# ALTERNATIVE FORMS OF CONTINUOUS ASSESSMENT IN MATHEMATICS

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## Abstract

In Dublin Institute of Technology, there has been a recent move to semesterisation, with an increased emphasis on continuous assessment. In mathematics, this would traditionally mean that students would sit a number of short, written assessments during the course of each semester, in conjunction with an end-of-module exam. However, it was decided to combine these usual assessments with presentations on mathematics for certain cohorts this semester.

As part of their continuous assessment mark, students were required to work in groups of three, to prepare and deliver a short presentation to their classmates. Two techniques were employed: in one instance, third-year Engineering students gave presentations revising one of a selection of fundamental mathematical topics studied in previous years; in the second instance, second-year Product Design students explored possible applications of the mathematics they had studied to their other modules or future careers.

The aim of the first technique was to ensure that students were familiar with core mathematical concepts, which would be necessary for the new topics they would meet in the coming year. It also allowed them to experience the challenge of presenting this material in a clear and interesting fashion, giving them a new appreciation for the position of the lecturer. The second technique was employed to encourage students to consider the relevance of mathematical topics to their area of study, providing them with an opportunity to discover the importance of fundamental mathematical concepts in the design process. In both cases, the students developed an important skill for the workplace in which they may often be required to give presentations on technical matters.

Every group in the class was required to anonymously award a mark out of ten to each presentation, and these marks were combined to produce the final mark. The lecturer also awarded a mark to each group, and this was compared to the mean mark awarded by the students, to examine the difference between this and the peer-marking system. Arising from this, some possible issues associated with peer marking are discussed.

In addition to the presentation itself, students were required to complete a reflective survey on WebCT. The purpose of this was two-fold: to encourage the students to reflect on their own learning experience and how the presentations had contributed to this; and also to provide valuable feedback to staff as to students' perceptions of this learning methodology. The results of this survey are provided in the paper.

### Keywords
Engineering maths, Alternative continuous assessment, Presentations, Applications of maths, Peer assessment, Review of basic maths.

## 1. INTRODUCTION

In Dublin Institute of Technology (DIT), 2006-2007 has seen the introduction of semesterisation, with an increased emphasis on continuous assessment (CA). Traditionally in mathematics, CA has consisted a number of short, written assessments during the course of each semester, in conjunction with an end-of-module exam, or possible a "project". For students completing an ordinary degree, or students in the earlier years of an honours degree programme, these projects usually consist of a fixed mathematical problem which each student must solve using different parameters, randomly assigned to them. Both of these forms of CA are similar to examination-style assessment and do not really provide the students with any extra skills or challenges.

In addition, two major issues that are frequently encountered whilst teaching mathematics at third-level are a difficulty with core mathematical concepts and a feeling amongst students that the mathematics they study is irrelevant to their degree programme, not to mention their future careers. Many students enter third level with poor basic maths skills: they may have achieved respectable grades at second level, but lack a fundamental understanding of the core concepts. At third level, they are introduced to more advanced mathematics, but if their basics are poor, they may never have the opportunity to revise these core concepts. They often progress to later years without having fully understood material from earlier years. Also, not enough emphasis is placed on the applications of the mathematics being studied. This causes many students to lose interest in the subject.

In this study, we worked with two cohorts of students, third-year ordinary degree students in Mechanical Engineering and second-year honours degree students in Product Design, and developed an alternative means of continuous assessment in their mathematics modules. In addition to the usual short, written examinations during the semester, students were required to work in groups of three, to prepare and deliver a short mathematical presentation to their classmates. Two techniques were employed: the third-year Mechanical Engineering students gave presentations revising one of a selection of fundamental mathematical topics studied in previous years; while the second-year Product Design students explored possible applications of the mathematics they had studied to their other modules or future careers. In this paper, we discuss the structure of these presentations, the assessment model used, and report the results of a reflective survey completed by students on WebCT, giving their opinions of this mode of continuous assessment.

