

Researching reflection in an engineering internship program

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SESSION C1: Integration of theory and practice in the learning and teaching process. S1: Is Integrated Engineering Education Necessary?

CONTEXT At the University of Technology Sydney, engineering students undergo a 2 phase internship program consisting of a junior and a senior 6 month internship. Students are taught a framework for reflecting on their internship experiences based on an adaption of the 4 stage Kolb cycle process informed by the work of Schon and Jarvis. Previously reported analysis of students' reflective writing has established that such writing can be taught. However, further study is required to determine if the framework used is actually achieving the intended goals of students identifying their learning, widening their understanding of its application, affecting transformation of behaviour and adopting reflection into practice as a lifelong learning skill.

PURPOSE This paper seeks to answer the question: How can rigorous research be undertaken to test whether this reflective framework is achieving its intended goals and where may teaching processes need to be improved?

APPROACH The research design in this paper is based on multiple data collection methods. Grades, reflective writing submissions, interviews, questionnaire survey, and observations serve as the major sources of data.

RESULTS Grades can be related to feedback from students and their employers and plots made from which implications about the efficacy of the framework and teaching methods can be drawn. Correlation between students' reflective writing and observation can also reveal if the framework is creating "reflective-learners". Other observation may help reveal if reflection is adopted to establish a lifelong learning skill.

CONCLUSIONS Whilst it has been established that frameworks for reflection can be taught, this may not necessarily indicate the framework used is actually achieving the intended goals. The research approach proposed in this paper may help to answer the question of how rigorous research can be undertaken to test whether the reflective framework used is achieving its intended goals and where teaching processes may need to be improved.

KEYWORDS Reflective learning, engineering internship, learning outcome evaluation

Introduction

In their book “A whole new engineer”, Goldberg and Sommerville (2014) describe the need for engineers to be equipped with six minds: analytical, design, linguistic, people, body and mindful. From a practical perspective these largely intellectual and cognitive features are highly relevant to the shaping of future engineering professional identities. Goldberg et al. (2014) also contend that transforming engineering education to reveal the happiness of engineering is critical and that engineering education is now standing at the edge of transformation. Building life-long learning skills and self-agency through mindfulness and reflection are key components in the education of young engineers. Some of these educational transformations have already been introduced in Australian engineering education. One obvious example is perhaps the adoption of reflective learning in tertiary engineering education (Kavanagh & O’Moore, 2008).

Reflective learning aims to enhance people’s insight into their practice (Dewey, 1939), which in today’s more human resource oriented terms might be considered a lifelong learning skill. Kolb (1984) explored experiential learning and proposed a 4 stage cycle for reflection. Schön (1983) discussed reflective practice as key for developing professional competence, in particular “reflection-in-action” and “reflection-on-action”. Jarvis (1992) made a distinction between non-learning, non-reflective learning and reflective learning, and examined reflection in practice based environments.

Engineering students the University of Technology Sydney undertake a substantial two-phase internship program where a framework based on an adaption of the Kolb cycle informed by the ideas of Schön and Jarvis is taught and practiced. The motivation derived from a recognition that reflective learning would be an effective approach for developing engineering competencies in the “transferable” or “professional” skills areas used extensively by engineers in the workplace. Such skills are not always easily developed through technical coursework. Past analysis of students’ reflective writing has been done to ascertain that the reflective writing framework can be taught (Figuroa, Parker & Kadi, 2014). However, it must be acknowledged that reflective writing done in an assessment based context could be “normative” in that students may be coerced into writing what they believe the assessor wants to read (Boud, 2001). Therefore, analysis of student writing may not necessarily be strong evidence that the framework used is actually achieving the intended goals, these being: identifying their learning, widening their understanding of its application, affecting transformation of behaviour and adopting reflection into practice as a lifelong learning skill. Further study is required to determine the efficacy of the framework in these respects by answering such questions as:

- 1) Is there evidence students understand the wider application of their experiential learning and change behaviour as a result of implementing this reflective framework?
- 2) Do students and their internship employers perceive improved development in skill areas that have been the basis of a reflection – are learning outcomes improved?
- 3) Is reflection genuinely adopted and integrated into students’ thinking forming the basis of a lifelong learning skill – is it used voluntarily or spontaneously?

This article seeks to answer the question: How can rigorous research be undertaken to test whether this reflective framework is achieving its intended goals and where may teaching processes need to be improved?

Approach of Teaching

At the University of Technology Sydney, engineering students undergo a 2 phase internship program consisting of a junior and a senior 6 month internship bookended by preparation and review subjects. This paper focuses on the first internship phase where reflection is first

taught. Prior to undertaking the first internship, students do a preparation subject in which, amongst other things, they are introduced to the reflective framework.

