Thanks,

To Zoë for coping with me. To Paul for helping and encouraging me. To Clare and the PCUTL team for supporting, understanding and allowing my curiosity to go where it wanted to go.

Postgraduate Certificate in University Teaching and Learning

Module 3 Submission Cover Sheet

Participant number:

Participant name: Vincent Knight

School: School of Mathematics

Mentor: Professor Paul Harper

This portfolio is submitted in fulfilment of the requirements for PCUTL: Module 3.

I declare that I have completed the compulsory elements of the programme as follows:
a) workshops;
b) one mentor Peer Review of Learning and Teaching;
c) one PCUTL-peer reciprocal Peer Review of Learning and Teaching;
d) Group project elements;
e) response to previous PCUTL assessment feedback;
f) Mapping of learning to date against the UKPSF.

I confirm that the evidence contained within this submission has been collected by me during the last 3 years, while teaching and/or supporting learning on recognised H.E. provision at Cardiff University

Unfair Practice: Plagiarism and Collusion

Plagiarism: In the University Academic Regulations Handbook, plagiarism is defined as 'using the words or ideas of others without acknowledging them as such and submitting them for assessment as though they were one's own work' (para 2.1.1). Plagiarism includes direct copying, close paraphrase, the unacknowledged use of ideas developed by others and commercial essay bank services.

Collusion: In the University Academic Regulations Handbook, collusion is said to occur when 'work that has been undertaken by or with others is submitted and passed off as solely the work of one person' (para 2.1.2). Where this is done with the knowledge of the originator, both parties can be considered to be at fault.

By submitting this portfolio, you are confirming that it is your own work and does not involve plagiarism or collusion.

The word count for the text of this submission is:

Signed: **Date:**

Note: Portfolio assessors are entitled to reject any portfolio that does not have a signed copy of this form attached.

Postgraduate Certificate in University Teaching and Learning

Module 3: Summative assessment

To be completed by Participant

Name of participant: **School:**

Verification of contents

Please state the location of the following evidence:	Linked ILO	Location of compulsory evidence	Confirmed by marker
1) Peer review related (must be in the area of design or assessment): a. One PCUTL-peer reciprocal PRLT with accompanying resources and reflections; b. One PCUTL-mentor PRLT with accompanying resources and reflections	**1, 2, 3, 4, 5**	Both peer review documents are attached.	
2) Group project-related (must be in the area of design or assessment) a. Project presentation resources b. Group assessment using created assessment criteria; c. Project report; d. Evidence of group 'e' discussions e.g. wiki	**6**	a. Presentation resources linked to in supplementary resources document and screencast of presentation referenced (with url) in essay. b. Group assessment attached as an appendix to group report. c. Project report document. d. Evidence included in essay.	
3) Examples of real feedback / feed-forward given to students		Document attached of written feedback on class test, screenshots of email feedback included in essay and links to all videos that serve as feedforward and feedback mechanism included in supplementary resources document.	
4) Response to feedback received from Module 2 assessment		Response to feedback document.	

5) Mapping of learning against the UKPSF		Attached mapping.	

Postgraduate Certificate in University Teaching and Learning

Summative Assessment of Reflective Teaching Portfolio: ***To be completed by Participant***

Name of participant: **School:**

Self assessment of your achievement of the Module's Intended Learning Outcomes:

Learning Outcome	Location of evidence (e.g. page number)	Self-assessment including commentary to assessors
1. Integrate scholarship, research and professional activities with teaching and supporting learning;	This is in the introduction of my essay and in my peer review with my mentor.	My discussion in the introduction of my essay addresses this ILO showing a creative reflection of my practice on the whole. I also feel that the pure amount of work I have put in to this portfolio shows my engagement with the course and thus my willingness to integrate scholarship, research and professional activities with teaching and learning.
2. Design and plan effective modules or clusters of sessions or programmes of study that facilitate quality learning and the achievement of appropriate learning outcomes by a range of learners;	This is in section 2 and 3 of my essay.	This ILO has multiple dimensions to consider. I have given a details and critical description of my pedagogic methods which ensure quality learning by a range of learners. I fully justify this in section 2 of my essay taking data from feedback, literature and the group project. I have also addressed the appropriateness of my ILOs in section 2 of my essay by referring to the subject benchmarks, the relevant Cardiff university documents and also a wider discussion of what it means to be a mathematician. I finally address how my module fits in to the wider programme in the School of Mathematics in section 3. I feel that I have addressed this ILO

		comprehensively through the design of my new module. I feel that I have shown a sophisticated grasp of ideas whilst developing rigorous independent insights and approaches.
3. Design and implement appropriate and effective assessment and feedback schemes using a range of methods that align with the tenets and principles of the Cardiff University Assessment Strategy and Feedback Policy;	This is in section 2 of my essay, in my peer reviews and also in the group project.	Firstly our group project was entirely on the subject of (formative) assessment. Through this group project we investigated the perceptions of assessment which allowed me to not only ensure that my assessment and feedback schemes were in line with the Cardiff University strategies but also would be well received by students. In Section 2 of my essay I give a clear description of how the entire module design is around the notion of feedback (a flipped classroom is a reactive and dynamic teaching method that ensures a constant feedback loop is in place). Furthermore I have considered the appropriatenessl' of assessment in my essay but also in detail in my peer reviews (with my mentor concentrating on assessment of a particular part of the module and with my peers concentrating on feedback). I again feel that I have addressed this ILO very strongly. The details justification of my own novel ideas have not only been rigorously analysed (for example through the group project work) but have also been applied successfully.
4. Draw on multi-source data to evaluate the impact of their module design and assessment on the breadth / diversity of students' learning and development, and plan modifications accordingly;	This is in section 2 and 3 of my essay and in my peer reviews.	I have achieved this ILO through a critical evaluation of my personal methodologies, in particular taking I to account comments by students and peers.

5. Identify further professional development needs in relation to designing and assessment for learning;	This is in the conclusion of my essay and in my mentor peer review.	I have identified a wide range of further dimensions for professional development in a comprehensive and imaginative way.
6. Work with colleagues to enquire critically into an aspect of planning or assessment / feedback relevant to their context.	This is demonstrated by the group project and my peer reviews.	I feel that our group project showed a thorough analysis of student perceptions. I think our work is of publishable quality.

Evidencing the Programme Values:

Programme Value	Location of evidence (e.g. page number)	Self-assessment including commentary to assessors
1. An understanding of how students learn.	Section 1, 2 and 3 of my essay.	I feel that I continue to show a good grasp of this. In particular I build on my understanding and critical review of the literature.
2. A commitment to reflection and evaluation and consequent improvement of professional practice.	The entirety of my essay as well as my peer reviews.	I demonstrate this in my essay for example through my plans for further development that will concentrate on the evaluation of my teaching methodologies (a novel research area in itself). I believe to show this in a comprehensive and detailed way.
3. A respect for individual learners and for their development and empowerment, no matter what their circumstances.	Section 2 of my essay as well as my peer reviews.	I show this by my care (throughout my portfolio) to ensure that no students are left behind by my novel teaching approaches. I also contribute to the empowerment of students through the novel inclusion of entrepreneurship skills. I feel that I have presented this in a polished and imaginative way.
4. A commitment to scholarship in teaching, both generally and within their own discipline.	The introduction and conclusion of my essay.	I feel that I continue to show this in a committed and strong way.
5. A commitment to the development of learning communities, including students, teachers and those engaged in learning support.	Section 2,3 and the conclusion of my essay.	As above, I feel that this is strongly shown in the conclusion of my essay.
6. A commitment to encouraging participation in higher	Section 1 of my essay and my	I have addressed the main

education with respect to the issues of equality and diversity. In this regard, professional practice should be informed by equal opportunities legislation, policy and best practice.	peer review with Pete Burnap.	purpose of the submission with regards to this value, although this is one area for on going consideration and reflective practice.

PCUTL activities	Areas of Activity					Core Knowledge Knowledge and understanding of:						Professional Values			
Module 3	Design and plan learning activities and / or programmes of study	Teach and / or support learning	Assess and give feedback to learners	Develop effective learning environments and approaches to student support and guidance	Engage in continuing professional development in subjects / disciplines and their pedagogy, incorporating research, scholarship and the evaluation of professional practices	The subject material	Appropriate methods for teaching and learning in the subject area and at the level of the academic programme	How students learn, both generally and in their subject /disciplinary area(s)	The use and value of appropriate learning technologies	Methods for evaluating the effectiveness of teaching	The implications of QA and QE for academic and professional practice with a particular focus on teaching	Respect for individual learners and diverse learning communities	Promote participation in higher education and equality of opportunity for learners	Use evidence-informed approaches and the outcomes from research, scholarship and CPD	Acknowledge the wider context in which HE operates recognising the implications for professional practice.
PRLTs (Mentor + Peer), resources, reflections	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔		✔	✔
Group-project	✔	✔	✔	✔	✔	✔		✔		✔		✔		✔	✔
Focus on Feedback	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Written text	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Other experiences illustrated in appendices and reflections	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

PCUTL - Module 3:
Covering Claim

Vincent Knight

In this short covering claim I will provide an overview to my portfolio and describe how I meet the ILOs.

This portfolio contains the following documents (in order):

- My response to feedback for Module 2;
- "The design and delivery of a new module within the School of Mathematics with ramifications on what it means to be a mathematics graduate from Cardiff." (I will refer to this document as 'MA1003doc');
- "Description of spring semester" (document used for peer review with my mentor);
- Marking criteria and guidance notes for student assessments relevant to spring semester;
- My mentor's peer review with my response;
- "Description of feedback" (document used for peer review with Phil Anderson)
- Phil Anderson's peer review with my response;
- Peter Burnap's peer review with my response;
- My peer review of Phil Anderson;
- My peer review of Peter Burnap;
- A page containing links to all supplementary materials (lesson plans etc...)
- "Understanding the perceptions and factors that influence student engagement with formative assessment in mathematics education." (the group project).
- Two documents relevant to the group assessment portion of our group project.

As for my previous portfolio the bulk of my covering claim serves to summarise my various documents, indicating where the ILOs have been achieved. This is shown diagrammatically in Figure 1.

There are two main complementary bodies of work in this portfolio:

- My essay: MA1003doc;
- The group project I participated in.

I plan on doing module 4 in the future but nonetheless I feel that completing module 3 marks the end of a journey. Throughout this journey I have been able to identify and place myself as a facilitator of learning within the UK higher education system but also within my school. I have also grown an immense fondness for pedagogic literature and research. Carefully considering state of the art educational methodologies and how they can be incorporated within my own practice has been a strong factor in my PCUTL journey. Finally in this module I feel that I have been able to put a lot of this in practice as I have designed and delivered a brand new module that changes the answer to what it means to be a Cardiff Mathematics graduate.