## 2. STRUCTURE OF ASSESSMENT

For the purposes of this assignment, students were split up into groups of three. Each group had to prepare a five-ten minute oral presentation, to be given to their classmates, along with a short handout on the topic in question. Each group could opt to have every member of the group actively present or could nominate only one member to do the presentation. Every group in the class was required to anonymously award a mark out of ten to each presentation, and these marks were combined to get a final mark. The lecturer also awarded a mark to each group and this was compared to the mean mark awarded by the students, to examine the difference between this and the peer marking system. In addition to the presentation, students were required to complete a reflective survey on WebCT.

### 2.1 Third-year ordinary degree in Mechanical Engineering

The ordinary degree in Mechanical Engineering is a three-year programme. More than half of the class would be expected to proceed into the third year of the four-year honours degree programme, with the rest going straight into the workplace. This class contains a total of 57 students. The majority of the class entered the course directly from the Irish second-level system, although there are also three full-time international students on the programme, as well as four one-year exchange students. All of the students who completed secondary school in Ireland (with one exception) would have studied Ordinary Level Mathematics at second-level.

The main aim of having these students present topics from basic maths to their classmates was to ensure that all students would be familiar with the core concepts necessary for the topics they would meet in the remainder of their course. Each group was assigned one of the topics listed in Table 1.

| **Topics** | |
|---|---|
| 1. Logs | 8. Vectors |
| 2. Trigonometry | 9. Scientific Notation |
| 3. Differentiation | 10. Partial Differentiation |
| 4. Integration | 11. Integration by Substitution |
| 5. Matrices | 12. Equation of the Line |
| 6. Complex numbers | 13. Probability |
| 7. Statistics | 14. Fractions |

**Table 1.** List of topics given to groups from Mechanical Engineering programme.

## 2.2 Second-year honours degree in Product Design

In the Honours Degree programme for Product Design, students only study mathematics during first year and the first half of second year. There are 24 students in the current second-year cohort. The range of mathematical abilities within the class is very wide as there is no specific maths requirement for the programme, and this can cause problems, as the more able students easily become bored with the material, while the weaker students may be struggling significantly. Because these students are not studying Engineering, they often question the relevance of the mathematics on their curriculum.

As a result, the idea arose of providing the students with the opportunity to work in groups to research a single area they have covered in third-level mathematics, and determine its possible relevance to either future aspects of their programme, or else their career paths, and then present their findings to their class. This assignment would count for 15% of their grade in mathematics. The aim of this assignment was to improve students' attitudes towards the mathematics they have learned, to help them to discover its relevance in other fields, and to improve their skills in terms of group-work and technical presentations.

As in the case of the third-year engineers, the class was divided into groups of three students, which were assigned alphabetically. Each group was randomly allocated one of the topics listed in Table 2 below.

| **Topics** | |
|---|---|
| 1. Differentiation | 5. Vectors |
| 2. Integration | 6. Statistics (excluding probability) |
| 3. Trigonometry | 7. Probability |
| 4. Matrices | 8. Wildcard (any topic not already on list) |

**Table 2.** List of topics given to groups from Product Design programme.

As well as giving the presentation, students were required to produce a short, group document giving a brief mathematical description of the topic, details of the relevant applications, and a list of references used. This was to encourage the students to research the topic correctly, and provide them with a possible structure for their presentations.

## 2.3 Implementation of Presentations

Having been assigned their groups and topics, students were given approximately five weeks to research and prepare their presentations. All presentations took place on the same day, in a single session. Attendance was compulsory, regardless of whether or not all students from a group were presenting. The atmosphere during the presentations was very positive and light-hearted, and students genuinely seemed to enjoy and benefit from their experience of public-speaking.

# 3. ANALYSIS OF PEER-ASSESSMENT

There were several options available to us in the choice of the most suitable form of assessment for these presentations. We were keen to introduce an element of peer assessment, as Stefani et al [1] found that giving students the opportunity to mark another student's assignment can help them to develop an ability to self evaluate and reflect on their own work, leading to a greater understanding of the expectations of lecturers at third level. A further benefit of allowing students to peer-assess in relation to presentations is that: *"the requirement to assess meant that students were actively involved with all the presentations…this increased their attentiveness compared to previous courses when they were more passively involved"* [2]. There are also some disadvantages to peer assessment, for example, *"Students may not take it seriously, allowing friendships, entertainment value, etc to influence their marking"* [3].

