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Promoting deep learning in a teacher education programme through self- and peer-assessment and feedback

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The incorporation of self- and peer-assessment and feedback has significant potential as a pedagogical strategy to promote deep learning in project based coursework. This study examined the impact of a deeper approach to learning on pre-service teachers' critical thinking and metacognitive skills. It also examined the impact on student learning outcomes within a project based module with a significant design element. Forty-seven students participated in the pilot of an online peer feedback system. Results suggest that the quality of students' reflections through peer feedback and overall satisfaction with the module remained high despite students' citing a preference for instructor feedback. The data also indicate that the incorporation of self- and peer-assessment and feedback resulted in higher quality learning outcomes and enhanced critical thinking skills.

Keywords: peer feedback; project-based learning; teacher education

Introduction

The distinction between deep and surface learning is well established (Entwistle and Ramsden 1982) with deeper approaches to learning associated with higher quality learning outcomes (Trigwell, Prosser, and Waterhouse 1999). It is also clear that students' perceptions of their learning environment are related to the approach to learning they adopt (Entwistle 1991; Black and Wiliam 1998a; Dow 2006). That deep learning is allied to deeper pedagogical approaches, focusing on *teaching for understanding* and more importantly *personal understanding* (Entwistle 2000). However, developments in teaching and learning approaches require equivalent adjustment and advancement of assessment strategies. Biggs (1999, 2) stresses the importance of this constructive alignment; 'Does the format of assessment match your teaching objectives? If it does match your objectives, the backwash is positive, but if it does not, the backwash will encourage students to use surface approaches to learning'. It appears that assessment strategies which encourage students to think for themselves, to become critical and creative thinkers, shift students' focus in a class towards a deeper approach to learning (Scouller 1998). Conversely, assessment which encourages memorisation and recall is more likely to result in students adopting a surface approach, especially when combined with perceived heavy workload demands (Trigwell, Prosser, and Waterhouse 1999; Gunderman et al. 2003). It is

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clear therefore that optimising the role of assessment in education can greatly enhance student learning, especially assessment that moves beyond a summative focus to a more formative purpose (Black and Wiliam 1998b; Liu and Carless 2006). However, summative approaches to assessment still dominate in education (Knight 2002), especially in the Irish context which employs a matriculation system in the form of a final exam (entitled Leaving Certificate), the results of which are employed for the allocation of university places to students. With such emphasis placed on summative assessment at second level it is not surprising that students are frequently cited as focusing solely on achieving the highest possible grades in the exam, often resulting in surface learning (Gunderman et al. 2003; Ryan et al. 2004).

This summative assessment approach encourages memorisation and content recall, in turn promoting the didactic transmission of facts and skills by the teacher (Broadfoot 1996). As providers of pre-service technology teacher education courses, the authors seek to develop approaches to teaching and assessment that promote deep learning and higher quality learning outcomes for students. They believe that project work and problem based learning is an effective means by which to achieve this and that self- and peer-assessment and feedback has a significant contribution to make to the cognitive and affective development of the student teacher. For the purpose of this study, project work is defined as an attempt to embody constructivist theory in a practical, experienced-based learning activity (Barron et al. 1998), in this case the design and manufacture of a model motorcycle. As highlighted by the results of a study conducted by Meirink et al. (2009) 'teachers often learn by critical individual reflection and by involving colleagues in particular challenging or problematic situations'. Whilst acknowledging the dominance of the terminal assessment paradigm, the authors seek to place greater emphasis on assessment for learning as advocated by Carless (2007) and Black, Harrison and Lee (2003). Assessment for the promotion of learning is supported by the pedagogical context in which this research took place, which was an initial teacher education programme in a large regional university in Ireland. Within this context, this study aims to emulate the 'teach as you preach' philosophy as advocated by Struyven, Dochy and Janssens (2010). As highlighted by Cheng, Cheng and Tang (2010), it is essential that teacher educators model the pedagogical strategies they would require student teachers to employ, thus bridging the gap between the 'theory and practice of teaching'.

Problem-based learning (PBL) has gained a significant foothold in higher education and is perceived to be a useful pedagogical approach to enhance student learning (Felder and Spurlin 2005; Prince and Felder 2006). Successful PBL requires more than simply the modification of existing curricula, it also entails changes in teaching and learning strategies and in the approaches taken to assessment (Barron et al. 1998). It requires stronger engagement with the formative potential of assessment. Peer feedback potentially enhances the outcomes of PBL because it can engage students in thinking critically and making judgements about their own work and/or the performance of their peers (Somervell 1993). Engaging students in peer feedback helps develop their skills of reflection, encourages critical thinking (Sluijsmans, Dochy, and Moerkerke 1998; Boud, Cohen, and Sampson 2001) and generates feedback that draws on the knowledge and experience of the collective student cohort (McMahon 2010). Peer feedback and assessment helps support the building of student capacity to critically evaluate tasks and their own performance, which are essential skills for student teachers to develop (Sadler 1998; Sadler and Good 2006). It also enables students to reflect on their role in the learning process as argued by Sadler (1998, 81):

> A strong case can be made that students should be taught how to change their pattern of thinking so that they know not only how to respond to and solve (externally sourced) problems but also how to frame problems themselves. They need this partly to guide their learning in between, or to prepare for, teacher assessments, but equally as part of their progressive journey into self assessment, and at more advanced levels, as a key skill for professional life.