A 4 stage process based on Kolb's learning cycle was chosen as it was considered to be a simple, intuitive, and logical process founded in strong theory. It has been adapted to suit a practice based engineering environment based on the ideas of Schön and Jarvis. In particular, the framework focuses the "Abstraction" and "Experimentation" stages as being a way to translate what has been learned in a specific situation into a wider context so as to recognise its broad application and then to plan for future improvement.

During their first internship, students are required to maintain a reflective learning journal in which they must write, as a minimum, one reflection every 4 weeks. In Weeks 4, 12 and 20, students are free to reflect on an experience they have had recently at work where they encountered and learnt about a transferable or professional engineering skill used in the workplace. Some topic prompting is provided including communication, time management, stress management, assertiveness, problem solving, teamwork, and others. In Week 8, students are required to reflect on one aspect of their performance they have learnt about through a Performance Review they are required to arrange with their workplace supervisor in the preceding week. In Week 16, students are required to reflect on how successful their plan was to improve in the skill area reflected on in Week 8 – i.e. what did they learn about their approach to learning and how might they improve.

Boud (2001) argues that it is not appropriate to grade reflective writing based on whether or not the experience being reflected on and the learning derived from it is "important" or "good". However, assessment and feedback in this phase of the internship program is largely based on how fully and consistently the student has applied the framework taught as opposed to the "quality" of the experience being reflected on or the writing itself.

Assessment is done via a rubric and tutors are trained about the framework and how to assess its application in students' reflective writing. A set of standardised feedback comments is circulated to tutors. Whilst tutors can make their own comments if required, they are encouraged to use the standard comments (or combinations and adaptations of them) whenever possible to ensure consistency. The rubric and feedback comments are designed to focus on the structure of the reflection and how completely the student has addressed the guideline questions and criteria in the framework. The rubric comprises 5 columns going from Very Poor (0%), Poor (25%), Adequate (50%), Good (75%), to Excellent (100%). The framework and assessment rubric are discussed below.

In stage 1 of the framework, students are asked to document a recent workplace experience, their role in it, what they expected would happen going in to the experience and what the actual outcome was. This is assessed as a single row in the rubric worth 13% based on how clearly they describe the experience, their expectations and the actual outcome.

Stage 2 of the framework is covered in two parts. Firstly, students should analyse why this outcome occurred. They are asked to consider what actions of theirs and what actions of those around them might have contributed to the outcome. They should discuss the emotions and feelings they were experiencing at the time of the experience and also when considering it in hindsight. This is intended to create awareness in students that their emotional reactions during an experience influence how they handle it and their emotions when remembering it later may influence how they approach this type of situation in future. If appropriate, there should be discussion of any external, or non-human, factors that may have contributed to the outcome (such as hardware or software issues, weather events, procedural requirements, etc). Finally, they should evaluate their performance given the circumstances at play. This is assessed as one row of the rubric worth 13% based on how thoroughly these prompts have been discussed. The second part of Stage 2 requires the student to focus on one main thing they have learnt from this experience and articulate this concisely as a skill relevant to professional engineering practice - establishing a skill area

“theme” for the reflection. This is assessed as one row in the rubric worth 13% based on whether they can focus on one key “lesson” and how relevant this is to engineering practice.

Stage 3 of the framework is covered in two parts. Firstly, students are asked to abstract their “lesson” by describing two engineering related situations in which they think it could be applied that are different to each other and to the original experience. This is designed to help them recognise that learning obtained in a specific situation has wider application. This is assessed as one row in the rubric worth 17.5% based on whether the examples are consistent with the “lesson” from Stage 2, the relevance of the examples to professional engineering, if they have at least two examples and how different and wide ranging the examples are (the degree of abstraction). The second part requires students to do some research (get external input) into a tool or method to improve performance in this skill area. It is considered that once they recognise the broader implications and application of their “lesson” they are well placed to find a method or tool that can be applied widely. This is assessed as one row in the rubric worth 17.5% based on whether or not a tool or method is identified and whether there is evidence this has been found through research (i.e. it is new to the student and a citation is provided) or if it is something they thought of themselves or already knew.

Stage 4 of the framework is covered in two parts. Firstly, students are required to discuss their plan for future improvement based on how they will implement the tool or method they have found from research. This is assessed as one row in the rubric worth 13% based on how clearly the plan is articulated, if it consistent with the skill area “theme” originally identified and if it is based on research findings. Secondly, students are required to discuss what evidence they have that the plan is likely to work, to discuss why they think it is a plan they are likely to want to use in future and why it is a plan that suits the situations in which they expect to work. This is assessed as one row in the rubric worth 13% based on how fully these points are discussed.