We chose to introduce peer-assessment, without relying solely on this. Therefore, as mentioned earlier, each group anonymously gave a mark out of ten to every other group. The mean mark was then calculated, and is compared with the mark given by the lecturer in Figures 1 and 2 below.

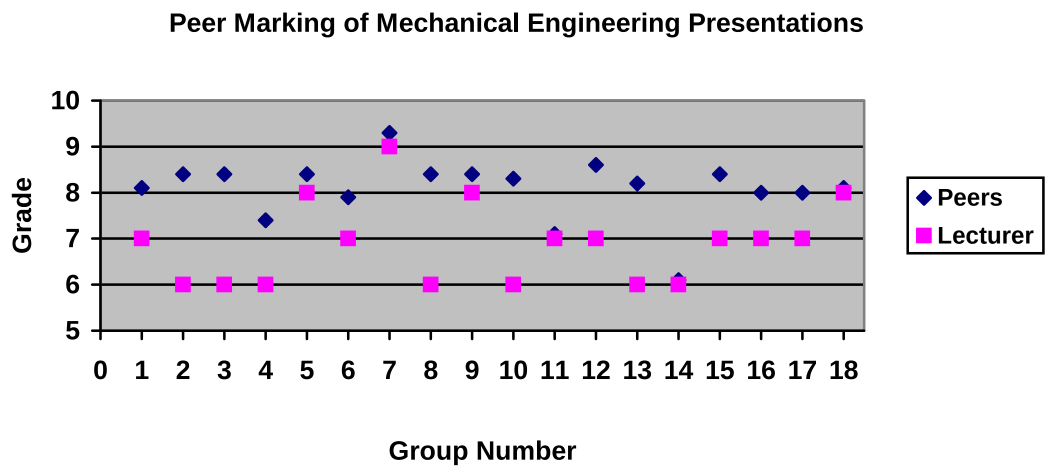


**Figure 1.** A scatter plot of the mark allocated to each group in Mechanical Engineering by their peers (blue) and by the lecturer (pink).

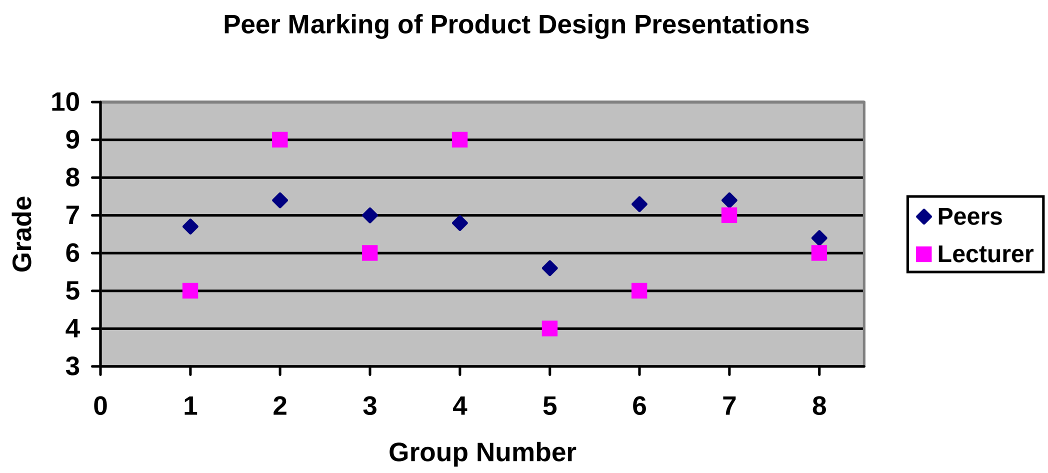


**Figure 2.** A scatter plot of the mark allocated to each group in Product Design by their peers (blue) and by the lecturer (pink).