This does however require considerable attention from the lecturer as the literature points to the greatest challenge of peer feedback lying in student reluctance to criticise the work of their peers (Clifford 1999; Papinczak, Young, and Groves 2007). Being able to critically engage with ideas and concepts and to offer critical feedback in meaningful ways are key skills for prospective teachers to possess (van Gennip, Segers, and Tillema 2009) and therefore it was deemed appropriate to encourage their development in this student cohort.

Students' involvement in self- and peer-assessment and feedback has been found to promote deep learning (Boud and Feletti 1998; Falchikov and Goldfinch 2000). This paper assesses the impact of such involvement on students' thinking and metacognitive skills by employing Bloom's Taxonomy for the cognitive domain (1956). Bloom (1956, 198) advocates the pedagogical benefits of peer-assessment and feedback stating that 'Judging the correctness of answers is an additional opportunity for students to deepen their understanding about a topic'. Bloom (1971) also highlights the potential metacognitive advantages to self- and peer-assessment, demonstrating that pupils develop a capacity to take initiative in evaluating their own work and use 'higher order thinking skills to make judgments about others' work'. This is of particular importance for pre-service teachers where formative assessment is central to their reflective practice and the subsequent development of their future pupils.

Background

This initiative was implemented with third-year students on an initial teacher education degree programme entitled 'Materials and engineering technology education'. The university in which this initiative was implemented is the largest national provider of teacher education at undergraduate and postgraduate level in Ireland. The programme in which this research was conducted is the only initial teacher education course for teachers of engineering in Ireland. For the purpose of this initiative, an existing module on manufacturing processes was adapted to incorporate a significant project-based element. Modules in the university are 13 weeks in duration and this initiative continued for one additional week. Students were assigned a design challenge where they were required to conceive, design and manufacture a model motorcycle. Grading for the module was broken down into a 25% end of term exam and a 75% project based element. The project based element was further broken down into 50% for the finished model motorcycle, 20% for students' level of reflection and engagement with an e-portfolio system, and 5% for students' level of formative peer feedback provided through an online blog. By incorporating a design and a project-based element worth 75% of the module, the authors aimed to promote the development of creative and autonomous learners capable of self-evaluation, peer appraisal and critical thinking. Sluijsmans, Brand-Gruwel, and van Merriënboer (2002) highlight the importance of teachers' ability to design creative lessons, therefore this module also aimed to provide pre-service teachers with a pedagogical model to develop as advocated by Cheng, Cheng and Tang (2010).

The only restriction given to the students regarding the model motorcycle was in relation to its size. The model was restricted to a maximum dimension of 600mm between wheel axles. By providing very little restrictions to the model parameters it was envisaged that this would remove any limitations on students' creative freedom and exploit their natural competitiveness. The authors were influenced by the belief that the development of a learning environment which nurtures students' creative endeavors is central to the philosophy of project-based learning (Sydow, Lindkvist, and DeFillippi 2004). By providing students with the minimum of didactic instruction, students were encouraged to draw on their previously developed repertoires of knowledge as well as expanding and developing existing skill sets to solve new problems. The traditional approach to learning and assessment previously employed in this module required students to complete four interim practical tests worth 40% and a summative written examination of their knowledge of joining processes worth 60%. This traditional approach did not align with the aims of the newly developed curriculum. As a result new pedagogical and assessment approaches were created which included the development of e-portfolios to support students' projects and the use of online peer feedback through a blog hosted on these portfolios as promoted by Palloff and Pratt (2001) and by Keppell, Au and Chan (2006). However, in order for self- and peer-assessment to promote deep and meaningful learning outcomes it is important that all involved are aware of the aims and formal requirements of the module, an issue highlighted by Sluijsmans, Dochy, and Moerkerke (1998). During the first week of the programme students were provided with a module outline, clearly delineating its aims and objectives, the project brief, a detailed breakdown of grading for the module, as well as the requirements of each student from the module. A one-hour workshop was also provided for students during this week on the e-portfolio system setup and usage. This module focuses on developing students' knowledge and implementation of manufacturing and joining processes, as well as their creative design and critical thinking skills. Students were informed that the purpose of the blog was to document and track their development in these areas from conceptual design to completion of the project, and to highlight significant work and engagement on behalf of the student that may not otherwise be evident in the finished product. It was also outlined to students that 20% of their grade would be allocated for depth of critical reflection, quality of critical thinking (with particular focus on higher order thinking skills) and engagement with the aims and objectives of the module, through continuous evaluation of their e-portfolios. As third-year students of an initial teacher education programme where a predominant focus is afforded to the development of pupils' pedagogical skills, all participants in this study were able to draw on their prerequisite knowledge of cognition and Bloom's Taxonomy of educational objectives for the cognitive domain.

