



2014-03-10

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## Recommended Citation

Keane, G., Bowe, B. (2014), 'Assessing The Effectiveness of a Problem-Based Computer Modelling Module from the Student's Perspective' 8th International Technology, Education and Development Conference (INTED 2014), Valencia

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# ASSESSING THE EFFECTIVENESS OF A PROBLEM-BASED COMPUTER MODELLING MODULE FROM THE STUDENT'S PERSPECTIVE

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## Abstract

The Computer Modelling module delivered to the third year Level 8 Mechanical Engineering students in the Dublin Institute of Technology is marked completely by continual assessment. It was developed using a problem based approach in that the theory of Computer Modelling methods is first explained but is then illustrated by demonstrating its application to the solution of real life problems. It is delivered in a traditional manner for the first six weeks in that the underlying principles and techniques of the finite difference method are covered in lectures and practical assignments are completed in the weekly computer laboratory classes. A problem based approach is adopted for the remaining six weeks of the semester. The students form their own groups of three and choose a unique project from a list supplied to them. The primary aim is to get the students to use numerical modelling to solve practical Engineering problems drawn from many different areas such as thermal processing in the food industry, heat transfer in engines, fluid modelling using ANSYS CFX and vibration analysis of structures and machines using Matlab.

The students are assigned a supervisor who meets them for at least 30 minutes each week to advise them and to monitor their progress. Each individual student is held to account for their contribution to the project effort. At the end of the semester, each group must create an A1 poster on their particular topic. They are given a standard template to follow and are advised on the structure including Literature Review, Methodologies, Results and Conclusions. The students are assessed on a ten minute presentation of their project to the module lecturers and their peers.

A shorter open session is also held in which the students must present their posters to other staff members and students and a prize is awarded to the best poster.

A survey was carried out on a group of 12 students who completed the module in 2013. It includes fourteen questions under the headings: Group Dynamics, Project Management, Poster Presentation and Personal View of the Project. In addition, a focus group with a small number of students who had completed the module in 2012 was conducted independently by the second author. The response of the survey was mainly positive with some negative comments. The comments of the focus were broadly in line with the more positive comments from the survey. The responses from the survey and focus groups are reported and discussed in the paper. The overall conclusion is that in general, the module is perceived to be enjoyable and challenging to complete but it equips the students with useful skills going forward.

## 1 MODULE CONTENT

The Computer Modelling module under discussion in this paper is delivered to the third year students on the Level 8 Mechanical Engineering Honours Degree in the Dublin Institute of Technology. When it was originally developed in 2006, it was decided by the author to design the module using a problem-based learning approach. Therefore, unlike most other modules on the course which are assessed primarily by an end-of-term written examination with a smaller practical assessment component, this module is marked on a 100% continual assessment basis.

### 1.1 Weekly Assignments and Assessments

In the first six weeks of the semester, the material is delivered in a lecture followed by a related practical computer laboratory session. In a typical lecture, the underlying theory of a computer modeling topic is presented and its use in solving a real engineering problem is demonstrated. For

example, in week five the solution of non-linear equations using the finite difference method is presented and its application in solving a real heat transfer problem such as the prediction of the cooling rate of a molten iron casting is demonstrated. In the computer laboratory, the students implement variations of the problem solution to reinforce their understanding of the topic. In this particular example, the solution is implemented using commonly available software with which the students are familiar, namely VBA (Visual Basic for Applications) in Microsoft Excel. In addition to the weekly laboratory exercises, each student must complete an assignment by themselves every two weeks. The assignments are formulated with individualized data sets to prevent plagiarism. The various components in this half of the module are awarded a total of 50% of the total module marks, with the other 50% assigned to the project phase described in the next section.

## 1.2 Project Phase

The module transitions into the project phase in the second half of the twelve week semester. The students are invited to form their own groups of three. Each group fills in their 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> preference from a large list of project titles supplied to them. Every effort is made to assign the group its first choice. The groups can also propose their own project title and undertake it if it is deemed suitable by a staff member. The primary aim is to get the students to use numerical modelling to solve practical engineering problems drawn from many different areas such as thermal processing in the food industry, heat transfer in engines, fluid modelling using ANSYS CFX and vibration analysis of structures and machines using Matlab.

In some cases, the groups must develop and code their own finite difference models and compare their predictions against analytical results where available or against predictions generated using well established modelling packages such as ANSYS. In other cases, they conduct physical tests in the college laboratories to record experimental data for comparison purposes. There is an emphasis on encouraging the students to analyse the model predictions critically and investigate how any assumptions made in the model development might be responsible for discrepancies between model predictions and expected outcomes.

The groups complete the work in their own time and are only required to meet the lecturer assigned to their project once a week. The lecturer (or project supervisor) monitors their project for assessment purposes and advises them on ways to overcome problems that they encounter. Each group member is expected to account for his contribution to the overall project effort and it is recommended that a project notebook is kept in which a record of work done can be kept.