In order to test whether there is a statistically significant difference between the peer-marking and those marks awarded by the lecturer, a chi-squared goodness of fit test was used, with the lecturer's marks as the "expected results". The results of the test are given in Table 3.

| Programme | Degrees of Freedom | Significance Level | Expected Chi-squared Value | Calculated Chi-squared value |
|---|---|---|---|---|
| Mechanical Engineering | 17 | 0.05 | 27.587 | 61.693 |
| Product Design | 7 | 0.05 | 14.067 | 33.144 |

**Table 3.** Results of a chi-squared goodness-of-fit test conducted to determine whether there is a statistically significant difference between the marks awarded by the students' peers and those awarded by the lecturer.

With a significance level of 0.05, the calculated chi-squared values far exceed the expected chi-squared values, and therefore, we reject the null hypothesis that there is no difference between the two sets of marks and conclude that this difference is statistically significant.

We also looked at the correlation coefficients between the grades awarded by the lecturer and the peer grades. The coefficient for the Mechanical Engineers was found to be 0.43, and the coefficient for the Product Designers was 0.55. Both figures imply that there is little correlation between the peer grades and the lecturer grades.

| Programme | Mean Peer Grade | Mean Lecturer Grade |
|---|---|---|
| Mechanical Engineering | 8.1 | 6.9 |
| Product Design | 6.8 | 6.4 |

**Table 4.** Comparison of the mean peer grades and the mean lecturer grades for both the Mechanical Engineering and Product Design students.

As a result of the statistical tests represented in Tables 3 and 4, it is evident that the students received significantly higher grades from their peers than from the lecturer. The Mechanical Engineering students were told in advance that they would be assessing each other, and as a result, some students seem to have struck deals with other groups in order to obtain higher marks. There is also some evidence of students awarding marks based on how well they liked another student. As one student commented, *"it kind of turns into a popularity contest"*. By contrast, the Product Design students were only told on the day of the presentations that they would be assessing their peers and their marks are closer to those of the lecturer.

In this study, students were deliberately not given rigid assessment criteria in order to encourage them to think independently about the process. These presentations will be repeated in the second semester and clear criteria will be negotiated with the students. We will then be in a position to compare the correlation coefficients for the two different approaches.

## 4. RESULTS OF STUDENT SURVEY

In addition to the presentation, all students were required to complete an individual, reflective survey on WebCT. The purpose of this was two-fold: to encourage the students to reflect on their own learning experience and how the presentations had contributed to this; and also to provide valuable feedback to staff as to students' perceptions of this learning methodology. Of necessity, the surveys given to the two cohorts were different, to reflect the nature of the presentation in question; therefore, we present the results from the two groups separately, before making some general comments about common themes.

### 4.1 Results from Third-year Mechanical Engineering

The questionnaire for Mechanical Engineering students consisted of five questions, largely multiple choice, presented on WebCT. The students' responses to the questions are listed below. Firstly they were asked if they felt that "I learned a lot by teaching others this topic". The results are shown in Figure 3.

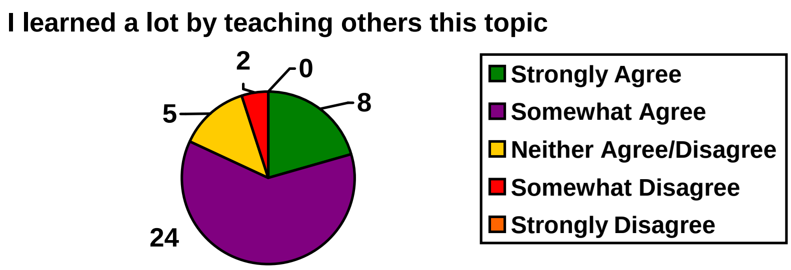


**Figure 3.** Pie-chart showing the opinions of Mechanical Engineering students about how much they learned from doing this assignment.

As we can see, no student selected "Strongly Disagree" and only two selected the "Somewhat Disagree" option with the vast majority of the students' selecting either "Strongly Agree" or "Somewhat Agree". One student commented *"Presentations are a great idea. It made people take an interest in basic maths. People did research and found it surprisingly interesting."*

The next question asked for the students' responses to the statement "I learned a lot about basic maths from the other presentations".