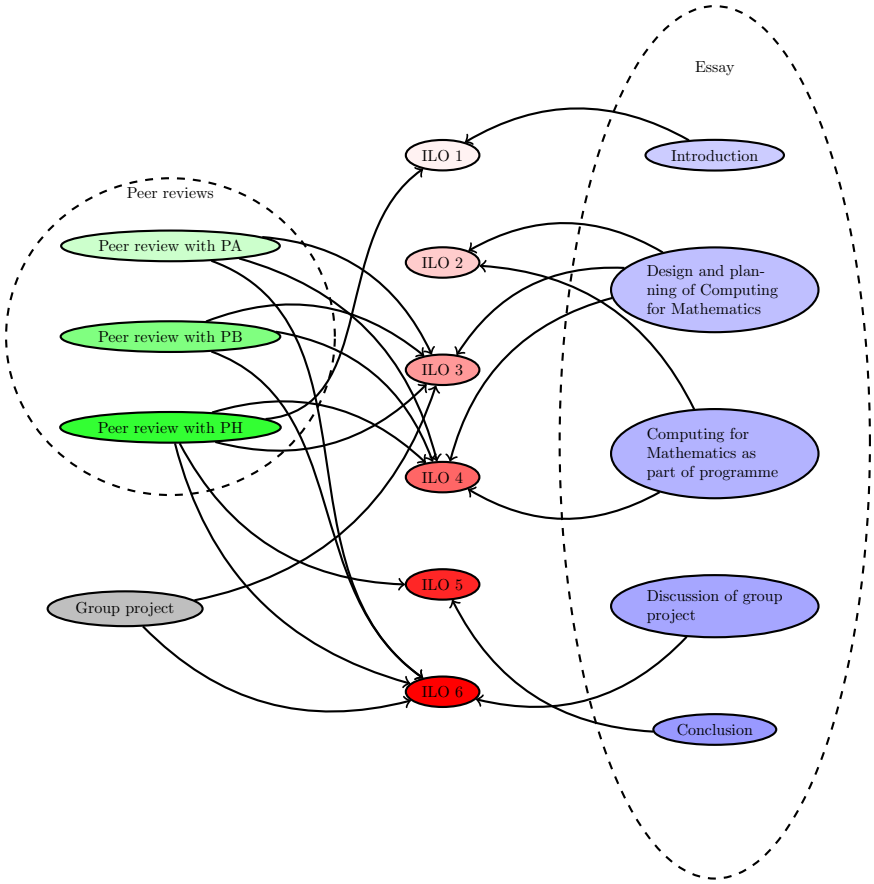

Figure 1: Structure of this portfolio

I cover a range of topics in MA1003doc which is mainly the description of a new module delivered to all single honours first year mathematics students. **I feel that this essay addresses most of the ILOs of this module but mainly concentrates on ILO 2 and 3 by the fact that I justify the effective module design ensuring efficient and quality learning in line with the appropriate learning outcomes. I give particular attention to the range of learners that will undertake this couse given that I do not want any students to be 'left behind' by the pedagic approach: a flipped classroom. The module is designed very much with feedback as a core motivating factor and I discuss this extensively in the essay.**

- In the introduction I address ILO 1 by discussing my ongoing activities through the entire PCUTL process (discussing my previous portfolios). This ILO is also addressed throughout my portfolio and MA1003, in particular through my engagement with the literature.
- The next section of MA1003doc entitled: 'Design and planning of Computing for Mathematics' addresses ILOs 2 and 3, discussing my new module including details with regards the context and the pedagogic approach. Note that I base a lot of what is said in this section on the literature, feedback from students and data from our group project thus ILO 4 is also addressed.
- The section entitled 'Computing for Mathematics as part of a programme' specifically addresses ILO 2 and 4. As I discuss the place of the new module within the programme at the School of Mathematics (once again basing myself on multi-source data).
- I give my thoughts on the group project, specifically discussing how my experience of it will be useful in the delivery of my new module, thus addressing ILO 6.
- Finally I conclude this MA1003doc by discussing my plans for further development and engagement with pedagogy (addressing ILO 5). I also comment on the PCUTL process in general.

My peer reviews allowed me to address ILO 6 yet again but also ILOs 3 and 4 as I discussed feedback in particular with my peers and the design of my module with Paul. The discussion with my mentor (Paul) was particularly helpful to ensure that my module was placed within the general strategy of the School of Mathematics but also to ensure that the assessment was appropriate. The review of Phil's module design gave me various ideas that I plan on taking forward with my own module (for example details I need to concentrate on when considering speakers for my autumn semester: something I also talked about with Paul). Pete indicated some valuable things to think about with regards to putting in place directives to tutors for future years but also pointed out certain aspects with regards to inclusivity that I need to consider. Such as the potential for students with lesser mobility that cannot take part in role play during my reactive lectures. Furthermore Pete's introductory session that ensures an alignment between student expectation and the ILOs is something I will try and implement in my teaching in the near future.

The original motivation for having two peer reviews with PCUTL colleagues was simply that Pete had not been able to find someone to carry out his peer review with him. On reflection, this was an extremely beneficial thing to do given the untraditional pedagogic approach. All of my peers (including my mentor Paul) have been very encouraging of my chosen methodology which is reassuring. Furthermore the particular comments and suggestions will all be helpful as I go forward.

In our group project we carried out a rigorous statistical analysis of a questionnaire given to all students studying mathematics within the School of Mathematics and the School of Engineering. The survey allowed us to gain an understanding of student perceptions of formative assessment. This was complimented by a review of the literature. **This group project obviously allowed me to achieve ILO6 but more importantly aspired to address ILO3. The findings in this group project were taken in to account (and referred to in MA1003doc) in the design of my new module.**

PCUTL - Response to Module 2 Feedback

Vincent Knight

In this document I will respond to each element of feedback from my module 2 portfolio.

1 Learning Outcome One

> "I thought a strength of this submission Vince was your engagement with pedagogic literature. Your reading (and Maths literature in particular) helped you locate your approach but did so in an enquiring manner. Very good work!"

Thank you for your kind words. I felt that I did invest a lot of time and effort going engaging with the literature and this is something that I have perhaps done more of with in my third portfolio. Furthering my understanding of the research related to my pedagogical approaches.

I enjoy reading this literature and plan on doing so in the future.

2 Learning Outcome Two

> "Well! Your plans are radical! Carefully thought out plans here Vince. Do be careful to ensure that no student is left behind in your wish to radicalise your teaching and learning."

This is a very valuable piece of feedback. I think that I must be very conscious of not 'being radical for the sake of being radical'. I feel that I have spent more time during this portfolio/module design carefully putting in to place traditional alternatives so that no student is left behind.

3 Learning Outcome Three

> "You have used data from a number of sources which was good to note. Your new Module will, of course need careful evaluation. You might find it helpful to have a disinterested person involved here... Your mentor will, of course be able to help."

The evaluation of the module (through the usual feedback forms) has shown that students reacted favorably to it. Furthermore, the marks obtained were also of a high standard and students performed well against the intended learning outcomes. This coming year, due to my workload a post-doc will be teaching the module which will allow me more time to evaluate it.

4 Learning Outcome Four

> "This was very well done Vince. I could see the links that you were making to your reflection and also to literature. Very useful set of ideas to take forward. M3 will offer you some space to attend to some of these."

I have been able to expand on some of the ideas set forth but sadly not on all of them. I have again set myself an ambitious plan for module 4 which I look forward to doing.

5 Programme Values

> "Very comprehensively underpinned."

Thank you.

6 Engagement with the UKPSF

> "Good engagement with the UKPSF also."

Thank you.

7 General comments / thoughts for module 3

> "Thank you for completing your self assessment form Vince. I think that you have indicated your willingness to reflect/evaluate and act on this. Very well done. What I would suggest is that you now allow your plans to bed down. Ensuring these innovative plans work will take time and effort especially the aspects highlighted by Nikos i.e. preparing students for the IBL/flipped classroom approach! This will be a new way of learning for many... your reading on pedagogic theories will help with this.
>
> Very good work! Well done."

Thank you again for your kind words. I agree with you completely with regards to needing to let my 'plans bed down'. I am indeed planning on doing this for MAT013 (the module

discussed for the portfolio relevant to this feedback) and will be able to step aside and watch the post doc lead the module so as to better assess.

The design and delivery of a new module within the School of Mathematics with ramifications on what it means to be a mathematics graduate from Cardiff.

Vincent Knight

1 Introduction

This text forms part of the third portfolio in the PCUTL process (all of my previous portfolios are available at my personal website `www.vincent-knight.com`). In the concluding remarks of my first portfolio I state:

> *I hope that the main theme of PCUTL for me will be to ensure that I 'create learning opportunities'.*

I feel that this has indeed been the underlying principle that has guided me through this process and in particular through the preparation of a new first year double thin core module: MA1003 - 'Computing for Mathematics' (CfM) that will be the main focus of this portfolio.

I have continued to grow as an educator incorporating scholarship and research within my teaching. It was in fact very flattering to be recently named as an example of a connected educator influencing other teachers in an article on the New York Times website: [41].

Apart from an introduction to pedagogic theory, one of the greater contributions of the first portfolio was the initial understanding of my place within the UK higher education system, Cardiff University and also Cardiff's School of Mathematics. Since writing that, the situation at Cardiff University has changed with a college system being brought in to place and a new document [43] which states the vision for the University. Whilst these changes are having certain drastic effects throughout the spine of our institution, from an educational point of view the goals and aims for all the educators remains very much the same. The very first line of the educational section of this document states:

> *We will educate our students to the very highest standards and support them through the transition to independent learning.*

Another quote from [43]:

> *We will produce graduates who are delighted with their experience, who are well-rounded, flexible, mobile and highly employable individuals, many with work based and/or international experience.*

I will return to both of the above statements in further sections of this portfolio. It is reassuring to see that the main conclusions I made in my first portfolio regarding the place I hold as a lecturer in Operational Research (OR) are still relevant now. Indeed, as a lecturer in OR I am actively ensuring that our graduates are highly employable individuals. In [40] OR is listed as one of the top ten subjects in the UK with regards to employability.

My second portfolio allowed me to gather a much wider range of knowledge with regards to modern pedagogic theory. In particular I placed myself as a promoter of 'social constructivism' [25] through the use of Inquiry-Based-Learning (IBL) methodologies [31] and flipped classrooms. These are the theories I have based the development of a new level four module entitled: 'Computing for mathematics' (CfM) on and will expand on them further throughout this text.

This new module (CfM) is the answer to a fundamental question in Mathematics education:

Does a mathematics graduate need to know how to write computer code?

Over the past 50 years or so the answer to this question will most probably have changed. I personally believe that the answer is: **yes**. After various meetings within our School it now seems that the collective opinion of the school is also: **yes**. This is not only relevant to creating competitive employable graduates but also to creating well rounded mathematicians as most of modern mathematics requires some level of computing.

In this text I will discuss the design and planning of the delivery of CfM before concentrating on the various assessment and feedback provisions. Before concluding I will also present a critical assessment of [1] and indicate how the work done in this group project has influenced my design of CfM.

2 Design and planning of Computing for Mathematics

2.1 Context

In 1976, the four colour theorem became the first theorem in mathematics that **used a computer program** for part of the proof [20]. This in itself created a minor identity crisis amongst mathematicians as in a way it changed what it meant to **be** a mathematician. However it is my belief that, even without proving theorems that are only in reach of some of the greatest thinkers of our time, all mathematicians need to know how to program.

This idea, accepted within the School of Mathematics is what has lead to the following intended learning outcomes for CfM:

1. Understand and be able to write in Python the following programming ideas: Conditional Statements; Flow Control; Data Structures; Recurrence, Basic ideas of Object Orientated Programming.
2. Use the above and a mathematics package (Sage) to tackle mathematical problems.
3. Have a basic knowledge of LaTeX.
4. Work in groups to tackle problems and convey solutions to those problems through presentation.