Extra weighting is placed on the Stage 3 “Abstraction” part as this is considered to be the key that enables “reflection-on-action” or true “reflective learning” to occur, leading to understanding of the wider application of learning and the subsequent generalised transformation of behaviour. To borrow from Gray, Cundell, Hay & O’Neill (2004), only when experience or route learning are “integrated with practice, evaluation and/or reasoning and reflection does it lead to reflective learning that includes the ability to apply skills and knowledge to unique or novel situations”.

Hypothesis

Referring to Jarvis (1992), the distinction between non-learners and learners draws upon the ability of learners to avoid repeating the same mistakes. Further, reflective learners differ from non-reflective learners in their ability to recognise the wider application of this learning, consider ways to improve and then manifest this generally in their practice. Schön (1983) discusses “reflection-on-action” as being a process of analysing the causes of an unexpected outcome to help recognise what needs to be changed in order to improve future performance. Gray et al. (2004) also contend that reflective learning leads to the application of acquired knowledge into solving new problems. In this respect, students who have been taught the reflective framework outlined in this paper can be differentiated into non-learners, non-reflective learners and reflective learners.

With the definitions above, compliance to the reflective framework, perceptions of benefits and evidence of application of learning into a new contexts serve as the indicators of measurements toward a relatively more comprehensive evaluation of effectiveness concerning the teaching and learning of the framework. Students may also be differentiated into adopters and non-adopters if evidence of voluntary or spontaneous application of the framework can be found.

Because of the way assessment is conducted, marks can be used as an indicator of how fully and correctly the framework has been applied and also contributes to understanding the effectiveness of the teaching and feedback approach.

Students' feedback or their self-evaluation of the learning experience reflected in this proposed research derives from their perceptions of benefits – in terms of competency development – gained from exercising the reflective framework. Similarly, employer evaluation of the effectiveness of the framework derives from their perceptions of students' improvement which can be correlated against skill areas that students reflected on. In this way, feedback can be mapped against marks with individual students represented in a node differentiated by a particular shape, as follows:

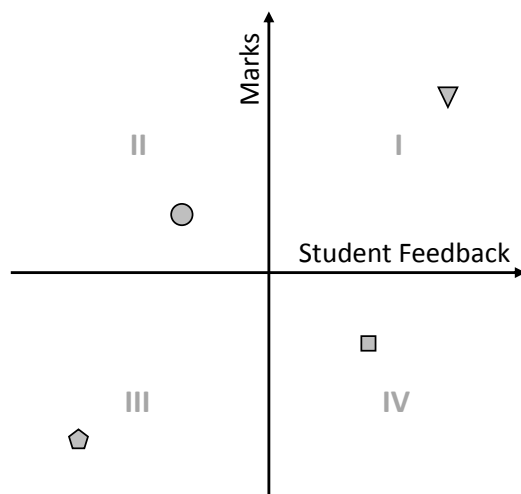


Figure 1: Student Data

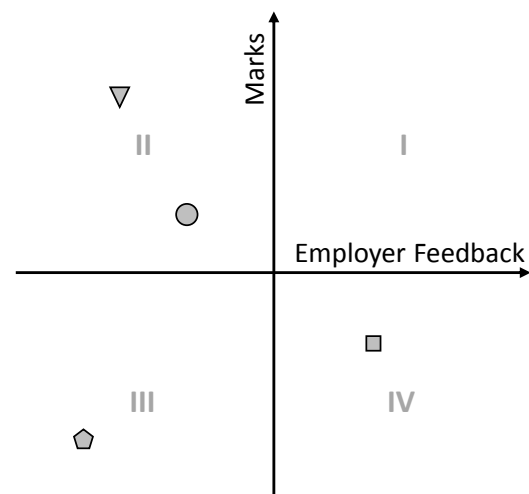


Figure 2: Employer Data

Figure 1 shows possible illustrations of student performance of reflective learning. Each quadrant indicates a scenario of performance. In this diagram, Quadrant I, indicates positive recognition of benefits together with high conformance with the reflective thinking framework. Quadrant II depicts negative recognition of benefits but conformance with teaching requirements. Quadrant III shows both negative results. Quadrant IV reveals positive recognition but negative conformance.

Figure 2 shows the student's performance from the employer perspective. The horizontal axis is replaced by employer feedback toward the benefits of reflective learning. It is noticed that employer may not have the same recognition of benefits as the student. Therefore, nodes may move horizontally as illustrated by the triangular node in the above diagrams.