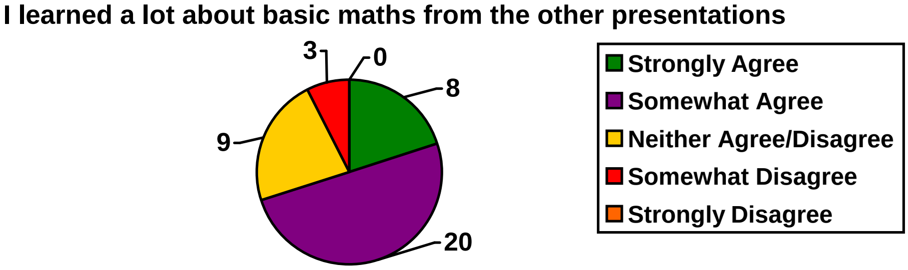


**Figure 4.** Pie-chart showing the opinions of Mechanical Engineering students about how much they learned from other groups' presentations.

This time, no one selected "Strongly Disagree" with only three selecting "Somewhat Disagree", and again the vast majority of students selecting either "Strongly Agree" or "Somewhat Agree". One student commented *"The handouts on the basic principles are useful to have"*.

The students were then asked for their opinion on the best approach for continuous assessment: whether presentations are more effective than exams, or vice versa, or whether a mixture of the two is the optimum way forward, as shown in Figure 5.

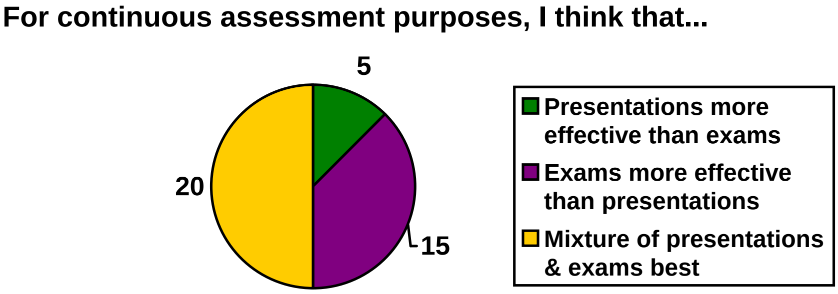


**Figure 5.** Pie-chart showing the opinions of Mechanical Engineering students about whether exams, presentations, or a mixture of both, represent the best approach to continuous assessment.

Only five students selected "Presentations are more effective than exams" whilst fifteen selected "Exams more effective than presentations". Half of the students who expressed an opinion felt that a "Mixture of presentation and exams was best". Thus the majority of students (63%) felt that it was a good idea to use presentations such as this as a form of continuous assessment.

Finally, in an effort to determine the range of potential benefits from this type of assessment, students were asked to consider the possible ways in which doing this presentation benefited them. They were allowed to choose as many options as were relevant. The results are collated in Figure 6. Only five students in the class felt that the presentations did not help in any of the above ways, where as everyone else identified at least one benefit, and the majority of students identifying at least two benefits.