Students at the end of this module will not only have extremely desirable employment skills and experience but will also be (as prescribed in [43] and in line with the Welsh framework for this level of course) competent 'self learners'. This later aspect is not necessarily by design but as a consequence of the pedagogic theory required/used in this module.

Furthermore this module will better align the School of Mathematics programme with the subject benchmarks [35]: '*All graduates of practice-based programmes and many from theory-based programmes will have some knowledge and understanding of mathematical computing, often with direct experience of one or more computer packages. They will have an awareness of the appropriateness of the package(s) to the problems being addressed and, when feasible, some awareness of the nature of the algorithms on which the package(s) are based*'.

The intended learning outcomes will take students through various levels of Bloom's taxonomy [5, 36]. For example learning outcome one is a task of application whereas learning outcome four is a task of synthesis.

In traditional pedagogical theory the base of the pyramid corresponding to Bloom's taxonomy is where most contact time occurs whereas students are often left to climb the tip of the pyramid on their own.

As I have already mentioned, I now consider myself to encourage learning in a social constructivist framework [25] with one tool in particular: flipped classrooms. There is a very wide range of literature on the subject of flipped classrooms, see [33, 45] and references therein. A diagrammatic representation (taken from my second portfolio) of the flipped classroom is shown in Figure 1.

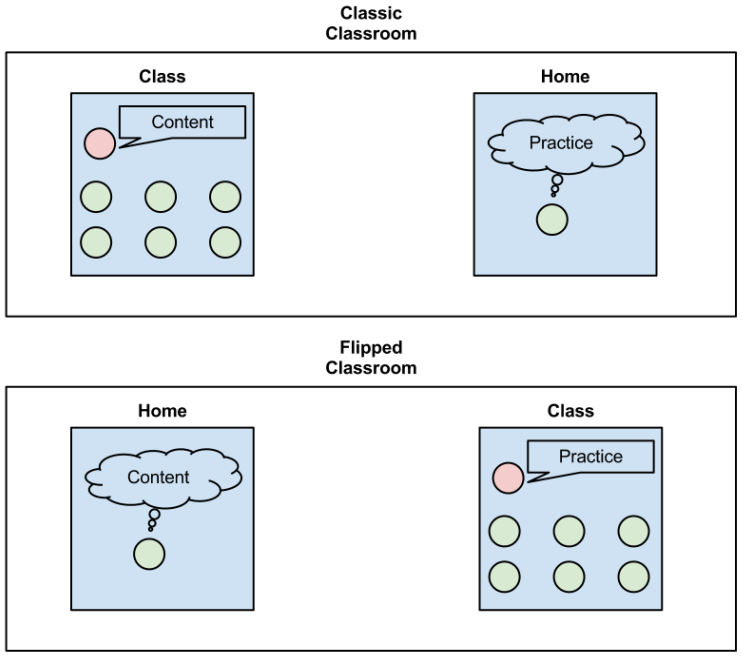

Figure 1: A diagrammatic representation of a flipped classroom.

As stated in [39] flipped classrooms allow for the reversal of Bloom's taxonomy so that students are able to go through a constructive process to grasp the base of the pyramid with contact time used to reach the summit. This is shown diagrammatically in Figure 2 (a diagram very similar to one in [39]).

As will become clear a flipped classroom approach is suited to the teaching of this module facilitating quality learning and ensuring the achievement of the intended learning outcomes. I base this assertion on the three following points:

- **The body of literature**:

  First of all it is evident that flipped classrooms can work in large classes, as indicated in [3, 15, 21, 32]. Not only is this an appropriate approach for the class size but flipped classrooms have been shown to promote effective learning and achievement of relevant intended learning outcomes by students from a range of learning styles; see [2, 3, 15, 32, 33, 34]. Further to this research showing benefits there is also research that reassuringly shows that there are no reasons to believe that a flipped classroom would give *worse* results [19]. Finally there is also evidence that flipped classrooms improve cooperation and innovation [38] as well as promoting inclusive environments [29].

- **Feedback from previously taught courses**:

  In my second portfolio I discussed some feedback I collected from a questionnaire distributed to my students at the end of a portion of a module I taught using a small amount of flipped classroom

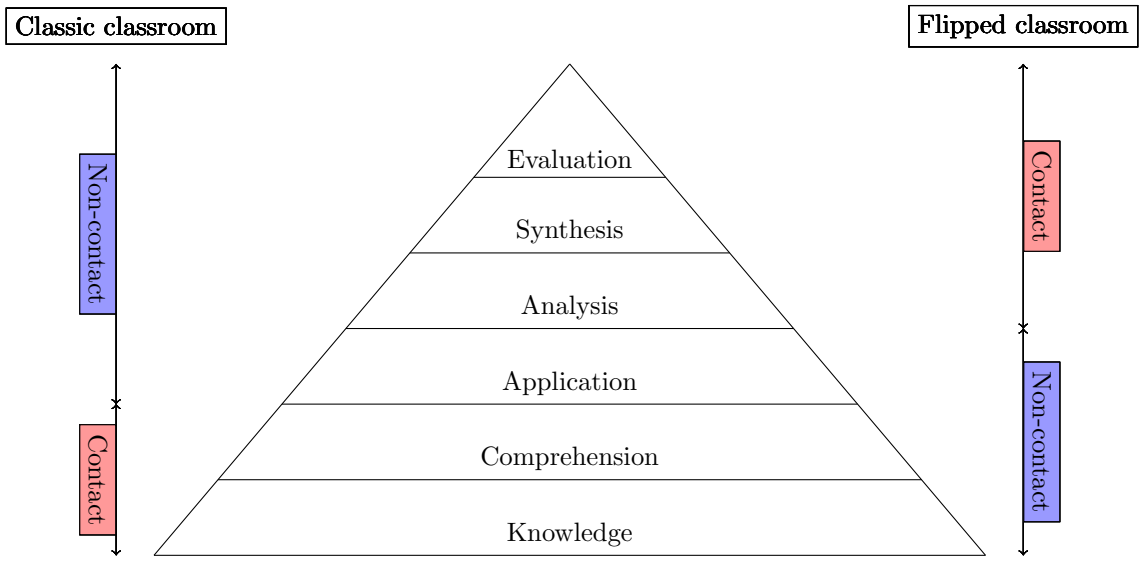

Figure 2: Bloom's taxonomy and contact time in classic versus flipped classrooms

methodologies. I gaged that students seemed to be quite receptive to the various resources presented to them prior to lectures and as such I developed a new module (MAT013 delivered for the first time in the spring semester of 2013) that was delivered entirely using a flipped classroom and IBL pedagogy. I am very pleased to say that this was a resounding success. I base that conclusion on the performance of the students in their various assessments, end of module feedback questionnaires but also on numerous discussions held with the students throughout the module. Whilst some found the shift of responsibility and focus (from the teacher to the learner) difficult to master at the beginning, there seemed to be a quasi unanimous agreement at the end of the module that the students had empowered themselves to be better learners.

- **Work carried out in the group project for this module [1]**:

  Given that a flipped classroom requires student engagement in an exercise that they can ultimately choose to not engage in. Content delivery can be thought of as a form of formative assessment. Engagement with and perception of formative assessment was the particular focus of the group work for this PCUTL portfolio [1]. I will not present here the main findings of that study, a major aspect of which was the analysis of a questionnaire, however relevant to the current discussion is the following statement which was presented to participants:

  I am more likely to do homework if it is to be done before a lecture on the subject.

  The responses to this question were bi modal with some students being quite receptive and some being less receptive as shown in Figure 3.

  In general most of our responses seemed fairly similar when it came to innovative teaching and assessment methodologies. As stated in Chapter 1 of [8] by Gibbs this is most probably explained by students' resistance to methods of assessment that are new to them or that they feel might take more time. I certainly feel that this applies in the case of flipped classrooms given the previously cited literature as well as previous experience with students who all seem to engage well. Nevertheless, the main consideration I must make is that certain students will potentially not engage without incentive to the methodology and/or would not benefit from this pedagogical approach. I will discuss how I have planned to address this in the next section.

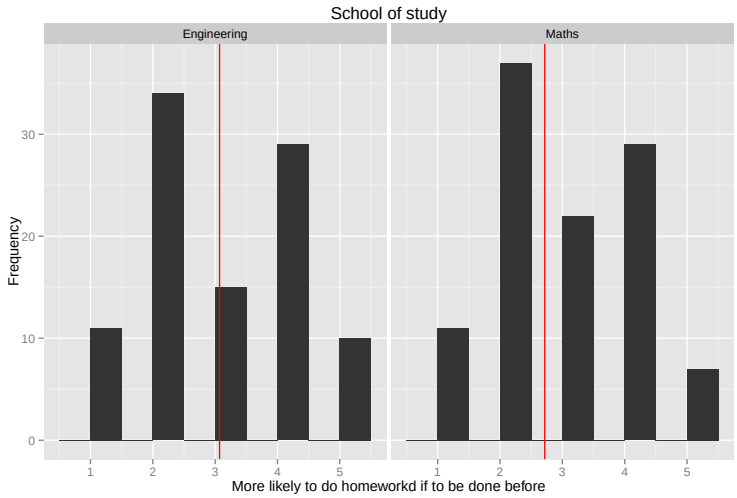

Figure 3: Responses to a statement relevant to flipped classrooms. (1: Strongly disagree; 2: Disagree; 3: Indifferent; 4: Agree; 5: Strongly agree)

In the next section I will describe the delivery, assessment and feedback for CfM that not only fits in line with [42] but also fully allows for the creation of independent learners as prescribed by [43].

2.2 Delivery, assessment and feedback

A diagrammatic representation of the delivery of the module is shown in Figure 4.

As can been seen in Figure 4 the delivery of this module is dependent on the semester. Indeed CfM can be thought of in two parts:

1. Autumn semester: acquisition of programming skills;
2. Spring semester: use of programming skills in an entrepreneurial environment.

2.2.1 Autumn semester: acquisition of programming skills

This semester will be taught in a constructivist framework [25] using a flipped classroom approach. Whilst traditional flipped classrooms imply students carry out work completely out of the classroom context ('at home'), as discussed previously the content delivery of a flipped classroom can be thought of as formative assessment and as such it is important to incentivise students to engage with the methodology (this is discussed in [1]). Keeping this in mind the following two approaches are going to be used:

- Scheduled lab sessions;
- "Tickables".

