Are power engineering students really using their formative assessments to achieve academic success? – A case study.

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Abstract: Industrial Projects IV is a compulsory capstone module for students enrolled for the Baccalaureus Technologiae (BTech) in Electrical Engineering (Power) in South Africa. Power engineering students need to submit six different assignments during the course of a year, where three of these assignments are formative in nature. Students have the opportunity to improve on their work with each subsequent assignment, with the sixth assignment being summative in nature. However, are power engineering students really applying the academic feedback given on their formative assessments to improve on their future submissions? The purpose of this paper is to highlight that only a small percentage of students in a capstone module are really applying academic feedback provided to them, while the majority of students seem to be fluctuating in its use, with some initially disregarding it and then finally heeding it again. This inconsistency is highlighted by contrasting student results for four different submissions, determining which students increased or decreased their grades from one submission to the next. Results indicate that those students who improved their grades on 66% of their submissions (being two out of three successive submissions) had a 97% chance of achieving academic success, while 76% of them finished within the top 25 students in the course. A key recommendation of this research is to share its findings with future power engineering students, thereby creating an awareness of the importance of engaging more with the academic feedback given on formative assessments.

Keywords: Industrial Projects IV, capstone, UoT, summative, feedback

1. INTRODUCTION

"Technology will not replace teachers. However, teachers who use technology will probably replace teachers who do not". This general statement highlights an important principle in our technological age that those who refuse to change are often left behind. This may further be extended to senior engineering students who do not really change their written reports, or improve on their learning, in accordance with adequate academic feedback. In fact, research has shown that more feedback may lead to higher student engagement and academic achievement [1]. However, some students are left behind in that they face academic failure at the end of a module as they disregard academic feedback during a course or module, such as a capstone module.

The purpose of a capstone module is to provide students with the opportunity of earning credits by integrating and applying knowledge and skills acquired from other modules so as to extract the best possible benefit from the programme in a particular career [2]. This often involves the design and development of an engineering project [3], with problem-based learning [4] featuring predominately in these modules. Some of these modules make use of the iUSE principle, where students need to identify (i) a problem, demonstrate that they understand the problem (U), develop suitable solutions to the problem (S) and finally evaluate (E) which solution is the preferred one [5]. These types of modules usually require more time than non-capstone modules, with a number of submissions required that contribute to the final assessment grade of the student.

However, the assessment procedures for capstone modules pose challenges and need careful structuring [6]. These challenges may relate to the number of different submissions that require specific rubrics. Another challenge relates to declining student engagement, as students fail to apply academic feedback given on their formative assessments, thereby influencing their future submissions. The purpose of this paper is to highlight that only a small percentage of students in a capstone module (termed Industrial Projects IV or IP4) are really following through on the academic feedback provided to them, while the majority of students seem to be fluctuating in its use, with some initially disregarding it and then finally heeding it again.

The importance of using both formative and summative assessments in the structure of a capstone module is firstly substantiated. The capstone module, IP4, is then introduced and contextualized. The research methodology follows with the results which are presented in a series of graphs and tables conveying quantitative data.

2. TYPE OF ASSESSMENTS

The fundamental purpose of engineering education is to build a knowledge base and attributes or skills that will enable graduates to continue learning and to proceed to formative development that will develop the competencies required for independent practice [7]. This highlights the need for students to continue to learn, to continue to build on their previous knowledge, to

continue to adjust and refine their competencies. This is often achieved through "scaffolding", which is a process of instructing and correcting the actions of a student. Scaffolding involves both a depiction of the desired activity and assessment to correct inaccuracies [8]. Scaffolding involves three key characteristics: a) contingency: refers to responsive, tailored or adjusted support; b) fading: refers to the gradual withdrawal of this support over time, and c) transfer of responsibility: refers to the eventual handing over responsibility for the performance of a task to the student [9]. These three key characteristics are typically experienced in capstone modules, where students need to submit different assignments based on the initial support and guidance provided by academics. Students then need to take responsibility for their own learning in that they need to implement the academic feedback before their next assignment is submitted. With each subsequent assignment, the support of the academic should decrease more and more, as students start improving their writing skills. Eventually, the student needs to submit the final assignment which would have required the student to take *full* responsibility for this task. This process may further be defined in the use of formative and summative assessments.

