THE FORMATIVE VALUE OF PEER FEEDBACK IN PROJECT BASED ASSESSMENT

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Abstract: This Study investigates the impact of peer feedback used as an instructional strategy to enhance undergraduate student learning in project based coursework. While peer feedback has been demonstrated to support students' learning in traditional classrooms, little is known about the efficacy in a project based learning environment. This study aims to examine undergraduate students' perceptions of the value of giving and receiving peer feedback, specifically related to a project based learning activity. In addition, the impact of that feedback on students' satisfaction with the project based module they undertook and on their thinking skills, based on Bloom's taxonomy, was also investigated. In order to explore this impact a comparative analysis was conducted with a concurrently running module that they completed which acted as the control. Results suggest that the quality of students' reflections through peer feedback and overall satisfaction with the module remained high despite students' preference for instructor feedback. Students noted that peer feedback can be valuable and, more importantly, described how giving feedback not only reinforced their learning but enabled them to achieve greater awareness of the strengths and weaknesses of their own project.

Keywords; peer feedback, project based learning, student perceptions, engineering education.

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1. INTRODUCTION

1.1 Forms of Assessment

It is commonly accepted that there are two main rationales for the inclusion of assessment in education: a) for certification (or summative) reasons and b) for learning (or formative) purposes (Liu and Carless 2006). The former is often highlighted as dominant in higher level education (Knight 2002), especially in an Irish context which employs a matriculation system which predominantly (often exclusively) charges summative assessment, in the form of the Leaving Certificate, with the responsibility of allocating university places to students. With such emphasis placed on assessment for accreditation at second level (high-school) it is not surprising that students are frequently being reported as driven by a natural desire to achieve high grades (Ryan, Irwin et al. 2004). However this form of assessment is primarily focused on the certification of students and is often based on the erroneous but widespread assumption that students can later transfer these skills and information with ease. Research has shown that this can lead to adverse consequences such as surface learning, with the inauspicious result that students find it hard to apply what they have learned to real-life problems and scenarios (see Gunderman, Williamson et

al. 2003). The authors of this paper are currently involved in the design and implementation of undergraduate modules which, whilst acknowledging the dominance of the summative paradigm, seek to place greater emphasis on the purpose of assessment related to the promotion of learning. This emphasis on assessment for the promotion of learning is supported by the pedagogical context in which it manifests, in this case a pedagogical environment based on constructivism and discovery learning.

1.2 Educational Context

Problem and project based learning (PBL) has rapidly been adopted by many institutions of higher education as the foundation of their educational concept (see Prince and Felder 2006). However the successful implementation of PBL requires more than the modification of existing curricula, but a change in teaching and learning strategies and in the approach to assessment, a principle given credence to by Barron et al. (1998, p. 271). For the purpose of this initiative a prior traditionally taught module on manufacturing processes was adapted and in many ways ameliorated to incorporate a significant project-based element. Students were assigned a design challenge where they were required to conceive, design and manufacture a model motorcycle incorporating different processes with specific emphasis placed on joining processes. By incorporating design and a project-based element worth 75% of the module, the authors aimed to promote the development of autonomous learners capable of self-evaluation and peer appraisal. However it was clear from the genesis of this initiative that traditional assessment practices, that encouraged particularised and 'rote' learning, would conflict with the aims of the newly developed curriculum, as highlighted by Sluijsmans, Dochy et al. (1998). As a result new pedagogical and assessment approaches were developed which included the development of E-portfolios to support students' projects and the use of peer feedback through these portfolios, as well as in the workshops during the manufacture of the projects. To ensure that students engaged in the peer feedback process, up to 5% was awarded based on the quality of students' responses. However it was clear from subsequent evaluation that most students were intrinsically motivated to critique and provide support through feedback for their peers (as discussed later in the paper). Students' fervour and support for the peer feedback process was however to a large extent reliant of the security provided by the E-portfolio system which logged every students design idea and creative development as well as the feedback provided to their peers on their designs and concepts. As the time and date of each update to the students E-portfolio and any feedback provided were logged, students felt secure in the knowledge that any plagiarism could be traced and addressed accordingly. This helped develop a collaborative and collegial approach to learning, which is lacking in traditional practical modules, as highlighted by one student:

"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".