The scheduled lab sessions (as depicted in Figure 4) occur before the lecture on a subject. Students will attend two lab sessions (over a period of three days) during which they will be required to tackle a set of problems. These problem sheeets are designed in such a way as to allow the students to construct their understanding of the programming concepts required to achieve the intended learning outcomes. Note that in [1] it was indicated that some students were more likely to carry out formative assessment if there was a timetabled session for it as shown in Figure 5. It can be seen that some students disagree with this

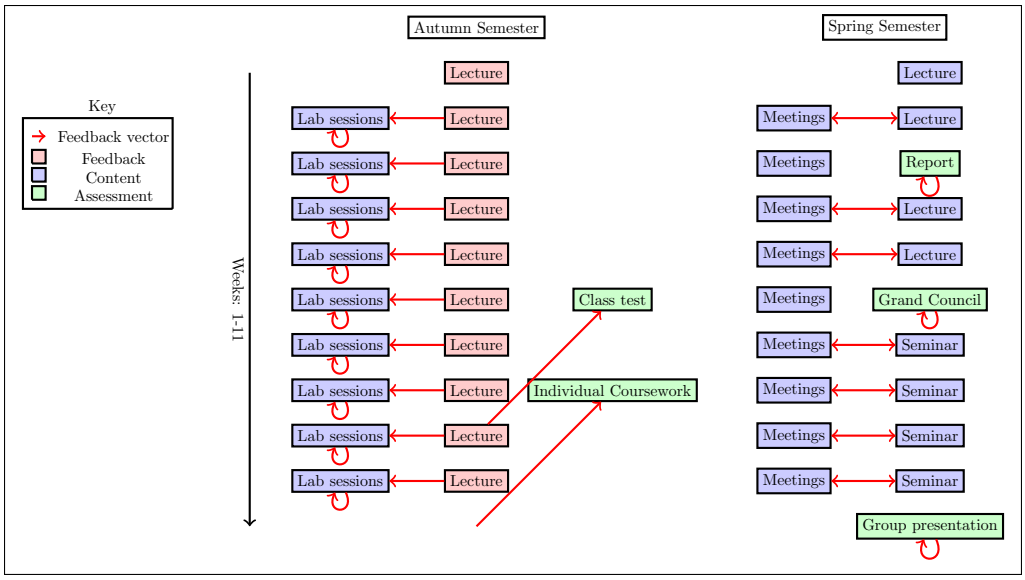

Figure 4: Delivery of content, feedback and assessment for CfM

statement. I believe that they are in fact indifferent to them: however as I am about to describe, the design of these timetabled slots take this possibility in to account, ensuring quality learning by students of a variety of learning styles.

Often, when discussing flipped classrooms one immediately thinks of 'videos' however this is not necessarily a requisite of a flipped classroom, all that is required is a shift in the locus of knowledge delivery [39]. Nonetheless to ensure that learners of all types are catered for in what will be to them, a novel pedagogic environment; 110 short (less than 5 minutes) videos have been developed that not only explain certain concepts (whilst still leaving enough scope for self constructed learning) but also act as a feed forward mechanism [10].

The purpose of these lab sessions is to encourage constructivist learning **and not "teaching"**. As such students will be encouraged to tackle problems independently. The following sequence of questions will be used by each tutor when a student is unable to carry out an exercise?

1. Have you read the description in the lab sheet fully?
2. Have you watched the video?
3. Have you attempted to search for other resources?

Of course, if a student is still unable to tackle a problem then the tutor will be most able to help.

As indicated in Figure 4 there is a feedback loop taking place within the lab sessions. **At this point, the reader might be enquiring how tutors will be able to give feedback during the lab sessions (given the large number of students).** The methodology used is called 'Tickables'. This is based on an approach by the same name used by Bath University. I attended a workshop organised by the HEA entitled: 'Experiences of learning programming within a mathematics course'. The idea is that on each of the lab sheets, a certain number of questions are marked as 'TICKABLE'. These questions are marked as pass/fail ('tick') in the lab sessions themselves by the tutors. Students who complete less than 80% of their tickables will lose 10% of their final mark for the module.

Importantly tutors are given some basic directions as to the marking of tickables:

- The marking ('ticking') is to be done in class;

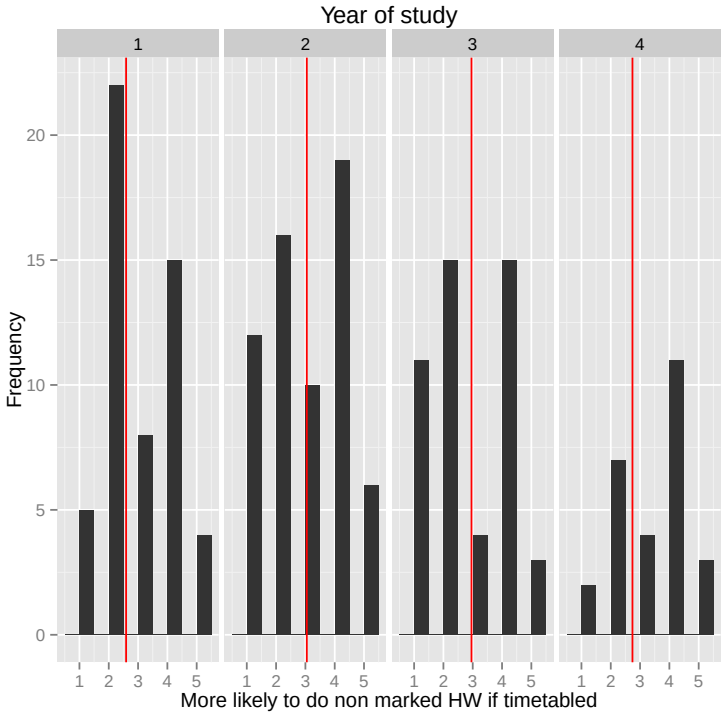

Figure 5: Responses by year of study to the statement: "I am more likely to do non marked homework if there is a timetabled slot for it". (1: Strongly disagree; 2: Disagree; 3: Indifferent; 4: Agree; 5: Strongly agree)

- To succeed at a tickable students must not necessarily succeed at doing it but more importantly spend a sufficient amount of time attempting to do it;
- Tutors are allowed a certain level of subjective judgement.

This allows tutors to give immediate feedback to students: 'nearly there, you need to include something like this...' but also to receive feedback from students as to what they are having difficulty with. This is where the process as indicated in Figure 4 is indeed 'flipped'. As the lecturer I will obtain feedback from the tutors as to the points that need to be addressed in the lecture.

Furthermore students are encouraged during the lab sessions to work in groups. Figure 6 shows an example of this occurring when the student in the checkered shirt was able to explain a particular concept to a large number of students in his particular lab session.

Figure 6: Peer instruction in action: the student in the checkered shirt is explaining a concept to his peers.

As stated earlier, students who would rather work outside of the lab sessions are very welcome to. It is entirely imaginable and acceptable for a student to arrive at their first lab session having completed all their tickables, gets them checked by a tutor and simply leaves. This again ensures that most types of learners are catered for.

Given the break from the traditional pedagogies that the students will experience in the School of Mathematics and also to ensure that students feel that they receive sufficient contact time with me (an element that is of high importance on the National Student Survey which is in turn important with regards to [43]) I have put in place official 'office hours'. Whilst my door is always open to students I am often away from the office and also am not always available. Thus I have made clear to the students that I will be in my office during office hours solely for the purpose of giving feedback and/or addressing queries that might potentially arise due to certain students not being comfortable within my pedagogic approach.

Figure 7 shows an email received from a student who has fully engaged with the process (having not only completed the tickables but the entire sheet before the first lab session). As can been seen I plan to use my office hours to address the needs for this particular student and potentially indicate further areas for him to explore.

Furthermore the nature of this class allows for a very clear evaluation of student comprehension by simply looking at their progress. Figure 8 shows an email exchange with a group of students who were working on

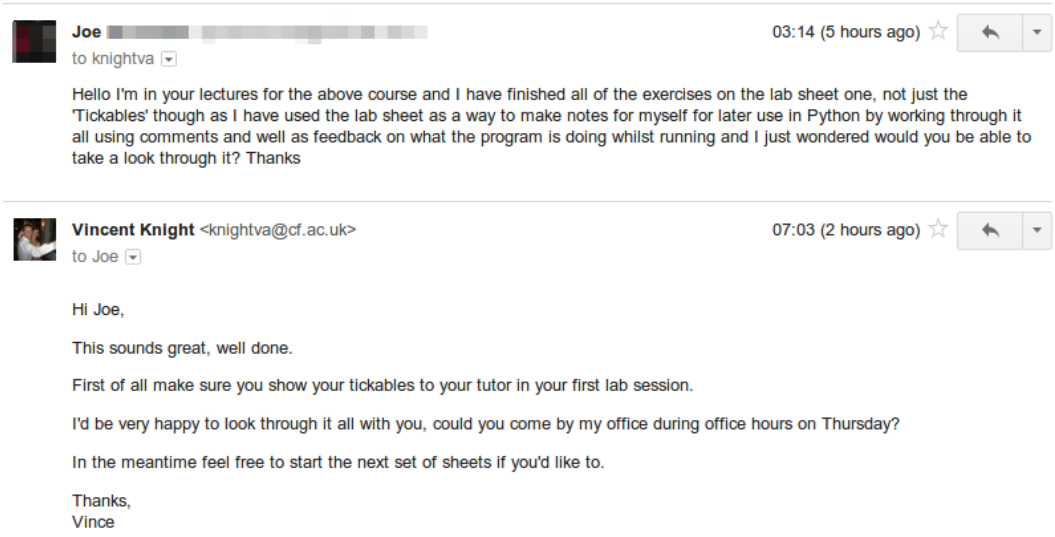

Figure 7: A student that will make use of office hours

a particular problem. Just by showing me their code I am able to give precise and relevant feedback.

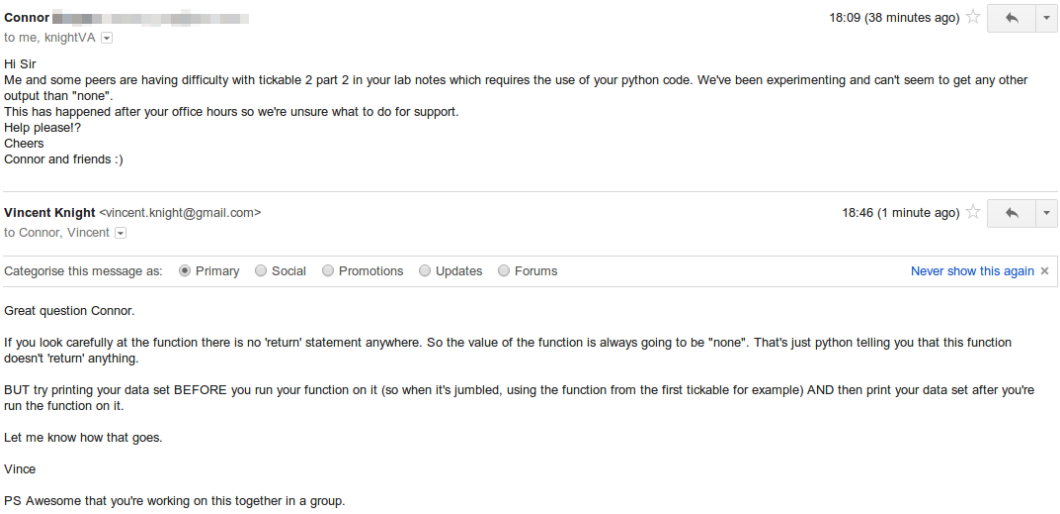

Figure 8: Giving precise feedback via email

Finding tutors for the large quantity of lab sessions (there will be 20 lab sessions a week) is in itself a challenge. In future years, to encourage peer learning [12, 18], students in their second year will be used as tutors however this is not possible as the course is running for the first time. As a result, various members of staff in the School of Mathematics have kindly given up their time to tutor the lab session this year.