Scriven (1967) originally made the distinction between formative and summative assessment [10]. Formative assessment contains academic feedback that indicates the difference in the level of the submission and the criteria, goals and standards set for that submission [11]. On the other hand, summative assessment is used to arrive at a final judgement of a student's work, without academic feedback being provided [12].

Formative assessment provides opportunities for students to receive academic feedback on their performance; building on their strengths while resolving their weaknesses [13, 14]. One of the main advantages of formative assessments is that it allows the immediate identification of student difficulties (see Table 1 for more advantages). These may include inappropriate methods or wrong calculations. The final report that is handed in by IP4 students is a scientific document that requires a specific format and structure. Students in this module often struggle with the structuring of this report that starts with an introduction and ends with a conclusion. Students often cut and paste images from the Internet, without adequate referencing or explanations of the image being provided. In this case, formative assessments provide students with academic feedback on how to reference each image and explain each one adequately in the narrative, thereby improving his or her competence in the module [15].

This improvement must be made ahead of a final summative assessment, which often occurs at the end of the module with the sole purpose of making a final judgement [16]. Advantages of summative assessments may include that it allows the academic to make a decision concerning the student's competencies in the module. The main disadvantage of summative assessment is that the results obtained by the academic can only be used for improvement in the next offering of the module. In IP4, a positive outcome of the summative assessment will be a sign that the learner has successfully mastered the specified learning outcomes of the module. For example, students need to master the methodology section in the report, where they clearly outline *how* they went about solving the problem. This assessment may also allow the student access to further studies and serve as an indication of employability. Summative assessments are therefore final judgement calls of a student's work, that encapsulate all the evidence up to a given point [12], and is made without academic feedback been given, except for a final grade.

A comparison between formative and summative assessment is given in Table 1, with specific reference to goals, characteristics, advantages and disadvantages. The main goal of formative assessments is to provide adequate feedback to students so that they may improve their learning, while the main goal of summative assessments are to determine the overall required competencies of the student at the end of a module. Formative assessment is characterised, among others, by a focus on the process of learning, while summative assessment focusses on the outcome of learning. The course structure and the type of assessments that are used for IP4 are discussed in the next section.

Table 1: Comparison between formative and summative assessments

	Formative assessment	**Summative assessment**
Goal	To monitor student learning and provide ongoing feedback that can be used by students to improve their learning	To evaluate student learning and overall competencies at the end of an instructional module by comparing it to a benchmark
Character-istics	Assessment of learning Focuses on the process Provide information about the improvement of knowledge and skills Requires little time from students and lecturers Done in class	Assessment of learning Focuses on the outcome Provide information about attainment of knowledge and skills Requires more time from students and lecturers Done outside of class
Ad-vantages	Can be used to: • improve learning, • provide adequate academic feedback, • motivate students, and • diagnose students' strengths and weaknesses.	Can be used to: • derive a final grade, • allow progression to further studies, • assure suitability for work, • predict success in future studies, and • signal employability.
Dis-advantages	Final grades cannot be derived	Information can only be used in future offerings

3. COURSE STRUCTURE OF IP4

IP4 is a compulsory module in the Baccalaureus Technologiae: Engineering: Electrical qualification (most commonly referred to as the BTech). The course structure (highlighting six different submission requirements) used at CUT for this module is shown in Table 2, which needs to be completed over a 10-month period (registration is completed in February with the final report (summative assessment) submitted in October). No formal electrical or electronic based circuits are required from these students who often work on high voltage systems (up to 132 kV). Their final report or dissertation is usually based on a real life case study which was identified in industry.

The structure and purpose of the project proposal, along with the research methodology course and project plan, is presented over the first nine weeks of the course. This usually comprises a singular 4-hour session per week arranged for a late afternoon or early evening in order to grant full time working students the opportunity to attend. Theory relating to the title, problem statement and proof of the problem is emphasized. The project proposal is assessed formatively, giving students the opportunity to rectify any deficiencies. This is important as the project proposal usually forms the core of the first chapter in the final report or dissertation.