The promotion of a collaborative and collegial approach to pedagogy was fostered by encouraging students to provide frequent and formative feedback to their peers through the use of an online blog hosted on this e-portfolio system. The provision of peer feedback was also promoted throughout the physical manufacture of the projects while students worked together in the workshops each week. Students were requested to focus on the aims and criteria provided in the module outline when providing feedback to their peers. The authors wanted to ensure that students engaged in the peer feedback process, so a small percentage of the module grade was designated to this (5% based on the quality of feedback and engagement). This concern proved unwarranted with levels of engagement indicating that most students were intrinsically motivated to provide support through feedback for their peers. However, students did initially require some security reassurances. Because the e-portfolio system logged every students' design idea and creative development as well as the feedback provided to them on their designs and concepts, and the time and date of each upload, students felt secure in the knowledge that all ideas provided remained associated with the original contributor.

In order to ensure that the focus remained on the formative value of appraisal and deep learning, students were not required to grade each other's work. All students involved in the module had access to each other's e-portfolios. To avoid overloading the students they were stratified into groups of four where each student was given the responsibility of critically evaluating the work of the other three members of the group. However, the students themselves opted to expand the parameters and to provide feedback to several other students in the class. The e-portfolios facilitated students to express their designs, ideas and thoughts through a variety of media which included graphical sketches, presentations, working drawings, audio and visual accounts, written reports and blogs. The ability to use a variety of media to represent student work has been highlighted by Granberg (2010) as central to the successful incorporation of e-portfolios as an effective resource in teacher education. As well as continuous feedback from their peers, students were also presented with feedback from their module lecturer at designated points in the module. Feedback on their progress was provided to students from an early stage in the module allowing them adequate opportunity to reflect and to implement any improvements required. The first lecturer feedback was provided at the end of Week 3 in the module and peer feedback commenced one week prior to this.

For comparative purposes the module ran parallel to a control module, which while also incorporating similar e-portfolios for students did not include a peer feedback element and relied entirely on lecturer feedback. The control module involved the same cohort of students and aimed to have similar engagement between students and e-portfolios. Both modules ran over the same period and were skills based with the control module focusing on student competencies in technical graphics. The same guidance was provided to students in relation to their e-portfolios and their respective reflections. Lecturer feedback to students was provided during similar phases of the modules with the aim of enhancing students' critical thinking skills and levels of metacognition in both. Although assessing different disciplines, equal weighting was afforded to the e-portfolios and student reflections in both modules. Both modules also had a significant project based element of equivalent value.

Methods

Forty-seven undergraduate students, 46 male students and 1 female student, agreed to participate in this initiative. A mixed method approach that incorporated both quantitative and qualitative data collection was adopted. In order to evaluate the initiative students were asked to complete an anonymous online survey upon module completion. The survey required students to rank, using Likert scales, different aspects of the module such as the pedagogical approach utilised, its aims and objectives, its structure and overall effectiveness (Appendix A presents an abbreviated version of the online survey). An interpretative approach was also adopted as advocated by Windschitl (1998). Data were collected via participant observation, the student blog and the e-portfolios. The authors monitored the blogs and portfolios over the 14 weeks of the module. Continuous observations of student interactions and participation in the workshops were used to help validate posts and reflections presented on the blogs and e-portfolios. As highlighted by Robson (2002, 310) 'data from direct observations contrasts with, and can often usefully compliment, information obtained by virtually any other technique'. The use of observations allowed the researchers to record 'live' data from naturally occurring interactions between students. In this way the researchers were not just relying on second-hand student accounts on the e-portfolio of interactions and support offered to peers. As highlighted by Cohen, Manion and Morrison (2007, 396) 'the use of immediate awareness, or direct cognition, as a principal mode of research has the potential to yield more valid or authentic data'. Therefore while feedback provided to peers on the blogs afforded an interesting insight into students' thinking skills and reflections; observations were also required to verify that these reflections went beyond rhetoric to being replicated in students' interactions, reflections and engagement with the project in the workshop.

Content analysis was also employed as an effective technique to analyse what occurs in an online environment where synchronous and asynchronous discussions are held (Agostinho 2004). In order to analyse the impact of the peer feedback process on students' judgments and critical thinking skills, Bloom's Taxonomy (Bloom 1956) for the cognitive domain was then applied to the analysis. Bloom's original taxonomy of educational objectives for the cognitive domain was used in this study over the revised taxonomy of Anderson, Krathwohl and Bloom (2001) as the authors felt it more accurately reflected the cognitive process involved in the design and manufacture of the model motorbikes. The original taxonomy presented a cumulative hierarchy in which each category was a prerequisite to mastery of the next more complex one (Krathwohl 2002). This more accurately reflected the requirements of this project-based module. It also made the analysis of students' responses and posts less complex as the hierarchy in the revised taxonomy is more relaxed allowing categories to overlap. For example the scope of the category 'Understanding' in the revised taxonomy has been considerably broadened over 'Comprehension' in the original framework making it much harder to categorise individual student responses (Krathwohl 2002). As a result the data were searched for evidence of student development from lower order engagement such as recall/comprehension to higher order such as synthesis or evaluation from Bloom's original taxonomy for the cognitive domain. Using the criteria for Bloom's Taxonomy as advocated by Athanassiou, McNett and Harvey (2003) (see Table 1) specific examples of evidence were attached to each level (see Table 2) and the students' posts were analysed for demonstrations of this evidence.