This section of the course will be assessed through a class test at the mid point of the first term which will evaluate students' knowledge of Python. This has been difficult to put in place once again due to class size as it is desirable to have this class test in front of a computer to ensure that it fully assesses the corresponding intended learning outcome. In [9] it is shown that this is an appropriate approach of assessing programming ability. It is important to have a class test to ensure a balance of assessment methodologies as well as an

appropriate evaluation of individual student abilities. In the literature concerns have been voiced trends to increase coursework assessment (due to increasing student numbers) [22] which often give higher marks than tests or exams [6].

After many discussions with members of the learning and teaching team within the School of Mathematics as well as with my mentor who is the director of our MSc programmes in Operational Research; it seems that there will be enough capacity within the School to assess all students in front of a computer. This is an effective and appropriate assessment of the first learning outcome for CfM.

The second method of assessment will be an individual coursework exercise. As for the class test, this is an effective and appropriate assessment of the second and third learning outcome for CfM ([9]). This coursework is meant to not only assess students ability to use Sage and LaTeX but also to prepare them for the independent work that will be required of them in the second semester.

To ensure that both these methods of assessment facilitate student learning I will give timely and relevant feedback as shown in Figure 4 in line with the recommendations of [23].

Before describing the second semester of this module (recall Figure 4) I will describe the method of delivery of all relevant teaching materials (lab sheets, videos, handouts etc...). All documents are delivered via my personal website (`www.vincent-knight.com`) in a variety of formats (html, pdf and word). Delivering mathematical teaching content in multiple formats is notoriously difficult however it is a problem I addressed and solved in my previous portfolio. All videos for this module are delivered via YouTube using an 'unlisted format' so that only students with the relative urls can find them (this links are distributed via the lab sheets). Figure 9 shows the top views of my YouTube channel from the first week of CfM. This shows that students are not only watching these videos but on some occasions watching them multiple times.

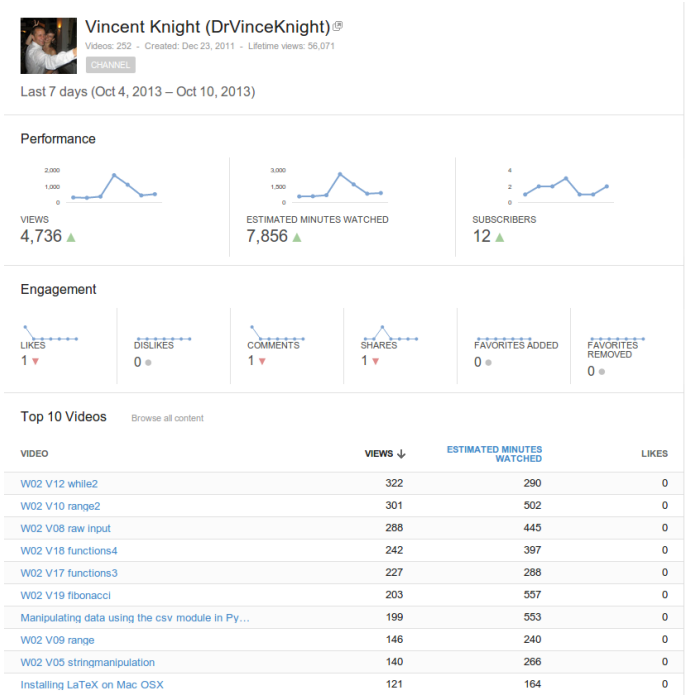

Figure 9: Some viewing statistics of the videos for this course

An appendix including links to all my teaching materials is available in this portfolio. This methodology ensures that students can access all of the materials on any platform and/or operating system. Finally, delivery through electronic resources has been described as an appropriate methodology for my pedagogic

approach [26] and there is even evidence showing that students prefer this method of delivery [7].

2.2.2 Spring semester: use of programming skills in an entrepreneurial environment

I will attempt to keep this section short as the Spring semester is the topic of my mentor peer review however here is a brief summary:

- Students will be organised into groups of 4. These groups will be called 'companies' and entrepreneurial themes will be present throughout the spring semester.
- Companies will agree on a structure which will include a 'project manager' and a 'secretary'.
- The roll of the secretary is to ensure that the company meets twice a week with minutes collected.
- Companies will have as a goal to identify a particular mathematical 'product' that can be created using the programming tools acquired in the autumn semester.

As shown in Figure 4 there is a limited amount of contact time in this part of the module with one session (lecture or seminar) timetabled a week. At the beginning of the term this will be used by the entrepreneurial team from the Cardiff University students' union (Figure 10 shows an ongoing email discussion ensuring that the assessment schemes for this are appropriate) as well as the library to present valuable skills to the students. The seminars will be used to expose students to further aspects of programming such as other programming languages and/or some research that is being done in the school. This later aspect fully ensures that students are exposed to research lead teaching.

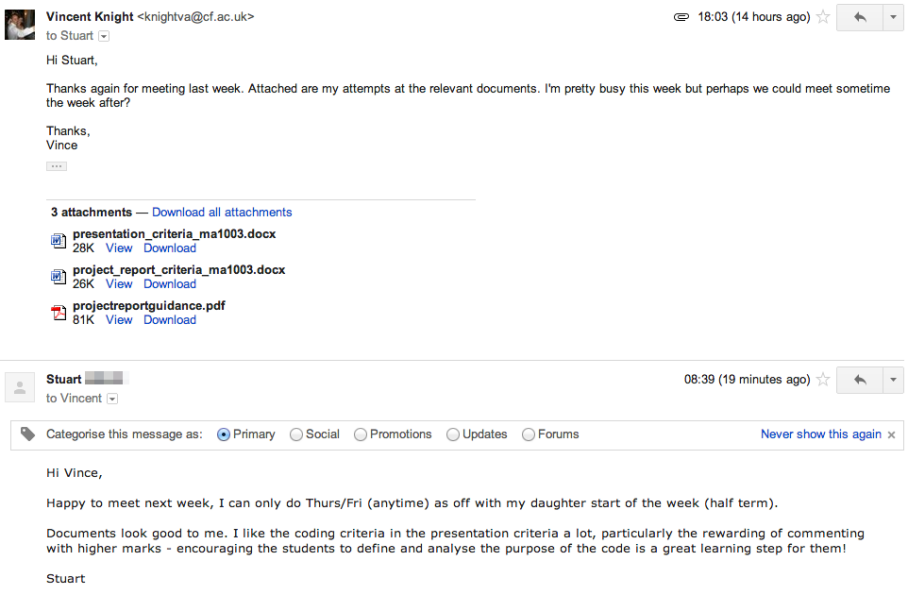

Figure 10: Ensuring the appropriateness of assessment

The work carried out this semester will be assessed using group coursework (three week report) as well as a group presentation. I feel that the three week report (although summative) plays more of of a formative role to ensure that students are on the right track (although it is also appropriate to assess the third learning outcome of CfM). The group presentation is an appropriate assessment methodology for the fourth learning outcome of CfM.

I feel that these approaches to pass entrepreneurial skills on to the students is in line with the literature [37]. Furthermore these are in line with the 'embedded' recommendations made in [17] (another PCUTL group

project) where a similar approach was suggested: it was suggested that students form 'research groups' and write research proposals.

In the next section I will briefly discuss how this module fits within the wider programme of study on offer at the School of Mathematics.

3 Computing for Mathematics as part of a programme

In [16] the opinion is given that degree programmes in the UK are becoming more diversified and 'standards are going sideways'. With the CfM module I would argue that the School of Mathematics is indeed diversifying their degree but as suggested previously this is a competitive diversification as it will lead to better mathematics graduates:

- A better understanding of what it is to be a mathematician;
- An ability to carry out mathematical research both independently and in a group environment;
- A competitive advantage in a competitive employment market.

Importantly, this module will allow for better learning by a range of undergraduates throughout their programme at the School of Mathematics. Indeed, I am in discussion with the leaders of second and third year modules to ensure that further programming will be embedded and/or used throughout the curriculum. On a personal level I will find the teaching of my third year Game Theory module to offer greater interactivity and understanding once all students have a comfortable set of programming skills.

This module was designed using a form of constructive alignment [4]. Indeed, as stated previously, it began with the assertion that modern mathematics graduates needed to know how to program. This would be assessed through their ability to write code but also through their ability to work with others which is in line with [43]. The teaching and learning activities were designed to ensure students would be able to attain the learning outcomes, and basing these on previous experiences as well the evidence from the literature, a novel pedagogic approach is being used. Specific consideration has been given to the contact and non contact time given the flipped classroom approach (recall Figure 4).

The assessment of the effect that this module has on the entire programme of study will be an ongoing study as students go through the years. I hope to make the learning of computing by mathematics students an area of investigation for my fourth PCUTL module but also for my future educational research activities.

In the next section I will briefly carry out a critique of the group project I carried out as part of this module of PCUTL and importantly place my experience gained through this group project in a valuable setting for my future teaching.

4 Discussion of group project

I will not in the section discuss the findings of the group project but more so my experience as a student working within a group. In [13] a wide range of advantages of group work are discussed which not only include pedagogic arguments but also certain pragmatic ones such as the fact that group work allows for an efficient way of handling large class sizes. The paper mainly discusses various difficulties linked to group work and how to address them:

- The free-rider problem;
- The sucker effect problem;
- Groupwork and ethnic mix;

- The social dilemma problem.

In our particular group project, whilst we did have a variety of differing opinions I would not say that any of the four above problems where specifically difficult to deal with.

I feel that the minor difficulties were indeed kept minor due to the maturity of the group members. This will not necessarily be the case with the group work planned for first year undergraduates in CfM and as such I will be sure to take on board the pre existent recommendations throughout the literature [2, 13].

One particular aspect that will hope help avoid the 'sucker effect' is how to incentivise students to ensure that they all work equally. I have discussed this already in my previous portfolio. In particular I have since implemented a methodology based on a game theoretic approach. I have already discussed the advantages and disadvantages of my proposed approach but in the near future I plan to investigate this further and importantly justify how I feel that this approach could contribute to the literature on the subject [30]. My approach is not the one that we chose to use within our group. The main reason for this was to ensure a fair workload amongst the group. My contribution included the majority of the statistical content analysis content for the project and so after some discussion it was decided to share the rest of the work.

Another aspect that was of interest during the group project was the use of technology. I have already widely discussed my use of technology in the classroom and it is something I am fairly confident with. However, it was nice to see that we were able to use Google Drive [24] in an efficient way to put our project report and slides together as shown in Figure 11.