Table 2: Industrial Projects 4 (IP4) structure

Requirement	Assign.	Month	Weighting
Project proposal	1	April	10%
Progress report (formative)	2	July	10%
Article (summative)	3	August	5%
Poster (summative)	4	August	5%
Oral defence (summative)	5	September	10%
Final report (summative)	6	October	60%
		TOTAL	100%

The progress report (a formative assessment) covers the first three chapters of the dissertation, along with the front matter (declaration, expression of thanks, abstract and table of contents), references (a minimum of 12 references are required of which at least 50% must be journal references). In-text references are emphasised as well as the importance of plagiarism during with weekly theory sessions. The first chapter basically comprises the revised project proposal, while Chapter 2 should cover relevant literature that seeks to explain the problem and the proposed solutions. Students are requested to include specific references to previous practical industry examples where their proposed solutions to their problem have been used before. This lends credence to their proposed solution, establishing its validity in the student's research project. Reasons must be given as to *why* the solution was required, *how* it was implemented and *what* the results were. Chapter 3 of the progress report should introduce at least three proposed solutions to the problem identified in Chapter 1, presenting proposed electrical diagrams, possible installation sites, geographical topologies and the advantages and disadvantages of each solution.

The article (a summative assessment) requires students to compile a two-page article based on the official IEEE template. This helps students to understand the importance of structuring a research publication as well as what important sections or topics are required. Limiting the number of pages helps negate the so called "cut and paste" syndrome so often encountered with student reports or dissertations. Students cannot simply copy a huge amount of data from the Internet or from another study, but need to evaluate the information and select only that which is relevant, phrasing it in such a way that it makes sense to the reader. All figures and tables need to be edited by the student to include three specific highlighted sections / blocks which need to be explained in the text. This helps students to reason on the figures and tables, interpreting their significance in the context of their study.

A poster (summative assessment) is required where the student must provide at least four images relating to the current geographical layout, proof of problem and results. Two sentences introducing and briefly explaining each image must be included on the A3 poster. In addition, each image must have three key aspects highlighted. This discourages students from simply cutting and pasting images from the Internet or software packages, with no substantial interpretation or explanation. A brief problem statement and conclusion section is required, while no references must be given on the poster. Excessive amounts of text are discouraged.

The oral defence (summative assessment) requires students to complete a 14-slide PowerPoint Presentation where their details, problem statement, proof of the problem, three possible solutions and results must be shown. Excessive amounts of text are discouraged, while the results must feature some type of simulation in order to make an informed decision about the preferred solution. All possible solutions must be visually presented, with as little text as possible. The conclusion must state the preferred solution and provide substantive reasons for this decision.

The final report (summative assessment) comprises the largest weighting towards the student's final grade which is based on academic feedback given to the student with regard to the project proposal and progress report. Although the article, poster and oral defence is summative in nature, informal academic feedback from these submissions may also be incorporated into the final report. This report must include chapter 4 (results section comparing the alternative solutions by means of simulation software and cost analysis) and chapter 5 (conclusion of the project substantiating the use of the preferred solution along with pertinent recommendations). The actual content of the report contributes to 60% of the student's final grade, while the

structure of the portfolio (front matter (declaration, expression of thanks, abstract, table of contents and list of figures) and back matter (references and annexures)) accounts for the remaining 40%.

4. RESEARCH METHODOLOGY

A case study using quantitative data is used. A case study intends to explore a bounded system in-depth [17]. A system could refer to a programme, event or activity which, in this research, is the formative and summative assessment grades awarded to IP4 students for the various submission as outlined in Table 2. The word "bounded" suggests that the research is conducted within the boundaries of a specific module or location, being IP4 at CUT. Quantitative data is used to highlight the progress of 85 students over four different submissions. The grades awarded to these students by academics during 2014 are used to determine the number of students who improved on their previous submissions, thereby indicating improved student learning. These grades are drawn from the project proposal, progress report, oral defence and final report. Although the oral defence is a summative assessment, it represents the first submission where the students evaluate their proposed solutions. Informal academic and peer feedback, obtained during the oral defence, may be incorporated by students into their final report. This quantitative data is given in the form of tables and figures.

It must be emphasised that the same rubric is used to assess all the power engineering students, with consistent feedback given for each submission which builds on the previous one. At least 40% of the next submission is graded with regard to improvements made on the previous submission, with the exception of the oral defence. However, the oral defence provides a good indication if the student has identified and understood the problem, having provided suitable solutions and evaluations to make feasible recommendations. This is really the crux of the project (iUSE principle demonstrated) that needs to be aligned throughout the final report.