2. RATIONALE

2.1 Peer Feedback and Assessment

Falchikov (1995) defines peer assessment as the process whereby groups of individuals rate their peers. However Falchikov's definition is principally concerned

with the grading of students and therefore simply describes peer assessment for accreditation purposes and discounts its formative value for both the assessor and the recipient. Somervell (1993) found that peer assessment engages students in making judgements about the work and/or the performance of their peers. This study and many others since (see Sluijsmans, Dochy et al. 1998; Boud, Cohen et al. 2001) have shown that by engaging in this decision making process it helps students develop into 'reflective practitioners' who are capable of not only reflecting critically on the work of others but also on their own professional practice. It is understood that in this formative capacity peer assessment provides greatest support for the development of 'life-long learners' capable of critically evaluating tasks and their own performance, thus enabling students to reflect on their role in the learning process. It is this role therefore that the authors envisaged peer assessment playing in the learning process of students. In order to assure that the focus of the peer assessment process remained directed towards the formative value of appraisal, for this module students were not required to rank each other but to continuously observe and evaluate each others' designs and projects. Students were then capable of providing critical feedback through a Blog available on their E-portfolios. While all students involved in the module could access each others' E-portfolios, students were further stratified into groups of four where each student was accredited with the responsible of critically evaluating other students in the group. It is important to note however that students wilfully went beyond what was outlined in the module requirements and provided feedback to many other students in the class.

2.2 Traditional Assessment versus Peer Assessment and Feedback

Bourdieu (1998, p. 20) metaphorically employed the image of physicist James Clerk Maxwell's demon to aid in his portrayal of traditional education. A similar analogy could be applied to traditional assessment practices. In explaining how the Second law of Thermodynamics could be suspended, Maxwell (1872, p.4) imagined a container divided into two portions; *A* and *B*. Both parts of the vessel contained the same gas at approximately equal temperatures. He then imagined a demon that could see the moving particles in the vessel, some being warmer, therefore faster moving, others cooler, therefore slower moving. By opening a small door the demon sends the fastest particles into container *A* and the slower particles into container *B*. The demon thereby maintains difference that would otherwise tend towards equilibrium. Traditional summative assessment practices act like Maxwell's demon, rewarding students with a specific set of skills; logical-mathematical and linguistic skills, and the ability to recall information, often to the detriment of those with alternative skills such as: spatial intelligence, intrapersonal and interpersonal aptitude.

Recognising this and the work of Howard Gardener (1993) on Multiple Intelligences, the authors aimed to design a structure for assessment that respected the varying skill sets that students possess. Students were set tasks and graded on these tasks at different stages of the manufacture of the motorcycle, from initial concepts and designs, to successful incorporation of different joining processes, and right through to the completion of the model. The E-portfolios allowed students to express their designs, ideas and themselves through a variety of media, graphical sketches, working drawings, audio and visual accounts, and through written reports and blogs. Students were also presented with continuous feedback from their peers and module lecturer at designated points in the module upon completion of set tasks. However in acknowledgement of the dominance of summative assessment in traditional education

structures and students' prior educational experiences, the final 20% of students' grades was allocated to the completion of a written examination at the end of the semester.

3. METHODS

3.1 Procedure for Peer Feedback

47 undergraduate students undertook the completion of this module. While each student was required to design and manufacture a model motorcycle of their own, they were also assigned to groups, eleven groups of four and one group of three students, for the purpose of providing peer support, guidance and feedback. 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 competiveness. As highlighted by Sydow, Lindkvist et al. (2004), the development of a learning environment which nurtures students creative endeavors is central to the philosophy of project-based learning, "It is a matter of freedom with responsibility, where creative and innovative activity is both a possibility and a duty" (Sydow, Lindkvist et al. 2004, p. 1480). By providing students with as little didactic instruction as possible, students were encouraged to draw on their previously developed repositories of knowledge as well as expanding their knowledge and skills to solve new problems.

For the purpose of recording and disseminating students feedback a blog was created on each student's e-portfolio onto which students could post their recommendations, evaluations and comments of support for their peers. It also provided a medium for students to discuss and share ideas. However this was not the only media through which the groups could interact and provide feedback. Students were also required to provide support to other group members in the workshop throughout the course of manufacture of the models. In order to monitor this process each group was requested to nominate a group leader who was assigned the responsibility of reporting back to the module lecture and/or teaching assistant on a regular basis.

3.2 Analysis of Peer Feedback Impact

Traditional summative assessment practices evaluate students' knowledge of the subject area, i.e. their ability to learn, recall, list and recite factual content (Broadfoot 1996). However through the structure outlined for this primarily project-based curriculum, it is envisaged that it will help promote a shift away from convergent student thinking with one single solution based principally on subjective experience. Is it hypothesised that the peer feedback process, in conjunction with the design initiative implicit to this project-based module, would help students see possible alternative solutions, as well as incorporating individual insights, previous knowledge, past observations and their owns subjective experiences in the final project. Therefore the pedagogical approach employed in this study aims to stimulate divergent student thinking.