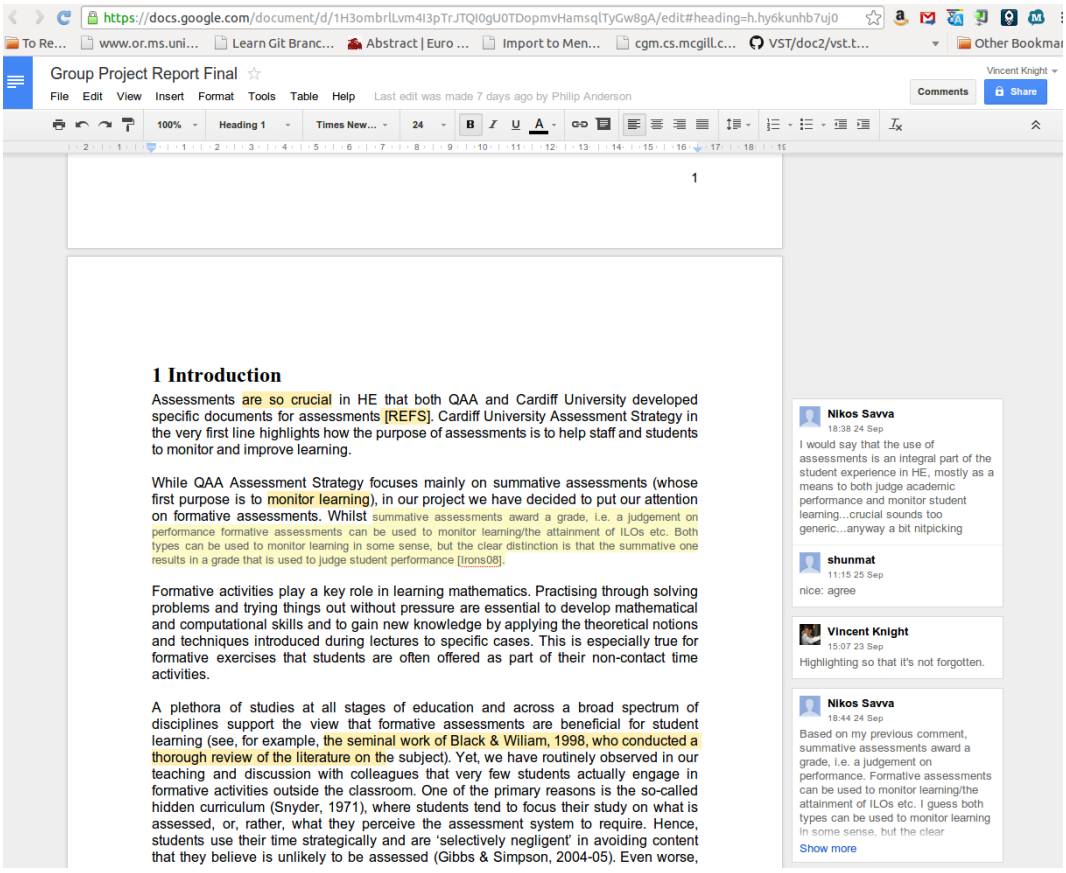

Figure 11: Discussing our document in real time on Google Drive

Interestingly, whilst most of us seemed quite happy with this as a tool and in particular thought it allowed us to work efficiently as a group, there was a member of our group who voiced certain aspects that were not to their liking. On a similar note I have blogged about the fact that Google Drive is not suitable for Mathematical work [27] and as such I have already planned to match the second intended learning outcome of CfM with writeLaTeX (`www.writelatex.com/`), a cloud based service similar to Google Drive.

Just before the group presentation some of our group members where not in the UK which made a practice run of the presentation difficult. One option would have been to use a VOIP service such as google hangouts or skype, however this was a busy time of year and as such it was difficult to find a mutually convenient time. As a solution I created a screencast of the talk and uploaded it to YouTube [28]. Importantly, as we did not necessarily know if we were happy with the presentation I uploaded it as an 'unlisted' video so it can not be found by anyone without the correct url. This was viewed by the group which allowed us to discuss certain aspects of the talk.

5 Conclusions

I have put together a well designed new module that fits within the programme of study at the School of Mathematics. Importantly the delivery, assessment and feedback has been carefully thought of and ensures that students from a wide range of learning styles should be able to effectively reach the desired learning outcomes. Whilst my methodologies are not as extreme as other proven techniques [14] they still will require careful monitoring and evaluation.

In the future I plan to undertake the fourth module of PCUTL as well as continue to engage with educational literature (ideally contributing myself). Whilst, I have discussed a wide range of literature that gives evidence to the benefits of flipped classrooms there is still research that can and must be done. Some of the 'missing research' has been discussed at [44]: pointing out that most studies show progression of learning but not on the same student group. I hope to concentrate my education research on the subject of how mathematics students learn to program. In [11], a paper written in 1998 student perceptions of mathematics are presented. I would very much like to carry out a similar study on a longitudinal scale. In [11] no mention of computing was made. It would be interesting to see if things have changed since but also if students' perceptions change over their time spent at Cardiff university.

Given the novel nature of CfM and my role as module leader I could use module four of PCUTL to investigate the above but also examine, critique and improve my delivery of CfM based on feedback from students as well as novel educational research.

I plan to continue my engagement with the educational research community. I am in talks with the director of Learning and Teaching at the School of Mathematics to organise a regular reading group meeting. With my mentor I am also planning a workshop entitled 'Workshop on Innovations in HE Mathematics Teaching'. This is being planned with the HEA and as well as having myself and others discuss flipped classrooms will have Dana Ernst and Theron Hitchman from the US visiting to present on Inquiry Based Learning.

Furthermore I feel that I continue to encourage the participation in higher education to students of all backgrounds and abilities. This is ensured through my role as chair of the OR society working group: OR in schools. I also continue to partake in various outreach activities. Furthermore, by the choice of open source languages as the pillar of CfM I ensure that students who want to introduce themselves to the language on their own machine will not need to be able to afford it.

Given that this portfolio concludes the 'compulsory' section of PCUTL I would like to end with some words regarding the process. Whilst, it has taken a ferocious amount of my time I am so extremely glad of the opportunity of going through it. It has opened my eyes to the world of pedagogic research and I hope has allowed me to reflect and improve my teaching and learning. I look forward to the opportunity to be able to mentor someone through the process one day. I also hope that some of the materials on the PCUTL section

of my personal website might be helpful to mathematicians going through the process in the future. This is an extremely valuable process, and one that is perhaps not given enough support as it should be in certain areas. I feel that this will change in years to come as more members of the teaching community at Cardiff go through PCUTL.

I will leave this essay with the following saying (I have found far too many different claims of origin to include them here):

Tell me, I'll forget. Show me, I'll remember. Involve me, I'll understand.

References

[1] Philip Anderson, Federica Dragoni, Vincent Knight, and Nikos Savva. Understanding the perceptions and factors that influence student engagement with formative assessment in mathematics education. Technical report, 2013.

[2] Robin L. Bartlett. A flip of the coin. a roll of the die: An answer to the free-rider problem in economic instruction. *The Journal of Economic Education*, 26(2):131, 1995.

[3] Simon Bates and Ross Galloway. The inverted classroom in a large enrolment introductory physics course: a case study. In *Proc. HEA STEM Conf*, 2012.

[4] John Burville Biggs, Catherine So-kum Tang, and Society for Research into Higher Education. *Teaching for quality learning at university.* Open University Press, Maidenhead :McGraw-Hill, 2011.

[5] Benjaman S. Bloom. *Taxonomy of Educational Objectives: The Classification of Educational Goals.* Longman Group United Kingdom, June 1969.

[6] Paul Bridges, Angela Cooper, Peter Evanson, Chris Haines, Don Jenkins, David Scurry, Harvey Woolf, and Mantz Yorke. Coursework marks high, examination marks low: Discuss. *Assessment & Evaluation in Higher Education*, 27(1):35–48, January 2002.

[7] Byron W. Brown and Carl E. Liedholm. Student preferences in using online learning resources. *Soc. Sci. Comput. Rev.*, 22(4):479492, December 2004.

[8] Cordelia Bryan and Karen Clegg. *Innovative assessment in higher education.* Routledge, London; New York, 2006.

[9] A. T. Chamillard and Kim A. Braun. Evaluating programming ability in an introductory computer science course. *ACM SIGCSE Bulletin*, 32(1):212216, 2000.

[10] P. Conaghan and A. Lockey. Feedback to feedforward: A positive approach to improving candidate success. *Notfall + Rettungsmedizin*, 12(S2):45–48, September 2009.

[11] K. Crawford, S. Gordon, J. Nicholas, and M. Prosser. University mathematics students' conceptions of mathematics. *Studies in Higher Education*, 23(1):87–94, January 1998.

[12] Catherine H. Crouch and Eric Mazur. Peer instruction: Ten years of experience and results. *American Journal of Physics*, 69(9):970, 2001.

[13] W. Martin Davies. Groupwork as a form of assessment: common problems and recommended solutions. *Higher Education*, 58(4):563–584, March 2009.

[14] Joshua Davis. How a radical new teaching method could unleash a generation of geniuses | wired business | wired.com, 2013.

[15] Louis Deslauriers, Ellen Schelew, and Carl Wieman. Improved learning in a large-enrollment physics class. *Science*, 332(6031):862–864, May 2011. PMID: 21566198.

[16] Lewis Elton. Are UK degree standards going up, down or sideways? *Studies in Higher Education*, 23(1):35–42, January 1998.

[17] Jeremy Evas, Angharad Naylor, Simon Robertson, and Peter Burnap. Embedding CU strategic graduate skills into the curriculum. Technical report, 2013.

[18] Nancy Falchikov. *Learning Together: Peer Tutoring in Higher Education.* Routledge, November 2002.

[19] Norah Frederickson, Phil Reed, and Viv Clifford. Evaluating web-supported learning versus lecture-based teaching: Quantitative and qualitative perspectives. *Higher Education*, 50(4):645–664, November 2005.

[20] Rudolf Fritsch, Gerda Fritsch, and J. lie Peschke. *The Four-Color Theorem: History, Topological Foundations, and Idea of Proof*. Springer, 1 edition edition, August 1998.

[21] Gerald C. Gannod, Janet E. Burge, and Michael T. Helmick. Using the inverted classroom to teach software engineering. In *Proceedings of the 30th international conference on Software engineering*, page 777786, 2008.

[22] Graham Gibbs and Lisa Lucas. Coursework assessment, class size and student performance: 198494. *Journal of Further and Higher Education*, 21(2):183–192, June 1997.

[23] Graham Gibbs and Claire Simpson. Conditions under which assessment supports students' learning. *Learning and teaching in higher education*, (1), 2004.

[24] Google. Go google: Google drive. http://www.youtube.com/watch?v=wKJ9KzGQq0w, April 2012.

[25] Anne Jordan, Orison Carlile, and Annetta Stack. *Approaches to learning a guide for teachers*. Open University Press, Maidenhead, 2008.

[26] S. Kellogg. Developing online materials to facilitate an inverted classroom approach. In *39th IEEE Frontiers in Education Conference, 2009. FIE '09*, pages 1–6, 2009.

[27] Vincent Knight. Using google docs for a sizeable mathematics project. http://drvinceknight.blogspot.co.uk/2012/06/using-google-docs-for-sizeable.html, 2012.

[28] Vincent Knight. Understanding student engagement with formative assessment. http://www.youtube.com/watch?v=soUWEQUVYzg, September 2013.

[29] Maureen J. Lage, Glenn J. Platt, and Michael Treglia. Inverting the classroom: A gateway to creating an inclusive learning environment. *The Journal of Economic Education*, 31(1):30, 2000.

[30] Mark Lejk, Michael Wyvill, and Stephen Farrow. A survey of methods of deriving individual grades from group assessments. *Assessment & Evaluation in Higher Education*, 21(3):267–280, 1996.

[31] Ted Mahavier, Lee May, and Edgar Parker. A quick-start guide to the moore method. Technical report, 2006.

[32] Marin Moravec, Adrienne Williams, Nancy Aguilar-Roca, and Diane K. O'Dowd. Learn before lecture: a strategy that improves learning outcomes in a large introductory biology class. *CBE-Life Sciences Education*, 9(4):473481, 2010.