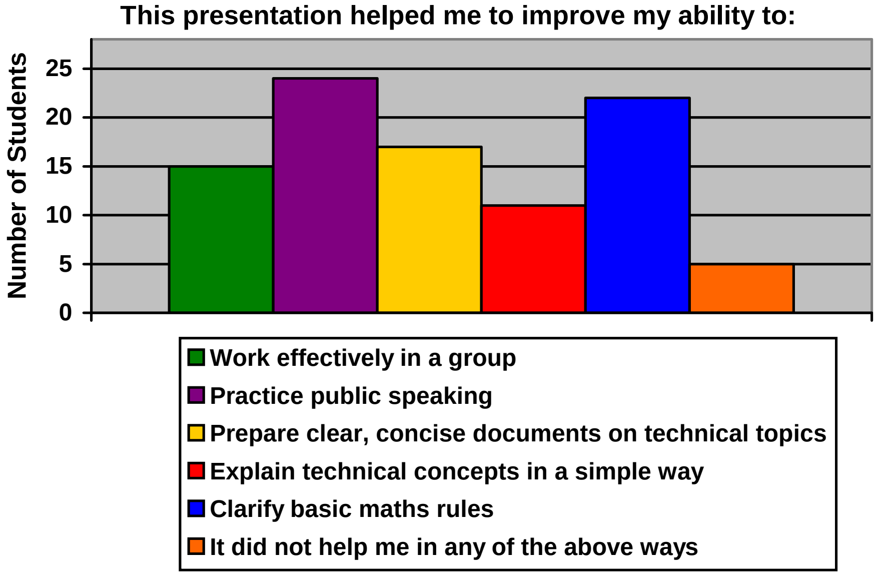


**Figure 6.** Bar-chart showing the ways in which Mechanical Engineering students felt that the maths presentation helped them.

Overall, students' feedback on the experience was very positive: *"Good idea, an enjoyable afternoon "* and the atmosphere during the presentations was very good. One student even felt *"These presentations should be done every month because they help in public speaking and self confidence ".*

## 4.2 Results from Second-year Product Design

The questionnaire for Product Design students consisted of ten questions, largely multiple-choice, presented on WebCT. The students' responses to the questions most relevant to this paper are presented below. Firstly, they were asked to respond to the statement "I learned a lot about how my area of maths can be applied to Product Design by doing this assignment". The results are shown in Figure 7.

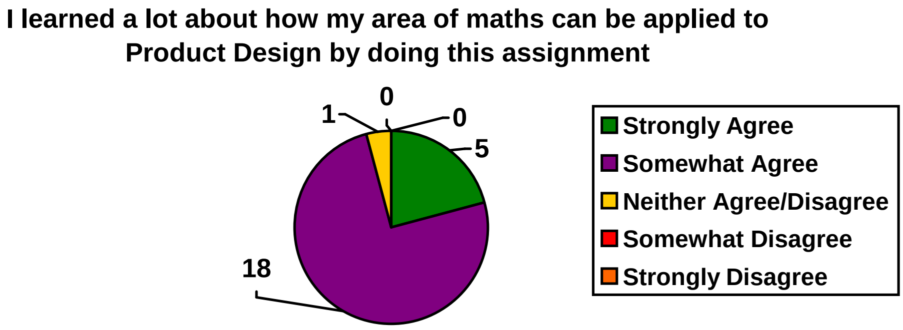


**Figure 7.** Pie-chart showing the opinions of Product Design students about how much they learned from doing this assignment.

As can be seen, no student selected the "Somewhat Disagree" or "Strongly Disagree" options in response to this question, with only a single student ambivalent about the benefits. As one said: *"I like the idea of doing the presentation; it's a nice break from maths and I did learn where the topic can be really used".*

The next question asked for the students' responses to the statement "I learned a lot about how other areas of maths can be applied to Product Design from other groups' presentations" and the results for this are shown in Figure 8.

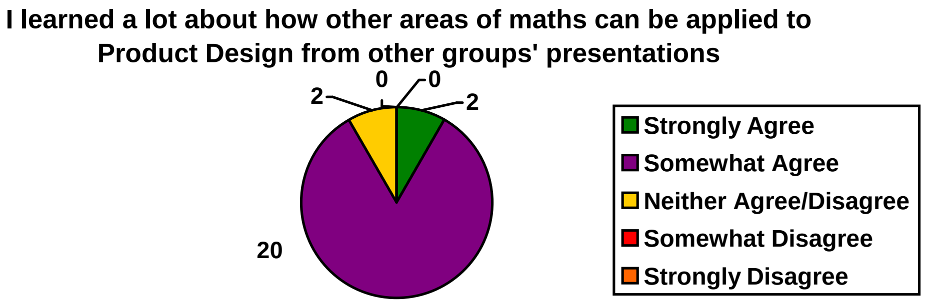


**Figure 8.** Pie-chart showing the opinions of Product Design students about how much they learned from the other groups' presentations.