In order to assess the success of this approach and the impact of the peer feedback process on students' judgments and reflections of their own work, Bloom's

Taxonomy for the cognitive domain was applied (Bloom 1956). From most demanding to least, Bloom' cognitive objectives are as follows:

- **Evaluation** – Shows the ability to judge the value of material for a given purpose based on definite criteria and rational. Includes decision-making and selection.
  - **Evidence**: Assessments, critiques and evaluations
- **Synthesis** – Recombines the parts created during analysis to form a new entity, different from the original.
  - **Evidence**: Creative behaviour such as the development of new solutions.
- **Analysis** – Breaks down material into its constituent parts so that its organisational structure can be understood.
  - **Evidence**: Breaking down, categorising, classifying, and differentiating.
- **Application** – Uses information, principles, and theory learned to answer a question, solve a problem or complete a task.
  - **Evidence**: Conceptual activities such as application, classification and development.
- **Comprehension** – Awareness of what the material means, allows one to demonstrate an understanding of the material based on prior knowledge.
  - **Evidence**: Demonstrate comprehension by applying comparisons and/or contrasts.
- **Knowledge** – The recall of previously learned material, of simple facts or complete theories. Bringing to mind appropriate information.
  - **Evidence**: Definitions and outlines. Reproduction of requisite knowledge.

4. IMPLEMENTATION OF THE FEEDBACK PROCESS

A well designed and automated peer feedback process can fail to produce meaningful results if care is not taken during its implementation. To begin with it is essential that both the feedback providers and recipients be acquainted with how the feedback process should work and in the case of the E-portfolios how the blog system operates. As highlighted by McGourty et al. (1998) it is important that the instructor takes the time to discuss the feedback process with the students, as the students need to be aware of the rationale for receiving feedback from their peers. Additionally, it is essential that the students understand how the competencies being measured are linked to the module objectives. Otherwise the validity of the students' feedback comes into question. Therefore without restricting the scope of the module it is important that all involved are clear about what its aims and objectives are prior to the introduction of the feedback process.

McGourty et al. (1998) also highlights the importance of instructor involvement in the feedback process. Students may receive peer feedback that contradicts their initial plans or designs and may wish to discuss this with an instructor. As a result the authors have made themselves available to students and in some cases facilitated group discussions with their peers in order to help them better understand the feedback they were receiving and the rationale behind that feedback. Feedback on their progress was also provided to students from an early stage in the module allowing them adequate opportunity to react to the feedback they received and implement any improvements required. Instructor feedback was provided as early as week three in the module and peer feedback had commenced the previous week. Students were informed that a significant proportion of their grades were allocated to their ability to assimilate this feedback and respond accordingly.

5. RESULTS

5.1 Development of Higher Order Thinking

Through the incorporation of the peer feedback initiative, and in collaboration with instructor feedback and the use of E-portfolios, this study aimed to develop students' higher-order thinking skills and engage them at elevated levels of Bloom's Taxonomy. Hopson et al. (2001) defines higher-order thinking skills as those cognitive skills that allow students to function at the analysis, synthesis, and evaluation levels of Bloom's Taxonomy. It is clear that as students progressed in the module a significant evolution in their thinking skills was evident in the reflections they posted and in the feedback they provided to their peers. In order to evaluate the thinking skills of the students, this study employed the use of repeated observations of students' reflections at three distinct phases of the module (weeks 2, 6 and 11 of a twelve week module). The observations were qualitative and therefore have a degree of subjectivity; however identical criteria were applied to all students and at all three phases of the study. Similar observations were previously employed by Athanassiou et al. (2003) in order to monitor the development of students thinking skills. The degree of cognitive sophistication as outlined by Bloom's Taxonomy is summarized in Appendix A for each student at all three stages of investigation. The student achievement was coded as follows: knowledge = 1, comprehension = 2, application = 3, analysis = 4, synthesis = 5, and evaluation = 6. 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 six levels of Bloom's Taxonomy would achieve the maximum average score of 3.5. 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.

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. Students' cognitive development, evident in their reflections, was shown to be greatest from assessment one in week 2, to assessment two in week 6 of the study, with an increase from 1.5 to 2.1 respectively (see appendix A). 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, are less apparent. However it is to be noted that on average most students demonstrated some higher-order thinking skills, as defined by Hopson et al. (2001), from a very early stage in the project. This was expected, as the project-based structure to the module requires by its very nature the analysis of a brief and the design of possible solutions. It is clear therefore that although students may already be operating at higher levels of Bloom's Taxonomy, through the use of apposite instruction and constructive feedback students can develop and apply higher-order thinking skills. However what is less apparent is the influence of instructor feedback over peer feedback in this development. Students received instructor feedback at two points during the completion of the project, at the end of weeks 3 and 9. By comparison, from the end of week 2 onwards, the peer support and feedback process ran concurrent to the manufacture of the project throughout the length of the module. In order to determine the impact of both the instructor and peer feedback process a semi-quantitative analysis of students' experiences of the module was conducted post completion. The module was also compared to a control module that the student

completed in parallel, which while also incorporating E-portfolios for students did not include a peer feedback element and relied entirely on instructor feedback.