Student cognition was coded as follows: knowledge = 1, comprehension = 2, application = 3, analysis = 4, synthesis = 5, and evaluation = 6 (see Table 2). Finally, an average score for each student was calculated for each stage of the study. Therefore, for example, a student who demonstrated cognitive aptitude at all

Table 1. Description of Bloom's Taxonomy as per Athanassiou, McNett and Harvey (2003).

Hierarchical Order		Description
6 Evaluation	-	Shows the ability to judge the value of material for a given purpose based on definite criteria and rationale. Includes decision-making and selection.
5 Synthesis	-	Recombines the parts created during analysis to form a new entity, different from the original.
4 Analysis	-	Breaks down material into its constituent parts so that its organisational structure can be understood.
3 Application	-	Uses information, principles, and theory learned to answer a question, solve a problem or complete a task.
2 Comprehension	-	Awareness of what the material means, allows one to demonstrate an understanding of the material based on prior knowledge
1 Knowledge	-	The recall of previously learned material, of simple facts or complete theories. Bringing to mind appropriate information

Table 2. Evidence of the hierarchically ordered level of Bloom's Taxonomy.

Hierarchical Order		Evidence
6 Evaluation	-	Assessments, critiques and evaluations
5 Synthesis	-	Creative behaviour such as the development of new solutions.
4 Analysis	-	Breaking down, categorising, classifying, and differentiating.
3 Application	-	Conceptual activities such as application, classification and development.
2 Comprehension	-	Demonstrate comprehension by applying comparisons and/or contrasts.
1 Knowledge	-	Definitions and outlines. Reproduction of requisite knowledge.

six levels of Bloom's Taxonomy would achieve the maximum average score of 3.5. Also to determine whether or not the class as a whole demonstrated greater use of higher-order thinking skills and an improvement in cognitive sophistication, an average of all students' results was taken as an estimate.

Students' recent reflections and posts on their e-portfolios were analysed at three different stages of the module for levels of cognition (as outlined in Table 1), at the end of Weeks 2, 6 and 11 respectively. Students were also provided with individual, formative feedback from the lecturer twice during the completion of the project, towards the end of Weeks 3 and 9 of the module. The blog was again utilised in the provision of this feedback, allowing the lecturer to comment on students work to date. All lecturer feedback reflected the aims of the module however the feedback in Week 3 specifically focused on the initial ideation process and students' resulting designs for the project. Lecturer feedback in Week 9 focused more on the development of students' design ideas and on the manufacturing and joining processes employed.

Ethical considerations were negotiated with participants. Participants had the right to withdraw from the study at any stage without prejudice. The four basic ethical principles of respect for persons, beneficence, non-maleficence and justice (LoBiondo-Wood and Haber 1998) were prioritised at all times.

Results

Analysis of the student postings shows evolution in their thinking skills during the process and was evident in the reflections and postings they provided on their e-portfolios. On average the cognitive sophistication of the class was shown to advance throughout the duration of the module, with students typically operating at higher levels of Bloom's Taxonomy at successive phases of the study (see Table 3). Students' cognitive development, evident in their reflections, was shown to be greatest between the assessments in Week 2 and Week 6 of the study, with an average class increase from 1.5 to 2.1 respectively (see Table 3). The development observed between the reflections made in Week 6 by the students and those made in Week 11, at the end of the project, was less apparent.

Observations of student interactions and engagement in the workshop also highlighted significant development in students' levels of reflection and commitment to deeper understanding of the material covered in the module between Weeks 2 and 6. A noteworthy shift toward deeper understanding and reflection was particularly evident post receipt of formal feedback from the lecturer in Week 3 which resulted in many students making significant changes or modifications to their designs for the project. Students also became more critical of their own work and the work of their peers after Week 3, demonstrating evidence of analysis, synthesis and evaluation not only in their reflections on their e-portfolios and blog but also in the feedback and support offered to their peers in the workshop.

Examples of postings that were related to the knowledge/comprehension range included:

> A common result of the thermal stresses induced by welding is a distortion or warping of the assembly ('Knowledge'). To avoid this I made the welds with the least amount of weld metal (filler) possible and used a jig to support the frame. It is essential that the frame does not distort as the wheel axle needs to line up so that it will spin freely ('Comprehension'). (Student 33, Week 2)

> Oxygen is not flammable, but will increase the combustion of flammable materials ('Knowledge'). Therefore it is necessary to make sure that the work area is completely clean and free of flammable materials such as oil when using oxyacetylene welding ('Comprehension'). (Student 2, Week 2)

In terms of conceptual activities that included application, classification and development, this was primarily evident in the actual application of the process skills students had previously developed in the physical making of the model bike. It was apparent, for example, in students' application and development of requisite machine skills. It was also evident in their application and implementation of the theory and principles related to joining processes such as welding, which were covered in the lectures. Students' ability to apply these principles and the information covered during the lectures to the manufacture of their model was assessed in Week 9 based on the quality and choice of joining processes utilised.

Table 3. Quality of student reflections according to Bloom's Taxonomy levels.