The main result compares the progression of grades for each student across the four submissions, highlighting the number of students who increased their grades for each subsequent submission, or who improved their student learning. A maximum number of three improvements may be achieved with four submissions. A Pearson correlation is also made between the final grades of the students and the difference in grades between specific submissions. This is done in order to determine which improvements are critical to student academic success.

5. RESULTS

Table 3 presents the four submissions, with the number of students who increased their respective grades from one submission to the next. For example, 28 students increased their grades from the proposal to the progress report, while 36 students had a higher final report grade when compared to their oral defence grade. Each submission has been designed to cover specific aspects of the iUSE principle. Identifying and understanding the problem exists across all four submissions. This is primarily where students demonstrate improved student learning, as adequate academic feedback from previous submissions may be used to improve on future submissions. However, it seems that *not* every student is applying the academic feedback, as many students are actually repeating their mistakes. For example, 57 students (total sample of 85 – 28) received a lower progress report grade, when compared to their proposal report grade, while 23 students (total sample of 85 – 62) did not improve on their progress report grade when considering their final report grade. Noteworthy is the Pearson correlation values, which indicates a correlation between the final report grades and the difference in grades between specific submissions. For example, the differences between the individual student grades for the proposal and oral defence where correlated to the student's final report grades, and yielded a value of 0.276. This indicates that *no* significant correlation exists between student progression between these two submissions and the final report grades.

Table 3: Grade improvements for Industrial Projects 4 (IP4) during 2014

Evaluating	Proposal	Progress	Oral Defence	Final Report
i identify the problem	Number of students who improved their individual grades: 28	p = 0.113		
U understand the problem	67		p = 0.276	
	50			p = 0.818
S solutions to the problem		Improved 75	p = 0.208	
		Improved 62		p = 0.673
E evaluate the solutions			Improved 36	p = 0.291

However, a moderate correlation (p = 0.673) exists between the final report grades and student progression (either increase or decrease of grades) from the progress report to the final report. An even higher correlation (p = 0.818) exists between the final report grades and student progression from the proposal report to the final report.

Bear in mind that the final report accounts for 60% of the final grade and that students must achieve a minimum final grade of 50% to successfully complete the module. This implies that students generally need to achieve a good final report grade if they are to achieve academic success. This grade can only be achieved if students apply the academic feedback provided on the proposal and progress report, as evidenced by the moderate and high correlation values.

Figures 1, 2 and 3 highlight the number of students who either increased or decreased their grades between specific submissions. It is portrayed as a histogram, where the frequency axis represents the number of students and the x-axis the grade differences. The student grade differences between their proposal and their progress report are shown in Figure 1, where 46 of the 85 students showed a decrease in their grades of more than 4%. This can be an indication that students did not act on the feedback that they received in the formative assessment of their proposal.

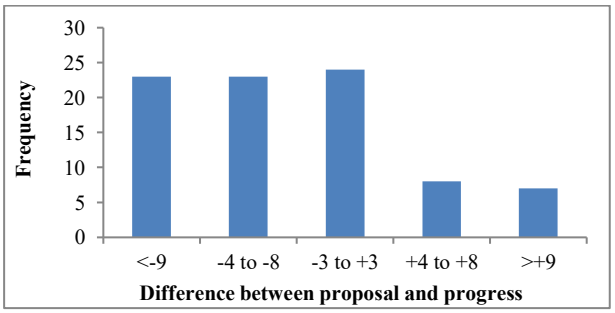

Figure 1: Grade differences between the proposal and progress reports

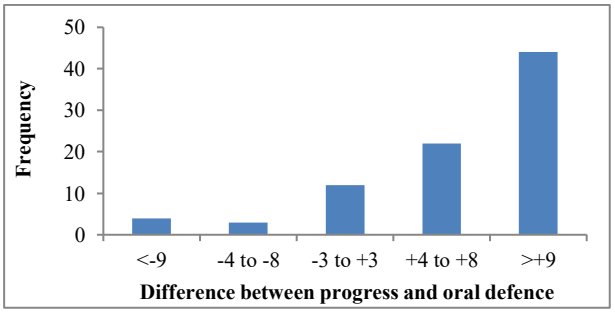

Figure 2: Grade differences between the progress report and oral defence

Figure 2 gives an indication of the difference in grades from the progress report to the oral defence. From the graph, it can be seen that 75 students either maintained or improved on their submission. It is also noted that 44 of the 85 students had a grade increase of more than 9%. This is an indication that students applied the academic feedback that was given to them on their progress report, with a subsequent positive effect on the grades of their next submission, being the oral defence.