5.2 Survey on Students' Perceptions of the Module

During the final week of the module students were asked to complete a survey on their perceptions of the module. The survey was completely anonymous and required the students to rank, using a likert scale, different aspects of the module such as the pedagogical approach utilised, its aims and objectives, its structure and overall effectiveness. At the end of the survey students were also asked to provide some qualitative feedback about their experience of the module. While on average 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, what is more informative is the comments provided in the qualitative section of the survey. It is clear from students' comments that they enjoyed the project-based structure of the module:

> 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 thought well with a unique approach. (Student 28)

However it is also clear from the students feedback that they felt the module occupied too much of their time and took from other modules running in parallel. This will be a contributing factor to their performance and perceptions of the control module used for comparison in this study and discussed later in this paper.

> The module was very interesting and very enjoyable but definitely led to neglect for other modules. (Student 14)

> I found that work on the bike could have continued on and on. I don't believe that our course work should interfere with our studies. (Student 1)

It is clear then that the project-based structure to the module was successful in its attempts to engage students in the learning experience. However based on students' comments and observations made in the workshop it can also be concluded that the lack of didactic instruction and of defined limitations to the design of the model motorcycle led to students not knowing when the model was finished. There were constant improvements that could be made to the design and a sociable but competitive environment developed as a result with each student driving the next. The peer feedback element to the module also emerged as a contributing factor to this:

> 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 persons' perspective at times. (Student 21)

> I thought the peer feedback part to the module was very good, but I would have liked more feedback from the lecturer at time so that I knew how I was doing in the module. (Student 2)

The views of student 2 were echoed by many other students. While each student was proved with individualised instructor feedback twice during the completion of the

module, this feedback was entirely qualitative and aimed at highlighting areas of success and areas where improvements were necessary in the students' designs. Instructor feedback was structured in this manor in order to maintain the formative focus of assessment for the module. However due to the impact of operant conditioning as a result of previous assessment models experienced by students, they often requested a grade from the instructor upon receipt of qualitative feedback.

5.3 Comparison with Control Module

Although both modules employed the use of E-portfolios and had a significant project-based element, students appeared less engaged with the control module. The subject area of the control module was technical graphics and although the project element was not workshop based, it did require the development and implementation of similar design and creativity skills on the part of the students. Feedback was instructor driven and the module did not include a group-work element. Students' provided much fewer records on their E-portfolio throughout the module and their reflections demonstrated primarily lower-order thinking skills when compared to those entered for the peer feedback module. As highlighted by the student's comments it is clear that the work on the motorcycle project lead to the "neglect" of alternative modules and coursework. However it is also clear that the peer feedback and open access E-portfolios utilised in the experiment module lead to the development of a positive but competitive environment, which in turn 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 experiment than in the control module.

6. CONCLUSIONS

A development in the cognitive sophistication of students' reflections was evident as students progressed through the module. 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 instructor feedback. This suggests that qualitative feedback of this nature can have immediate impact on the thinking skills of students. By offering students the opportunity to critic each others work, it encourages them to reflect more on their own project and design. This strategy automatically encourages students to intuitively engage at the higher levels of Bloom's Taxonomy.

The use of both a significant project-based and peer feedback element to the module, along with formative assessment methods, facilitated in the development of a positive, sociable, but competitive environment where students constantly strive to enhance their designs and projects. It was successful in not only delivering the course content but in thoroughly engaging the students. However this was often to the detriment of alternative modules that the students were involved in, with students dedicating an unbalanced percentage of their time to the completion of the project. In order for similar pedagogical strategies to be sustainable, a united and 'over arching' teaching and learning approach to the development of undergraduate courses must be established. While this approach was successful for this module and class of 47 students, more research is required into the implications of similar teaching strategies for alternative curricula and subjects with diverse student numbers.

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Appendix A

Quality of Student Reflections According to Bloom's taxonomy Levels

	Week 2							Week 6							Week 11						
	Bloom's Level						Student Average	Bloom's Level						Student Average	Bloom's Level						Student Average
Student	1	2	3	4	5	6	Score	1	2	3	4	5	6	Score	1	2	3	4	5	6	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
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			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	6	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**