At the end of the semester, each group must publish an A1 poster outlining their efforts on their particular project. A standard poster template is supplied with recommended headings including Literature Review, Methodologies, Results and Conclusions. A session is held in which each group must present their poster to the module lecturers and their fellow students in a lecture theatre with a large screen. They have ten minutes to describe the various aspects of their work with each student expected to make a contribution. After a short question and answer session, the module lecturers agree on a project mark. Although the project supervisor has the primary say in the decision, the moderating effect of the other judging staff ensures consistency in marking across the whole class. In some cases, more marks are awarded to an individual if it is obvious he/she had made a significantly greater contribution to the overall effort.

Having listened to the feedback from the lecturers, the groups can make any necessary modifications to their posters before the open poster presentation scheduled on a separate day shortly after. At this session which is held in a public area in the college, the project groups stand by their posters and answer questions from other interested lecturing and technical staff and students. This session can be a source of pride for the students as they get to present their work in an open forum. In many cases, the lecturers gravitate towards the projects from their own areas of expertise and the groups can come under pressure to justify the assumptions they made in deriving their models and their trust in the accuracy of their results can be questioned. In recognition of the efforts made by the students, a prize is awarded to the best poster.

In many cases, the students use the skills learned in this module to develop computer models in their final year thesis projects. In one recent case, the student developed his project as a final year thesis and he presented a poster on it at an ISSEC (Irish Society for Scientific and Engineering Computing) conference held in Dublin. A small number of other groups who have produced very good projects have submitted their posters to this conference over the years.

## 2 MANAGEMENT PERCEPTION OF COURSE

A problem based module structured in the way described is more costly to run than a standard module with a terminal examination. In spite of this, the management of the School of Mechanical Engineering have been very supportive in providing sufficient resources for the module to date. The poster presentation generates a positive perception of the School within the College itself and the general consensus among those who attend is that the projects are of a very good quality for students at this stage in the program cycle. There is also a belief held by management that the students benefit greatly from having one less terminal examination to complete.

In addition, at least every five years, the program itself must undergo a rigorous evaluation process to received accreditation by Engineer's Ireland, the professional body for engineering in Ireland. Without it, graduates of the program cannot apply for membership of the professional body. Each module is evaluated on a scale of 1 to 5 to indicate how well it satisfies each of the six required outcomes of a Level Eight program as listed in Table 1. This module scored highly on program outcomes (a), (b), (c), (e) and (f).

Table 1: Engineers Ireland – Required Outcomes for Level 8 Program.<sup>1</sup>

Programmes must enable graduates to demonstrate:	
(a)	The ability to derive and apply solutions from a knowledge of sciences, engineering sciences, technology and mathematics;
(b)	The ability to identify, formulate, analyse and solve engineering problems;
(c)	The ability to design a system, component or process to meet specified needs, to design and conduct experiments and to analyse and interpret data;
(d)	An understanding of the need for high ethical standards in the practice of engineering, including the responsibilities of the engineering profession towards people and the environment;
(e)	The ability to work effectively as an individual, in teams and in multi-disciplinary settings together with the capacity to undertake lifelong learning;
(f)	The ability to communicate effectively with the engineering community and with society at large.

## 3 RESULTS OF STUDENT SURVEY

A representative cohort of twelve students who completed the module in 2013 was surveyed to ascertain their views on the module. The students filled in a form anonymously in which they were asked a series of questions under the headings: Group Dynamics, Project Management, The Poster Presentation and the Personal View of the Module. For each heading, the questions asked and a general discussion on the replies is given below.

### 3.1 Group Dynamics

1. *You were allowed to choose your own groups – was it important to the success of the project that you knew (or were friendly with) the other group members well?*

Ten out of the twelve responders stated this was a very important factor in ensuring the successful outcome of the project. One positive response was “Yes, knowing the people in the group allowed us to interact more easily, and we knew each other’s approach to doing work and who was good at what subjects”. Another responder was quite honest with “Yes was important as you knew who not to work with”.

The two dissenters reckoned they would have worked better in randomly assigned groups.

While the reality of the workplace is that you don’t normally get to choose who you work with, this is counteracted by the fact that one is paid a salary and is expected to act professionally, regardless of personal likes and dislikes. It would be very interesting to compare the success of the project phase with randomized groups as opposed to the self-selected groups.

2. *Did you divide up the tasks between the group members or did you collaborate together on the different tasks?*

There were broadly three responses, namely:

clear division of tasks (5/12);

division of tasks but collaboration to solve problems that arose (4/12);

full collaboration (3/12).

This would indicate that in half the cases, each project is in fact a set of three sub-projects with limited collaboration. It is very likely that at least one of the students might do no modelling at all and may not be fulfilling the most important module outcomes which involve learning modelling skills.