Again, no student selected the "Somewhat Disagree" or "Strongly Disagree" options. However, one student observed that *"your own learning depends on how well organised other groups are, and if they're not clear about it, it's not always effective."*

The students were then asked to consider whether "doing this assignment helped me to see the relevance of the maths I have learned in college." The aim here was to have them reflect upon the importance of maths within their programme as a whole. The results are shown in Figure 9.

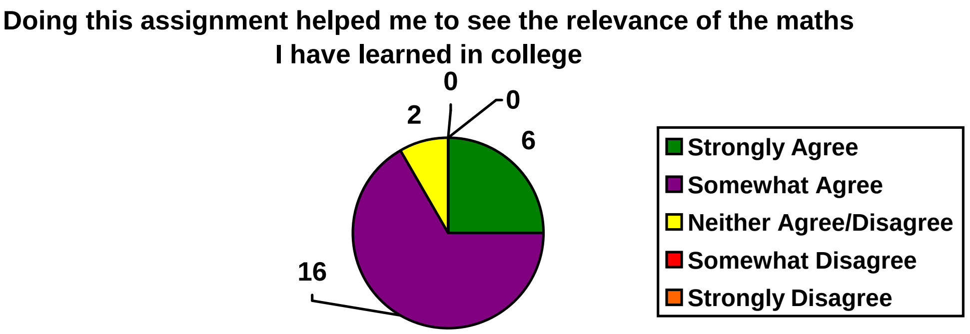


**Figure 9.** Pie-chart showing the opinions of Product Design students about how much this assignment helped them to see the relevance of the maths they have learned in college.

Again, students responded very positively, with nobody selecting "Somewhat Disagree" or "Strongly Disagree". One commented that it was *"a good idea to get students more involved and aware of the purpose of maths in the course".*

To further develop students' abilities to assess the effectiveness of their own work, they were asked to rate their own group's presentation against the others in their class, as shown in Figure 10.

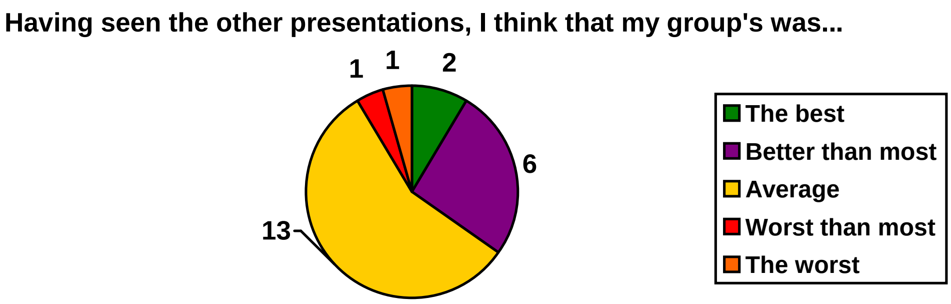


**Figure 10.** Pie-chart showing the opinions of Product Design students about how good their own presentation was, in comparison with the others.

It is interesting to note that two students felt that their own presentation was below par. This may have been as a result of problems within the group, as evidenced in the comments: *"I* *would like to have practised the presentation with my group beforehand as some of our group members did not realise how long/short their part was. This led to timing issues."*

Product Design students were also asked for their opinion on the best approach for continuous assessment: whether presentations are more effective than exams, or vice versa, or whether a mixture of the two is the optimum way forward, as shown in Figure 11.

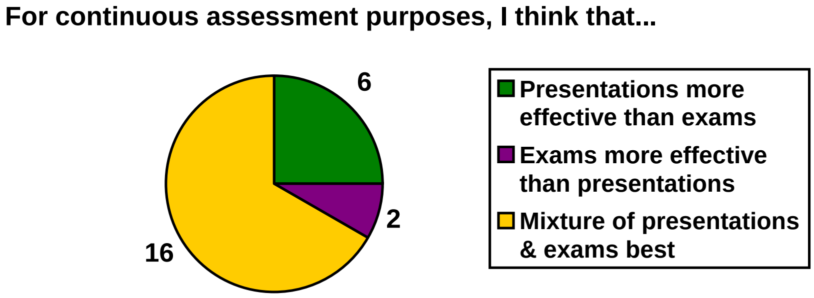


**Figure 11.** Pie-chart showing the opinions of Product Design students about whether exams, presentations, or a mixture of both, represent the best approach to continuous assessment.