	Week 2							**Week 6**							**Week 11**						
	Bloom's Level							Bloom's Level							Bloom's Level						
Student	1	2	3	4	5	6	Student average score	1	2	3	4	5	6	Student average score	1	2	3	4	5	6	Student average score
1	1	2	3	4			1.7	1		3	4			1.3	1	2	3	4			1.7
2	1	2	3	4	5	6	3.5	1	2	3	4	5	6	3.5	1	2	3	4	5	6	3.5
3	1	2	3				1.0	1	2	3	4	5		2.5	1	2	3	4	5	6	3.5
4	1	2	3				1.0	1		3	4			1.3	1	2	3				1.0
5	1	2	3	4			1.7	1	2	3	4	5		2.5	1	2	3		5		1.8
6	1	2	3	4			1.7	1	2	3	4	5		2.5	1	2	3	4	5		2.5
7	1						0.2	1						0.2	1	2					0.5
8	1	2	3				1.0	1	2		4	5		2.0	1	2	3	4	5		2.5
9	1						0.2		2					0.3	1	2	3				1.0
10	1	2	3	4			1.7	1	2	3	4	5		2.5	1	2	3	4	5		2.5
11	1	2	3	4		6	2.7	1	2	3	4	5	6	3.5	1	2	3	4			1.7
12	1	2	3				1.0	1	2	3				1.0	1	2	3				1.0
13	1	2	3				1.0	1	2	3	4			1.7	1	2	3	4			1.7
14	1	2	3				1.0	1	2	3	4			1.7	1	2	3				1.0
15	1	2	3	4			1.7	1	2	3	4	5		2.5	1	2	3	4	5		2.5
16	1						0.2	1						0.2	1	2					0.5
17	1	2	3	4			1.7	1	2	3	4			1.7	1	2	3	4			1.7
18	1	2	3	4			1.7	1	2	3	4	5		2.5	1	2	3	4	5	6	3.5
19	1	2					0.5		2					0.3	1	2	3				1.0
20	1	2	3				1.0	1	2		4	5		2.0	1	2	3		5		1.8
21	1	2	3	4			1.7	1		3	4	5		2.2	1	2		4	5		2.0
22	1	2	3	4			1.7	1	2	3	4		6	2.7	1	2	3	4	5	6	3.5
23	1	2	3	4	5		2.5	1	2	3	4	5		2.5	1	2	3	4	5		2.5
24	1		3	4			1.3	1	2	3	4			1.7	1	2	3	4			1.7
25	1	2	3	4	5		2.5	1	2	3	4	5		2.5	1	2	3	4	5		2.5
26	1	2	3				1.0	1	2	3	4	5		2.5	1	2	3	4	5		2.5
27	1	2	3	4			1.7	1	2	3	4			1.7	1	2	3	4			1.7

(*Continued*)

Table 3. (*Continued*).

	Week 2							Week 6							Week 11						
	Bloom's Level							Bloom's Level							Bloom's Level						
Student	1	2	3	4	5	6	Student average score	1	2	3	4	5	6	Student average score	1	2	3	4	5	6	Student average score
28	1		3	4			1.3	1	2	3	4	5	6	3.5	1	2	3	4	5	6	3.5
29	1	2	3	4	5		2.5	1	2	3		5	6	2.8	1	2	3	4			1.7
30	1	2	3				1.0			3	4	5		2.0	1	2	3	4	5		2.5
31	1	2	3				1.0	1		3	4	5		2.2	1	2	3	4	5		2.5
32	1	2	3	4			1.7	1	2	3	4			1.7	1	2	3	4			1.7
33	1	2	3				1.0	1		3	4			1.3	1	2	3		5		1.8
34	1		3	4			1.3	1	2	3		5		1.8	1	2	3	4			1.7
35	1	2	3	4			1.7	1		3	4	5		2.0	1	2	3	4	5	6	3.5
36	1	2		4	5		2.0	1	2	3	4	5	6	3.5	1	2	3	4	5		2.5
37	1	2	3				1.0	1	2		4	5		2.0	1	2	3	4			1.7
38	1	2	3	4			1.7	1	2	3	4	5		2.5	1	2	3		5	6	2.8
39	1	2	3	4			1.7	1	2	3	4			1.7	1	2	3	4			1.7
40	1	2	3		5	6	2.8	1	2	3	4	5	6	3.5	1	2	3	4	5	6	3.5
41	1	2	3				1.0	1	2	3				1.0	1	2	3	4			1.7
42	1	2	3	4	5		2.5	1		3	4	5	6	3.2	1	2	3	4	5	6	3.5
43	1	2	3	4	5		2.5	1	2	3	4	5		2.5	1	2	3	4			1.7
44	1	2	3	4			1.7	1	2		4	5		3.0	1	2	3	4	5		2.5
45	1	2	3	4			1.7	1	2	3	4	5		2.5	1	2	3	4	5	6	3.5
46	1	2	3		5		1.8	1		3	4	5	6	3.2	1	2	3	4	5	6	3.5
47	1	2	3	4			1.7	1	2	3	4	5		2.5	1	2	3	4	5		2.5
Class Average							**1.5**							**2.1**							**2.2**

Evidence of application was also to be seen in the themes students chose for the bike:

> I have chosen the theme of aerodynamics. I think the chopper is an excellent bike that would reflect this theme especially because of its shape. This theme will be seen throughout the bike as the fuel tank is going to look like a professional cycling helmet. This will form the backbone of the chopper and will give the chopper a sleek and aerodynamic look. The foot pegs on the bike are going to resemble wings of an aircraft (curved on the top, flat on the bottom and a winglet at the tip of the peg). Aerodynamics will also be portrayed in the paintwork. The entire frame will be curved made from rolled tubular steel. (Student 2, Week 3)