The hypothesis is that a high density of student or employer feedback nodes located in quadrant I coupled with observation of learning applied in novel situations is an indicator that the framework is producing reflective-learners. Higher correlation between student and employer feedback increases confidence in the data.

A corollary is that observation of students encountering new skills and later applying these in novel situations during times they are not required to undertake reflections as part of assessment activities, may imply that adoption of the framework has occurred inferring acquisition of a lifelong learning ability.

Data Collection Methods

Data collection for this research consists of two parts: firstly, a collection of feedback from both students and their employers and secondly, observation of students following internships.

The first part of empirical data can be collected from questionnaire surveys and/or open ended one-to-one interviews – to ensure independent response. Similar surveys and/or interviews with different questions can be done with their internship employers.

Observation can be carried out during student group projects done in subjects undertaken after their internship. Provided a student demonstrates an ability to problematize new situations and expresses a solution developed through a past reflective thinking process, his or her benefit from the reflective learning framework can be positively identified. Supported by student's learning journals in the first internship, abstraction of learning into novel situations can thus be traced.

The adoption of observation as a research methodology in this study can also be supported by some empirical evidence such as students' self-evaluation of their skills development mentioned in their reports submitted in the review subject undertaken following their internship. Although, it is not mandatory for students to claim for their progress using the framework taught, substantial evidence exists to show they demonstrate such progression with claims of adopting learning gained during their internship.

Expected Results and Discussion

The analysis of plotting student and employer feedback against marks should allow a number of conclusions to be drawn regarding how effectively the framework is being taught and whether the framework improves skills development. The distribution or density of results across the quadrants will be of particular interest. Some possible implications from this analysis might be as described in the tables below:

Table1: Feedback Plot Interpretation

Quadrant	Meaning	Implications
I	Framework has been applied reasonably correctly Reflection is perceived to be useful	Framework application is taught effectively. Framework appears to benefit learning outcomes. Student is reporting what they think is expected of them (rather than real opinion).
II	Framework has been applied reasonably correctly Reflection is not perceived to be useful	Framework application is taught effectively. Framework appears to require change (is not benefitting learning outcomes). Student does not value learning that the framework facilitates. Employer is not satisfied with skill advancement demonstrated by student to-date.
III	Framework has not been applied correctly Reflection is not perceived to be useful	Student is disengaged from process (communication and teaching around reflection and the framework need improving). Student does not value learning that the framework facilitates. Employer is not satisfied with skill advancement demonstrated by student to-date.

IV	<p>Framework has not been applied correctly</p> <p>Reflection is perceived to be useful</p>	<p>Reflection is beneficial even if not done in accordance with the framework.</p> <p>Teaching of framework application needs improving.</p> <p>Student is reporting what they think is expected of them (rather than real opinion).</p>
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Additionally, analysis of any divergence between employer data and student data, both individual and collective, can also be examined. Divergence will only occur in the horizontal plane as the mark for a student will not change between student and employer plots.

Provided general agreement exists between the student perception and the employer perception (i.e. the data nodes are in the same quadrant) then there can be high confidence in that node. However, two possible divergences can occur, as outlined in the following table:

Table 2: Student/Employer Plot Comparison

Quadrant	Implication
<p>Student II or III Employer I or IV</p>	<p>Student does not value the “soft” skills that the reflective framework facilitates.</p> <p>Employer does value “soft” skills.</p> <p>Student does not recognise their level of progress.</p> <p>Student considers reflective writing is not engineering relevant.</p>
<p>Student I or IV Employer II or III</p>	<p>Student is reporting what they think is expected of them (rather than real opinion).</p> <p>Employer has not had sufficient time to evaluate student progress.</p> <p>Employer feels student has not progressed skill to a high enough level even if student sees progress in themselves.</p> <p>Student and employer have different perception of what various skills mean.</p>

Observation of a student in post-internship group work situations in university subjects can be correlated with reflections they have written whilst on internship. Skill areas they have reflected on can be identified and their behaviour observed to see if there is evidence that the learning described in reflections is abstracted and its application to new contexts is recognised, with the plan prepared during reflection applied into the new context.

Further, observation of students could also reveal if new learning encountered in these group work situations is subsequently applied by students into other future new situations. If this can be detected, it may infer that the reflection framework is being applied by students voluntarily or spontaneously, which would indicate the goal of establishing a lifelong learning technique through reflection may have been achieved.

Conclusions

Whilst it has been established that frameworks for reflection can be taught, this may not necessarily indicate the framework used is actually achieving the intended goals. The research approach proposed in this paper may help to answer the question of how rigorous research can be undertaken to test whether the reflective framework used is achieving its intended goals and where teaching processes may need to be improved.

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