3. *Did you enjoy the process of working together with the other group members? Were there any conflicts and if so, how were they resolved?*

Many of the responses strongly linked the student’s ability to choose their own groups with their enjoyment of the process and lack of conflict. Where conflict arose, “it was resolved by talking it out”. The fact that only 3 out of 12 groups adopted a working style of full collaboration meant that the thrust of the question was missed by most. A more explicit rephrasing might be “Most modules involve individual study. Did you enjoy working together with your group members to solve problems that you encountered during the process?”

4. *Did other members contribute equally to the project effort?*

In line with the earlier questions, ten out of twelve responders stated that the each team member contributed equally. The reply of one of the other two was interesting: “it was divided so that tasks suited somebody’s capability/interest. Led to uneven workload but good outcome”.

### 3.2 Project Management

- 1 *Did you get your first choice project? If not, were you content with the project you were assigned?*

Nine of out twelve groups got their first choice of project. Two of the other groups were content with the project they worked on while one responder was concerned with the complexity of the project he worked on. The low number of conflicts among the first choices demonstrates that the

program group as a whole has a broad interest across the full range of engineering topics as only twenty four project titles were offered to twenty groups.

2. *Did you think that the structure of the weekly meetings was useful in guiding you towards the completion of the project?*

Eleven out of twelve groups were very positive about the meetings in terms of keeping them motivated and on track and in getting advice on problems that they encountered. Many described the meetings as essential.

3. *Did you find the process of keeping a project journal useful?*

The use of a project journal was recommended but not compulsory. Eight of the twelve responders didn't keep one or saw no necessity. Three found it useful in terms of keeping track of their work.

4. *Did your group work steadily throughout the six weeks or was the vast majority of the work completed in the final one to two weeks?*

Only one responder stated that his/her group worked steadily for the six weeks. Four groups made steady progress at the start but increased their effort towards the end to complete the project by the deadline. Seven of the groups stated that they completed the vast majority of the work in the last two weeks with the prospect of the presentations looming.

This indicates that the introduction of an intermediate submission in the third week might even out the workload. Alternatively, it might also indicate that procrastination is a common human trait and the ability to work under pressure to meet deadlines is a very useful skill for engineering graduates.

### **3.3 Poster Presentation**

1. *Did you find the process of preparing a poster to be useful for future work?*

Many of the responders stated that it is very useful as they have to prepare one for their intermediate presentation for their final year thesis.

2. *Did you enjoy/not enjoy the poster presentation?*

Eight out of twelve enjoyed the experience of the poster presentation while three didn't particularly like it.

3. *Did you receive many queries from other staff members about your poster? If so, how do you think you dealt with them? Did you receive any useful advice about how you might have improved your computer models or how you might improve the layout/content of your poster?*

There was a mixed response. The groups who succeeded in developing functional models enjoyed the experience of showing their work to interested lecturers and received many useful insights on their project topics. On the opposite side, there were weaker groups who had difficulty answering questions on their project.

4. *Do you think that preparing a poster was a preferable method of presenting your work rather than preparing a report?*

The vast majority answered that this was a preferable way to present as it forced them to organize the information in a concise and logical way. One commented that it was a simple means by which they could show the results of their hard work to others whereas a report would have just ended up a shelf.

### **3.4 Personal View of Module**

1. *It is most likely that you were being asked to develop a computer model in an area that was probably quite new to you. At that stage, how did you view the prospect of completing the project – with excitement or trepidation?*

This was answered evenly with six expressing trepidation and the other six saying they found the process exciting. Some had expressed mixed feelings at different stages during the six weeks.

2. *During the six week period, were you worried at any stage that you might not be able to complete your project (i.e. get the computer model to work)? If so, how did you deal with it?*

Some of those who expressed trepidation at the start stated that they relaxed once they got up and running. Other groups stated that they found it quite stressful towards the end but that they produced presentable work with perseverance. In many cases, the scope of the project was greatly reduced to ensure a working model was developed and results could be presented.

#### **4 RESULTS OF FOCUS GROUP**

The focus group consists of a number of students currently undertaking a Master's program who completed the course in 2012 and a single final year student from 2013, who was not part of the survey group of twelve. The response from this group was very similar to the positive responses from the full survey and does not need to be repeated again. The lack of negativity towards the module from this group is probably due to the fact that these are very good students. The course is designed to take the students out of their comfort zone and these students were better equipped to deal with the challenges they encountered in the module.

#### **5 CONCLUSIONS**

The bigger survey group is more representative of the class as a whole and includes people who had difficulty understanding the subject matter and completing the project. The fact that the students have to stand and present and defend their assumptions, results and conclusions and present their work in front of their peers and lecturers provides a very strong incentive for them to perform. Some are stressed by it while others find the challenge exciting. Many of the latter find the poster presentation very enjoyable as they get to show their work to other staff members. Overall, the module has received reviews although there is always room for improvement.

In terms of increasing the level of collaboration between group members, they might be encouraged to collaborate on some tasks while completing individual tasks elsewhere to ensure the project is completed by deadline.