In terms of analysis this was often evident in students' feedback postings to each other:

> While I agree with *Student X* that you should have an additional support for the back axle as drilling through the frame may weaken it, I think you should weld this on first and then drill it out afterwards. I don't think you will be able to get the holes to line up if you pre-drill it as *Student X* suggests. (Student 24, Week 4)

> I like the sketches you uploaded and the design for the bike but I don't think you will be able to get the shape shown. The bends are greater than 90^0 and pipe would kink if you try to bend it that far. I would suggest creating a jig, cutting the pipe at an angle and welding it back up to get the shape shown in the sketch. (Student 33, Week 4)

Analysis was also evident in the planning:

> There are 11 weeks left in the build so I have decided to outline a timeline for myself and will upload this on the next post. I am going to start the frame as this may distort when welding so I want to make sure it all lines up before moving on to the front forks. This I feel will take me the longest as it has a lot of lathe work. Next I will put in the engine that I have already sourced and wheels from the mini moto. I will then work on the seat and the tank but I won't finish these until the last week because I don't want the paint work to get damaged when working on the rest of the bike. Finally I'll work on the smaller things like the handlebars, exhaust and head lamp. I will be working on the electric circuit throughout the build. (Student 18, Week 3)

For synthesis levels, the evidence criteria included creative behaviour such as the development of new solutions and this was evident in students' design evolutions which demonstrated creative endeavors, as well as in the novel solutions students developed to overcome obstacles during production:

> I was unable to get an accurate development of the headlamp from sheet metal so I designed a mould and CNC milled it out of wood. I was then able to vacuum form the shape of the headlamp out of plastic around this mould. (Student 33, Week 9)

> The designs I have attached include my chosen frame and some various frames which I considered when designing the bike. I have also included pictures of my initial draft working drawing and will model it up on AutoCAD soon. (Student 2, Week 4–5)

Being able to engage in critical evaluation of their own work was the final stage and evidence criteria included self-assessment, self-critique and evaluation. These were evident in such postings as:

> Now that the bike is finished I think there are certain things I would change if I had the time. I think my own time management skills could have been a lot better on this bike project. I left the finalisation of my design too late and as a result I didn't have enough time to get the finish I would have liked on the bike. (Student 2, Week 14)

> While I am very happy with the overall look of my finished bike I think the welding let me down. A lot of the welds are poor. I burnt through the parent metal in places and in others the weld appears porous. By the end of welding the frame my welding had improved and I should have practiced more before moving on to the frame in the first place. (Student 28, Week 14)

The data show evidence of the different levels of cognition; it is however worth noting that according to the criteria applied, most students demonstrated some higher-order thinking skills, from an early stage in the project but this is related to nature of PBL which requires analysis at an early stage. However, for many students the synthesis and evaluative components were additional and did not prove evident in their postings upon assessment in Week 2 (see Table 3). Self-assessment and grading of their finished model was not a formal requirement for the module, nevertheless several students did provide a detailed evaluation of their finished project through the e-portfolios. As predicted by Papinczak, Young, and Groves (2007), students were slow to critique and evaluate each other's finished work and mostly provided analysis and synthesis through suggestions and ideas offered on how to overcome obstacles encountered by their peers throughout the production of the models.

Students clearly enjoyed the project-based structure of the module as the class score never fell below 3.8 out of a possible 5 on the Likert scale for any aspect of the module evaluated in the survey (provided in Appendix A). The module effectiveness and relevance to the educational goals of this teacher education course both received an average class score of 4.1 out of a possible 5. Students also responded very well to questions regarding the organisation and structure of the module, as well as its capacity to increase students' knowledge of their core subject matter, receiving a class score of 4.0. In addition, comments provided by students demonstrate that the problem based learning was challenging and motivating:

> Great module, very enjoyable, the project was very testing but also educational. Enjoyed learning how to weld and throughout the semester the atmosphere in the labs was great. (Student 17)

> I enjoyed the module, thought it was a good learning experience and one that was taught well with a unique approach. (Student 28)

The peer feedback element to the module also emerged as beneficial and informative for the students:

> I found the input from other members of the class very useful. While I didn't agree with some of their comments it was definitely good to get a different person's perspective at times. (Student 21)

> At a few points during the manufacture of the bike I ran into difficulty and it definitely helped being able to bounce ideas of the other lads in the group. (Student 22)

While a secondary aim of the individualised lecturer feedback was to try to move students away from reliance on the lecturer and from the focus on grading, these remained concerns for students: 'I thought the peer feedback part to the module was very good, but I would have liked more feedback from the lecturer at times so that I knew how I was doing in the module' (Student 2).

Lecturer feedback was structured in a way that maintained the formative focus of the module, however students often requested a grade from the instructor upon receipt of feedback and they were challenged by the focus shifting away from grading.

Because of their heightened critique students were more keenly aware of potential improvements which sometimes led to them not knowing when their motorcycle model was finished and looking to the lecturer for confirmation of this.