[33] Hamdan Noora and McKnight Patrick. A review of flipped learning. Technical report, 2013.

[34] Tershia Pinder-Grover, Katie R. Green, and Joanna Mirecki Millunchick. The efficacy of screencasts to address the diverse academic needs of students in a large lecture course. *Advances in Engineering Education*, 2(3):128, 2011.

[35] The Quality Assurance Agency for Higher Education (QAA). Subject benchmark statement: Mathematics, statistics and operational research, March 2012.

[36] Lindsey Shorser. Bloom's taxonomy interpreted for mathematics. Technical report, 1999.

[37] George Solomon. An examination of entrepreneurship education in the united states. *Journal of Small Business and Enterprise Development*, 14(2):168–182, 2007.

[38] Jeremy F. Strayer. How learning in an inverted classroom influences cooperation, innovation and task orientation. *Learning Environments Research*, 15(2):171–193, July 2012.

[39] Robert Talbert. The inverted classroom and peer instruction: designing classes for meaningful learning experiences. http://www.slideshare.net/rtalbert/the-inverted-classroom-and-peer-instruction-designing-classes-for-meaningful-learning-experiences, October 2013.

[40] Telegraph. Graduate jobs: Top 10 degree subjects by lifetime salary. http://www.telegraph.co.uk/education/universityeducation/9552659/Graduate-jobs-Top-10-degree-subjects-by-lifetime-salary.html, September 2013.

[41] The New York Times. What 'Connected education' looks like: 28 examples from teachers all over... http://learning.blogs.nytimes.com/2013/10/01/what-connected-education-looks-like-28-examples-from-teachers-all-over/, 2013.

[42] Cardiff University. Cardiff assessement strategy. Technical report, 2013.

[43] Cardiff University. The way forward. Technical report, 2013.

[44] Aaron Weinberg. Reviewing the research on flipped classrooms. http://mathflip.wordpress.com/2013/09/11/reviewing-the-research-on-flipped-classrooms/, 2013.

[45] Aaron Weinberg. What does it mean to flip a classroom? http://mathflip.wordpress.com/2013/09/03/what-does-it-mean-to-flip-a-classroom/, 2013.

Computing for Mathematics: description of spring semester for peer review

Vincent Knight

1 Context

The main focus of this semester is the fourth ILO of the course:

> "Work in groups to tackle problems and convey solutions to those problems through presentation."

To enhance the student experience and ensure that entrepreneurial skills are embedded in the curriculum, this will be done in an entrepreneurial setting:

- Students will be working in groups: referred to as 'companies'.
- Companies will carry out a form of market research to ensure they choose a topic that is relevant.

2 Delivery

The delivery of this part of the module will not involve a lot of contact time. Students will be expected to self regulate their groups and meet often.

2.1 Non Contact

- Students to form groups of 4 (this should be done by the end of week 1);
- Group roles to be assigned: project manager (pm) and secretary. It is the role of the pm and the secretary to ensure that the companies meet twice a week and that minutes are kept.

2.2 Contact

- In weeks 1 to 6 there will be one lecture a week. During this lecture the following themes will be covered:
  - General entrepreneurship (by the Cardiff University Union entrepreneurship team);
  - Library skills (by the Helen Staffer: Cardiff University Librarian);
  - Market strategy (by the Cardiff University Union entrepreneurship team);
  - Presentation skills (by the Cardiff University Union entrepreneurship team);
  - Meeting skills (by the Cardiff University Union entrepreneurship team).

- In week 6 pm's will attend a 'grand council' to give a short (less than a minute) presentation to each other. This will serve so as to encourage social learning between the groups and so that students know what else is happening in the class.
- In weeks 7 to 11, there will be a series of seminars instead of lectures. These will be used by invited speakers to discuss other languages but also in some cases I will ask students to potentially present to each other. In future years I will ask past students to present their project.

3 Assessment

There are two forms of assessments this semester:

- A short report: 'project proposal' to be handed in at the end of week 3. This will be summative however the main role of this assessment is formative. It will allow me to ensure that students are on the right track and give feedback to the groups.
- A group presentation to be given in week 11, during this presentation students will present their work.

See the marking criteria and related documents for more information about this.

MA1003 Computing for mathematics – Presentation task marking criteria (25% of total available module marks)

Criteria	%	0-40	40-50	50-60	60-70	70-100
Content (Knowledge, application, analysis, evaluation, structure, persuasiveness)	20	Goals not addressed. Content of little strategic value. Structure not apparent or confusing. Unconvincing or unappealing case made.	Goals addressed insufficiently. Descriptive and untargeted content. Needlessly overt and/or confusing structure. Unpersuasive case.	Goals achieved. Reasonable content evidencing some awareness of strategic value. Clear and coherent structure. Case held some sway.	Goals achieved. Critically targeted content demonstrating strategic awareness. Discrete, logical and structure. Persuasive and credible case made.	Goals surpassed. Perceptive, critical and strategically valuable content. Innate, cogent structure. Persuasive, influential and convincing case made.
Code (Difficulty of coding involved, clarity, efficiency)	20	Code not functioning correctly.	Very basic unclear code without any difficulty.	Code is clearly written with a low level of difficulty but is not efficient and no comments.	Code is clearly written with a high level of difficulty including some comments.	Code is of extremely high quality with various novel aspects included and excellent level of documentation.
Delivery (Spoken delivery, audience rapport, time management)	20	Poor delivery style Did not build relationship or rapport with audience.	Awkward or uncomfortable delivery style. Little relationship or rapport building. Inadequate time management impacting on other criteria.	Acceptable and practical delivery style. Satisfactory level of relationship building, lacking overall audience rapport. Adequate time management.	Articulate and expressive delivery style. Established relationship and rapport. Efficient time management.	Appealing, eloquent and enjoyable delivery style. Excellent relationship and rapport building. Perfect time management.
Visual aids (Co-ordination with content and delivery, PowerPoint, Beamer or similar, graphic design, images, graphs, handouts etc.)	20	Not co-ordinated. Impractical Inappropriate use of technology and new medias.	Not adequately co-ordinated. Overcrowded, complex or confusing design. Visually unattractive and/or impractical. Poor use of technology and new medias.	Generally well co-ordinated. Adequate design standard with minor faults. Suitable use of technology and new medias.	Co-ordinated and functional. Good, communicative design standard. Beneficial use of technology and new medias.	Subtle, purposeful, & complementary. Professionally designed & visually appealing. Creative use of technology and new medias.
Creativity (Innovative approach to meeting the above criteria)	20	Lacked creativity. Mundane and uninteresting approach taken.	Minimal evidence of original thought. Routine or standard approach taken.	Demonstrates some original and creative thought. Encouraging approach taken.	Novel, inventive, enthusiastic and thoughtful approach taken.	Innovative, original, imaginative and inspiring approach taken.

In addition to their specific criteria, the above components will be assessed according to their presentation and critical approach using the following criteria:

Presentation (Spelling, grammar, punctuation, references)		Poor standard of spelling, grammar, and/or punctuation. Inappropriate and confusing structure, incorrect referencing.	Confusing written/spoken style. Many mistakes in grammar, spelling and/or punctuation. Poorly researched, evidenced & presented.	Acceptable written/spoken style. Mistakes in grammar, spelling and/or punctuation. Acceptably researched, evidenced & presented.	Clear written/spoken style. Generally correct grammar, spelling and/or punctuation. Researched, evidenced & presented to good standard.	Articulate written/spoken style. Grammar and spelling wholly accurate. Researched & evidenced to high standard. Professionally presented.

MA1003 Computing for mathematics – Presentation task marking criteria (25% of total available module marks)

Analysis & Evaluation (Commercial awareness, enterprise competency, critical approach employed)		Does not provide adequate description. Demonstrates little awareness of the commercial process. Fails to analyse or evaluate.	Conveys superficial descriptive information only. Demonstrates limited commercial awareness. Little or no attempt made to contextualise, analyse or jevaluate points made.	Description is satisfactorily contextualised, analysed and evaluated. Demonstrates adequate standard of commercial awareness. Some consideration of real world issues.	Description is competently contextualised, analysed and evaluated. Good standard of commercial awareness and/or enterprise skills. Perceptive consideration of real world issues.	Conveys very good to professional standard of commercial awareness combined with strong knowledge of relevant industry.

MA1003 Computing for mathematics – Project proposal task marking criteria (5% of total available module marks)

Criteria	%	0-40	40-50	50-60	60-70	70-100
Strategy (Bus. model, strategy, regulation, conclusion & executive summary)	40	Does not present adequately 'joined up' strategic thinking. Fails to reach appropriate conclusion.	Inadequate standard of strat. analysis. Provides simplistic or unreasoned conclusion and summary.	Adequate standard of strat. analysis. Suitable conclusion & summary based on market analysis.	Good strat. Analysis. Informed conclusion and summary.	Very good to prof. standard of strategic analysis. Broad, reasoned and informed conclusions & summary.
Market Analysis (Potential customers, marketing strategy, possible competition)	35	Does not consider potential customers or competition. Fails to present marketing strategy.	Description of potential customers and competition only. Marketing strategy unaligned with findings.	Adequate consideration of potential customers and competition. Marketing strategy reflects findings.	Discerning analysis of potential customers and competition with clearly aligned marketing strategy.	Strong to professional market analysis. Strategically aligned and knowledgeable marketing strategy.
Product Definition (Product proposal, value proposition, development planning & tech. targets)	25	Does not provide adequate description or analysis of chosen product or product benefits.	Provides descriptive account of product, benefits and development only. Fails to analyse or evaluate these from strategic perspective.	Satisfactory product proposal and development planning. Demonstrates awareness of strategic value of product benefits.	Comprehensive product proposal and development planning. Identifies strategic value of product benefits.	Clearly defined product proposal and development planning. Capitalises on strategic value of product benefits.

In addition to their specific criteria, the above components will be assessed according to their presentation and critical approach using the following criteria:

Overall Presentation (Spelling, grammar, punctuation, structure, references)		Poor standard of spelling, grammar, and/or punctuation. Inappropriate and confusing structure, incorrect referencing.	Confusing writing style. Many mistakes in grammar, spelling and/or punctuation. Poorly researched, evidenced & presented.	Acceptable writing style. Mistakes in grammar, spelling and/or punctuation. Acceptably researched, evidenced & presented.	Clear writing style. Generally correct grammar, spelling and/or punctuation. Researched, evidenced & presented to good standard.	Articulate writing style. Grammar and spelling wholly accurate. Researched & evidenced to high standard. Professionally presented.
Overall Analysis & Evaluation (Application, analysis and evaluation of knowledge)		Does not provide adequate description. Fails to analyse or evaluate.	Conveys descriptive information only. Little or no attempt made to contextualise, analyse or evaluate points made.	Descriptive information is satisfactorily contextualised, analysed and evaluated. Some consideration of real world feasibility issues.	Descriptive information is competently contextualised, analysed and evaluated. Perceptive consideration of real world feasibility issues.	Very good to professional standard of commercial awareness combined with strong knowledge of relevant industry.

MA1003 Computing for Mathematics

Project proposal guidance

In week 3 you are required to write a short project proposal for your group. The aim of this proposal is to:

- Indicate what problem/opportunity you plan on tackling;
- Show that as a group you have carried out some research on the topic;
- Describe your approach to solving the problem/opportunity.