The majority of students favoured a mixture of the two, as was also the case for the Mechanical Engineers.

Finally, students were asked to consider the possible ways in which doing this presentation benefited them. They were allowed to choose as many options as were relevant. The results are collated in Figure 12.

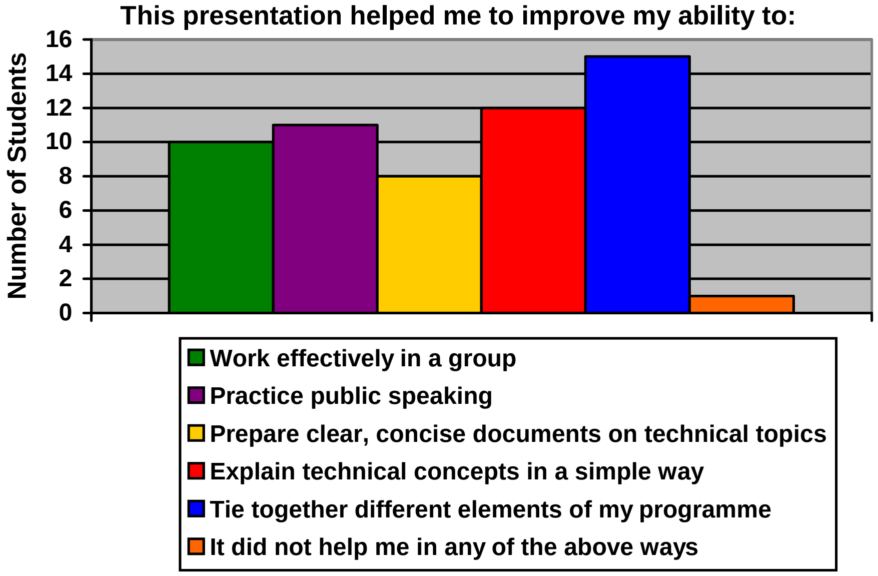


**Figure 12.** Bar-chart showing the ways in which Product Design students felt that the maths presentation helped them.

Only one student in the class felt that the presentation did not help in any of the above ways, with many students identifying two or more benefits.

Overall, students' feedback on the experience was very positive, and some students found particular benefits from working in a group environment: *"Really enjoyed working with the group…made me learn a lot easier and was really interesting".* As expected with group-work, issues arose within certain groups, with some students feeling that others had not contributed their fair share to the assignment: *"We should hand up our presentation with our names on the sections we did so as it would be clear if someone was not pulling their weight".* However, fortunately, this does not seem to have been the experience of most students in the class, and they appear to have enjoyed the experience and found it worthwhile.

## 5. CONCLUSIONS AND FUTURE WORK

The introduction of increased amounts of continuous assessment in mathematics, as a result of a shift to semesterisation within DIT, poses an opportunity to diversify the manner in which students are assessed. In this paper, two different student cohorts were given the opportunity to present a group mathematical presentation to their classmates as part of the CA for their maths modules. Peer-assessment was introduced for the first time, and significant differences between the peer-grades and the grades awarded by the lecturers were observed. Numerous possible reasons for this were identified: lack of awareness on the part of the students of assessment criteria (as a result of insufficient advance preparatory work with them by lecturers); the effects of friendship or entertainment value on the peer-grade awarded; the lack of anonymity associated with determining a mark between the group members, to name a few.

In the future, we propose to agree assessment criteria in advance with students, and develop a more rigid marking scheme, in order to overcome some of these obstacles, and also give students a clearer picture of how marks should be awarded. The use of some kind of clicker system to tally marks anonymously would also be an interesting avenue to pursue. We intend to extend this system to include numerous other programmes in the coming year.

However, overall, student feedback of the experience was extremely positive, and it would appear to have enhanced student learning and given students a greater appreciation for the subject and its relevance in their programmes and their future careers.

## References


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[3] University of Technology, Sydney *(**http://www.iml.uts.edu.au/assesment/students/peer.html**)*