The peer feedback encouraged the sharing of ideas and knowledge and meant that students could draw from the large pool of ideas within the student cohort:

> I like the fact that you could trace the ideas and designs for the bike back to the original owner so I wasn't afraid to share my ideas with the rest of the class as long as I had it uploaded onto the e-portfolio first. (Student 32)

Although both modules employed the use of e-portfolios and had a significant project-based element, students appeared less engaged with the control module. Students' provided fewer postings on their e-portfolios throughout the control module with a total of 1552 voluntary postings for the motorbike module, compared to 994 for the control module. The reflections posted in the control module demonstrated primarily lower-order thinking skills when compared to those entered for the peer feedback module with an average class score of 1.6 for the control module in Week 11, compared to 2.2 for the peer feedback module (see Table 3). The peer feedback and open access e-portfolios had a positive influence on learning outcomes. This was not only evident in the levels of engagement of the students but also in their overall grades for both modules, with students performing significantly better in the peer feedback module than in the control module. The average grade for this cohort in the peer feedback initiative was 61.8% (B2) and in the control module it was 55.7% (C1). A spearman correlation analysis of student results revealed that higher level of critical thinking (as evident in students' Week 11 reflections) was also associated with higher grades in the overall module ($r = 0.762$, $p < 0.005$). This was not surprising given that 25% of the module result was allocated to students' reflections and feedback through the e-portfolios and blog. However, a significant correlation was also evident between students' Week 11 reflections and their score in the formal end of semester examination ($r = 0.714$, $p = 0.014$). By comparison for the control module no significant correlation was evident between students' Week 11 reflection and their end of semester examination.

Finally as a result of the module all 47 students were successful in designing and manufacturing a unique module motorcycle, demonstrating not only a high level of manufacturing and joining skills but also critical thinking skills. (For examples of pupils' final projects and the work completed please see the following website: www.pn4105.wordpress.com.)

Discussion

The pedagogical approach employed in this study was utilised in order to stimulate student thinking and promote deeper approaches to learning. The assessment stages implemented were designed to ensure constructive alignment with the aims and objectives of the module which hoped to move beyond surface approaches to learning and in doing so encourage higher quality learning outcomes. A significant percent of the assessment strategy had a formative focus, aimed at promoting greater reflection and encouraging the development of students' critical thinking skills. The results suggest that this reflected positively on the learning outcomes of the module. On average students performed better in the peer feedback initiative when compared to the control module. However, the influence on student learning outcomes was perhaps more apparent in the level of student engagement with the experiment module when compared to the control. This engagement can be seen quantitatively by the number of posts provided by students but was also evident during observations of student interactions and engagement in the workshops.

The relationship between the pedagogical strategy experienced by participants in this module and the future approaches to teaching they employ deserves further investigation. Findings by Sluijsmans, Brand-Gruwel and van Merriënboer (2002) suggest that exposure to alternative assessment structures including the use of peer-assessment can have a positive effect on the development of student teachers' own assessment skills. However, in relation to this research it would require further exploration through a longitudinal study of the participating cohort. Although not the principal focus of this study, the module examined in this paper not only afforded student teachers space for critical thinking and reflection but rewarded them based on the quality of this reflection, an element that Hill (2007) argues has virtually been 'squeezed out' of many teacher education programmes. Hill (2007, 215) also argues that teacher education should enable student teachers to develop the skills to critically examine the nature of teaching, therefore 'transformative intellectuals must engage in self-criticism'. Findings from this study suggest that the incorporation of a significant element of self- and peer-assessment in this module encouraged reflective practice and helped develop student teachers' ability to critique and evaluate their own practice, as well as that of their peers.

A development in the cognitive sophistication of students' reflections was evident as students progressed through the module. However, the greatest shift towards higher order, critical thinking occurred early on in the first half of the module, shortly after the receipt of initial peer and lecturer feedback. It is clear from observations of the groups and from analysis of student reflections that the provision of lecturer feedback was essential for guiding the future peer feedback provided by students. Prior to the provision of lecturer feedback students were reluctant to criticise their peers' works as previously reported by Clifford (1999) and also highlighted by Papinczak, Young, and Groves (2007). However, post receipt of lecturer feedback in Week 3 students adopted a similar formative structure to that presented to them when offering feedback to their peers, providing constructive criticism where appropriate. This would support findings by Showers and Joyce (1996) which suggest that it is essential that both recipients and providers of feedback be acquainted with the feedback process. Once students had received lecturer feedback and consequently were familiar with what was required of them, they appeared better equipped to provide feedback themselves and were less reluctant to criticise their peers.

As highlighted by Sadler (1998, 82) self and peer assessment holds great potential but 'may become even more effect if students are specifically inducted into the process of making sound qualitative judgment'. This study would support Sadler's findings regarding the importance of effectively inducting students into the formative feedback process. Without effective induction student can struggle to assimilate the specific benefits of formative feedback (Sadler and Good 2006), as highlighted in this study with many of the students requesting a grade upon receipt of formative feedback throughout the module. The notion of peers having a critical role was challenging to students' previous experience in which the teacher has always played the central role in the feedback process. As highlighted by McNiff and Whitehead (2006) students may consequently need support in overcoming their dependence on the lecturer and may need to be supported to develop an understanding of themselves as having legitimate knowledge in the classroom. It is important that the lecturer takes the time to discuss the feedback process with the students, and students need to be aware of the rationale for giving and receiving feedback from their peers (McGourty, Dominick, and Reilly 1998). However the data suggest that through blending the use of lecturer and peer feedback students can develop and enhance their higher-order thinking skills. A well designed peer feedback process can produce meaningful results (Nicol and Macfarlane-Dick 2006), but as highlighted by Liu and Carless (2006) and supported by findings from this research it also requires careful attention of the lecturer.

