues.

Based on the findings of the survey there are two key areas where staff face challenges which have not been overcome yet. The first of these is the need to generate individual grades from group work and second is the challenges that international students face in project based learning courses. Finally there is a need to apply solutions consistently in each course.

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