In Figure 3, the difference in student individual grades between their oral defence and their final report is presented. During the oral defence, informal feedback was given by the academic to the students. It appears that many of these students disregarded the informal feedback, as 45 of the student's grades decreased more than 4% from their oral defence to their final report.

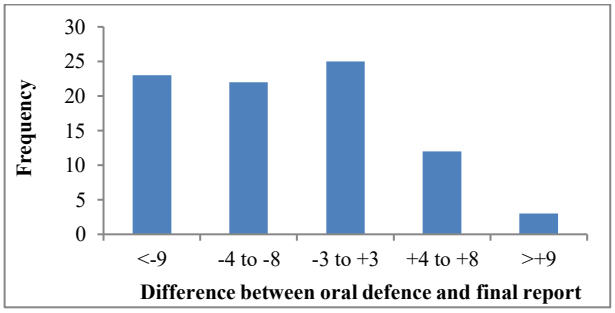

Figure 3: Grade differences between the oral defence and final report

Considering Figure 4, only nine out of the 85 students improved on all their submissions, as a maximum of three improvements may be attained when considering four submissions. This means that their grades consistently increased from their proposal report, to their progress report, to their oral defence, to their final report.

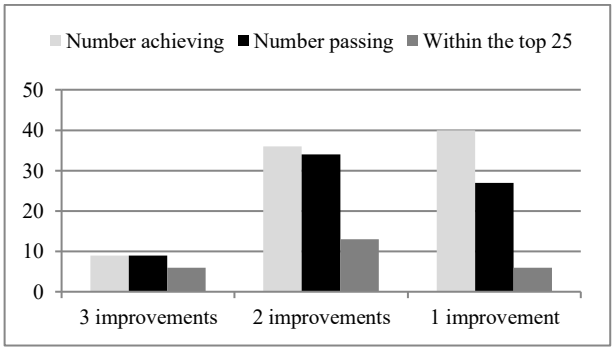

Figure 4: Number of students achieving different improvements and the number passing the module

All nine these students passed the module with six of them being included in the top 25 students. 36 students achieved two improvements in their grades across the four submissions, with 34 of them successfully completing the module (equates to 94% of those making two improvements). 40 students achieved only one improvement, where 27 of them passed the module (equates to 68% of those making one improvement).

6. CONCLUSIONS

The purpose of this paper was to highlight that only a small percentage of students are really applying the academic feedback provided to them, while the majority

of students seem to disregard the feedback with their next submission, then heeding it again with their final report. The structure of IP4 reveals six submissions, of which four submissions contribute 10% or more to the student's final grade. These four submissions (three formative and one summative) were considered in this research, where the improvement of grades from one submission to the next was analysed. Students who improved on their grades were judged as applying academic feedback, while those not improving on their previous grades were judged as disregarding academic feedback.

The results emphasized that those students who consistently apply academic feedback (66% of the time representing two or three improvements in this research) are more likely to attain academic success. In fact, if three improvements are made across four submissions, then a student has a 100% chance of achieving academic success. If only one out of three improvements are made, then a student has a 68% chance of academic success.

This again illustrates that students need to engage, not only with the course content, but also with the feedback given by an academic. Evidence of this type of student engagement is seen in the improvement of student grades over a period of time within a capstone module requiring a number of submissions. Subsequently, a key recommendation of this research is to share its findings with future power engineering students, thereby creating an awareness of the importance of applying academic feedback given on formative assessments. As students engage more with and apply the academic feedback given them, the greater their chances of academic success at the end of a capstone module.

In our technological age, it may be stated that those who adapt to change will most likely succeed. This is also true of power engineering students that seek to adapt to academic feedback given on formative assessments, thereby significantly improving their chances of achieving academic success in the future.

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