Traditional summative assessment practices focus on factual transmission and assess students ability to learn, recall, list and recite these fact (Broadfoot 1996). The authors contend that through the structure outlined for project-based curriculum such as this study implemented, student teachers may see the value of promoting peer feedback and peer assessment as a means by which to develop higher order cognition (Hopson, Simms, and Knezek 2001). Offering students the opportunity to critique each other's work also encourages enhanced reflection more on their own project and design. This strategy potentially encourages students to intuitively engage at the higher levels of Bloom's Taxonomy. Also given the educational context in which this module was implemented, it serves to expose student teachers to alternative teaching, learning and assessment strategies so they may examine their pedagogical potential first hand. As highlighted by Dow (2006, 317) 'an important way forward for initial teacher institutions is to give pre-service teachers opportunities to explore and make explicit their deeply embedded implicit theories, thus enhancing self knowledge and making a critical self analysis of practice more possible'. This module not only afforded students the opportunity to explore alternate pedagogy than that traditionally offered at higher level, but also encouraged reflection and 'critical self-analysis of practice'.

The incorporation of self- and peer-assessment and feedback in this project-based module helped create a learning environment that promoted deeper approaches to learning by stressing the importance of critical thinking skills. This was not only reflected in the finished models and overall grade for the module but also in students' results in the formal end of term examination. Higher levels of critical thinking as evident in students' reflections were also associated with higher results in the written examination on the manufacturing processes, reflecting deeper understanding. The structure and approach taken for this module encouraged the development of an environment of equal status learners where every student not only had a contribution to offer but were required to provide it. As highlighted by Black and William (1998b, 6), 'what is needed is a culture of success, backed by a belief that all pupils can achieve'.

Conclusion and recommendations for teacher education

There are some clear implications for teacher educators. There is evidence to suggest that schoolteachers teach the way they have been taught themselves (Britzman 2003; Parsons 2005), a process Lortie (1975) has identified as the apprenticeship of observation. Therefore, if initial teacher education is implemented from a more empowering and less authoritarian and didactic perspective, then it is likely that student teachers may replicate this in their own future teaching careers. In addition Trigwell, Prosser and Waterhouse (1999) have shown that approaches to teaching are directly related to approaches to learning. Initiatives such as this one that encourage higher order thinking through PBL and peer engagement and which challenge a traditional understanding of the teacher's role is important for the development of teachers who are committed to empowering education for their students (Hill 2007).

As highlighted by Cheng, Cheng and Tang (2010, 93) 'most student teachers observe faculty who teach them, and see higher education as an important source of ideas and models for teaching'. Therefore a prerequisite of all teacher education programmes should be the provision of learning environments that model pedagogical expectations for pre-service teachers. As well as promoting deep learning, this initiative aimed to provide student teachers with a model for the successful implementation of PBL and peer engagement under the mantel of 'teach as you preach' as advocated by Struyven, Dochy and Janssens (2010). By promoting self- and peer-assessment and feedback, student teachers were shown to develop their critical thinking skills which resulted in higher quality learning outcomes when compared to a control group. This pedagogical approach encouraged students to reflect not only on their own work but on the work of their peers, shifting the focus from traditional transmission methods to a deeper approach to learning. This focus on 'deep learning' resulted in a significant development in students' critical thinking skills throughout the module as evident in their reflections and assessed by applying Bloom's Taxonomy for the cognitive domain. However while this approach was successful for this module more research is required into the impact of such strategies on the classroom practices of graduates and indeed into the potential of similar teaching strategies for alternative curricula and for more diverse student populations.

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Appendix A

	Module	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
1	The module aims and objectives were clear.					
2	The module was organised and sequenced well.					
3	The module has significantly increased my knowledge in the subject areas.					
4	The module was very relevant to the educational goals of this teacher education course.					
5	The module offered creative freedom.					
6	The module afforded students the opportunity to reflect on and develop their design skills.					
7	The module provided students with exposure to and opportunity to experience joining and manufacturing processes.					
8	The module offered good insight into the subject matter.					
9	The module motivated and encouraged me to find out more about the subject matter.					
Student						
1	I found the E-portfolios helpful in mapping my designs and concepts.					
2	I found the **blogs** useful for sharing ideas and information with my peers.					
3	I found the feedback from my peers useful in developing on the concepts and principles of the project.					
4	I found the **blog** and feedback from my peers helpful when confronted with problems in the module.					
5	I enjoyed the module.					
6	I felt motivated to complete the project.					
7	I attended most or all of the required contact hours for this module.					
8	I have worked hard to succeed in this module.					
9	Overall this was an effective module.					

Additional Information

Please highlight any further details relating to your learning experience on this module.