Strategy (half a page)

In this section aim to answer the following question:

> "What problem and/or opportunity are we going to tackle?"

Be sure to consider the following points:

- What would be your strategy for your product to be used? (eg 'Building a program that identifies the location of the Mars Rover')
- How will your product be useful, who is it for? (eg 'The product will be used by NASA')
- What is the greater potential for your product? (eg 'If successful our product could be used by ongoing commercial Mars landing projects')

Market research

In this section you need to show that you have carried out some exploratory research to answer the following question:

> "What has already been done and what do we need to know to build our product?"

Be sure to consider the current state of the art (even if you are perhaps not quite capable of understanding it at this early point in your mathematical careers). Also, consider some of the tools you might need to learn (eg a new python library perhaps).

Product definition (half a page)

In this section you need to explain what exactly it is that you are going to try to do:

> "How are we going to tackle this problem/opportunity?"

This section could include a process diagram but might also importantly need some high level pseudo code.

Good Luck!

PCUTL - Module 3:
Response to Peer Review by Paul Harper

Vincent Knight

1 Context

"This peer review specifically address ILO's 1, 2, 3 and 6 of the PCUTL module 3, namely to:

- Integrate scholarship, research and professional activities with teaching and supporting learning [ILO 1];
- Design and plan effective modules or clusters of sessions or programmes of study that facilitate quality learning and the achievement of appropriate learning outcomes by a range of learners [ILO 2];
- Design and implement appropriate and effective assessment and feedback schemes using a range of methods that align with the tenets and principles of the Cardiff University Assessment Strategy and Feedback Policy [ILO 3];
- Work with colleagues to enquire critically into an aspect of planning or assessment / feedback relevant to their context [ILO 6].

Specifically, the peer review focussed on planning for a new module that Vince is teaching to our first year undergraduate Mathematics students, MA1003 Computing for Mathematics (CfM), which is comprehensively discussed in his module 3 portfolio. This module covers both Autumn and Spring semesters, the Autumn semester which is being taught within a social constructivist framework to encourage student learning via a flipped classroom approach. Might I add in passing how impressed I have been by the level of effort and considered planning that has gone into this module by Vince, and the innovative methods being employed. At the time of writing, the first couple of weeks have been hugely successful and indeed Vince is *creating learning opportunities* for students as very much his desire and indeed aligned to his overall theme for PCUTL.

For this particular peer review, we discussed planning for the Spring semester which is designed to meet the 4th ILO for MA1003:

- Work in groups to tackle problems and convey solutions to those problems through presentation.

The focus of the semester is on the use of programming skills in an entrepreneurial environment. Students will be organised into groups of 4 and these groups will be called *Companies*. Companies will contain a *Project Manager* and a *Secretary* (selected from amongst the members).

There is a limited amount of contact time in the Spring semester of CfM with one session (lecture or seminar) timetabled each week. At the beginning of the semester this will be used by the entrepreneurial team from the Cardiff University Students Union, and Librarians, to present key skills to the students. The seminars will be used to expose students to further aspects of

programming such as other programming languages and/or some research that is being done in the school.

The work carried out this semester will be assessed using group coursework (three week report contributing 5% towards the overall module) as well as a group presentation (contributing 25%)."

Paul has summarized my description of the Spring semester well. As will become apparent below, this peer review was very helpful as it allowed me to enquire critically in to various relevant details relevant to the second half of MA1003.

2 Critique

"Vince and myself discussed at length various aspects of his plans for this part of CfM. These may be summarised under the following headings, where a critique of each aspect is provided."

I will respond to each heading separately.

Group membership, dynamics and inclusivity

" Vince makes great efforts to ensure his teaching methods and materials are inclusive. We discussed how groups (companies) will be formed, either through self-selection or pre-defined groupings set by Vince, with an aim to create inclusive groupings. For other modules with group structures (such as the focus in previous PCUTL modules around MAT013) these have largely been constructed by our Knowledge Transfer Officer (Mrs Joanna Emery) to ensure a mix of ages, gender and cultural heritage etc. Vince needs to give more thought to this matter and if this approach is practical with 40+ groups or whether self-selection is acceptable (and perhaps look again at related educational literature for insights).

A further issue with a module of this nature (computer programming) is how satisfactory group dynamics and an equitable workload might be achieved given for example some members may have natural strengths in coding whereas others are much weaker (computer programming does tend to polarise students!). These are mostly addressed through the allocation of project manager and secretarial roles to oversee group progress, meeting regularly (twice weekly at least with minutes taken), the 3 week progress report, the week 6 'Grand Council', and that there are plenty of other activities required to take place alongside the coding itself (market research, report writing, presentation etc.). These are all excellent mechanisms that Vince has put in place, and coupled with the timetabled sessions to support student learning, one would hope for good group dynamics. Nevertheless there is potential, as always, for concerns on equitable contribution by all group members and Vince might give more thought to how to address and rectify such concerns that may arise during the semester (this is also picked up under "Assessment" below)."

In most of my previous teaching, as Paul has said I have used our KTO to make up the groups. This was mainly due to the fact that she often comes to know the students quite well and is able to put together groups that form a good mix and should avoid the pitfalls that can arise when grouping students together [3]. There is a wide range of literature on the subject of group selection (see [2] and the references therein). After my discussion with Paul I plan on using a hybrid of self selection and instructor selection of group makeup for this module. The literature does not seem to offer a uniform recommendation with regards to the optimal way forward. Thus, given the open ended nature of the project I will encourage students to self select groups but in cases where students are unable to select groups I will select them for them attempting to take in to account various factors such as learning styles: [1] (although I do not plan on using a questionnaire as suggested in that paper but using subjective judgement which will be made easier through the feedback I obtain from the tutorials).

To address the issue of equitable work, I plan on using a marking system that attributes individual marks to students. This is something I have spoken about before and will implement in the second term. Finally, I continue to be in discussion with the entrepreneurship team to ensure that appropriate group work skills will be given to the students. I will also prepare a handout offering a summary of things that need to be considered (similar to the appendix given in [2]). One example I will point out to students that meeting in a pub is not appropriate if members of the group are of a religious faith that does not permit them to go to a venue where alcohol is sold.

Employability and entrepreneurial skills

> "In recent years the School of Mathematics has been looking at ways to embed employability and entrepreneurial skills into its undergraduate degree programmes. What Vince is planning with this new first year CfM module truly addresses this need. This is particularly exciting as it is aimed at our first year students and will hold them in good stead throughout their degree programme. Indeed the School should now look to build on this module to ensure further learning opportunities of this nature and increased employability skills during years 2 and 3. Vince should be congratulated on putting together a schedule of lectures (weeks 1-6) in liaison with the entrepreneurial team from the Cardiff University Students Union. The indicative order of these lectures does not however seem to reflect the likely needs of the groups over time, since for example the 'Meeting Skills' session would ideally come first whereas "Presentation Skills" that aren't required until later on can be correspondingly scheduled later. Vince should give more thought on this matter and arrange in an order that is more appropriate.
>
> The seminars in weeks 7-11 by invited speakers are also an excellent idea and will reinforce employability and entrepreneurial skills as well as demonstrating research-led teaching (by exposing students to research activities within the School). We discussed how external speakers might also be invited to increase awareness amongst the students of where programming and mathematics are successfully used in industry."

I appreciate Paul's comment about the order of the entrepreneurial sessions. I am still in discussion with the entrepreneurial team and will be sure to make sure that the sessions are timetabled in the correct way.

Assessment

> "The three-week reports, although summative, act in a more formative role to ensure satisfactory progress by each group and that they are approaching the project in a sensible manner. It also has the benefit of assessing the third learning outcome of CfM to *have a basic knowledge of LaTeX* which is what the groups will use to submit their written work. The group presentation is an entirely appropriate assessment method for attaining the fourth learning outcome of CfM. I am entirely happy with the proposed marking criteria/framework that has been well designed and allows for all related ILOs to be assessed.
>
> As discussed earlier, it will be important to foster/encourage good group dynamics. The current assessment scheme awards the same mark to all group members, regardless of actual relative contribution. This is always a tricky issue and one that Vince and myself have discussed on several previous occasions in relation to group assignments on MSc modules. Vince might wish to consider mechanisms to encourage/incentivise inclusivity such as reserving some of the available marks to individual performance or at least the possibility to differentiate marks within the group based on peer-review/reflection."

Paul raises a good point here that I have addressed in an above response. I plan on using an approach to obtaining individual marks from a group project. There are various approaches that do this, see [4] and the reference therein. Almost all assign an overall mark to the work that is then used to obtain an individual mark. Paul and I have devised an approach based on Game Theory. This is most probably what I will use.

3 Concluding remarks

"Below I sumarise ways in which several ILOs from PCUTL module 3 are being specifically addressed by Vince in the planning and delivery of MA1003:

Integrate scholarship, research and professional activities with teaching and supporting learning [ILO 1]

Inviting internal and external speakers will encourage the **integration of research and professional activities** to benefit the students' learning whilst **firmly placing employability and entrepreneurial skills within the module**. Adopting business terms such as 'companies' and 'project managers', which are closely akin for example to the popular TV show *The Apprentice*, is an excellent way to incentivise students and foster such skills.

Design and plan effective modules or clusters of sessions or programmes of study that facilitate quality learning and the achievement of appropriate learning outcomes by a range of learners [ILO 2]

The nature of the planned group assignment facilitates independent research whilst the support mechanisms and additional sessions put in place encourage group working, research investigation, time-management and entrepreneurial skills. In summary this is an **exemplary** programme of study that creates **multiple learning opportunities** for our students within their first year of the degree programme. It permits the achievement of **learning outcomes by a range of learners**. Indeed it would be nice to see a similar module in our final year. Vince might well reflect on how skills acquired in this module can be built upon in other years, and discuss these opportunities with colleagues.

Design and implement appropriate and effective assessment and feedback schemes using a range of methods that align with the tenets and principles of the Cardiff University Assessment Strategy and Feedback Policy [ILO 3]

The proposed assessment and feedback schemes seem entirely sensible and appropriately aligned to the learning outcomes. Clearly much thought has gone into planning the nature of the coursework and deliverables with a clear and transparent marking scheme. Mixtures of summative and formative methods are to be used, with timely feedback. I particularly like the concept of the Grand Council in week 6 to facilitate collective learning as well. Certainly in my opinion the proposed module is well aligned to the overarching principles of the Cardiff University Assessment Strategy and Feedback Policy assessment, namely that it is **valid, reliable and explicit**.

Work with colleagues to enquire critically into an aspect of planning or assessment / feedback relevant to their context [ILO 6]

The very fact that we sat down to discuss and critique this module, focussing on planning, assessment and feedback, contributes to this ILO! In addition I know that Vince contributed significantly to the module 3 group exercise, and consequently gained a great deal, and he has translated insights and findings from that exercise to the planning for CfM group work."

I appreciate Paul's kind words and also how he has clearly indicated how my module design for MA1003 matches the ILOs of this PCUTL module. Furthermore, Paul's suggestion to include a similar module in the final year gives me something to think about in the near future which is ILO 5! With regards to the inclusion of the skills learned in this module in throughout the degree programme. It is hoped that the programming skills will be used throughout the degree programme. I am in discussion with other lecturers as to how these skills will be used but this will already have an effect on a non core programming module in the second year and I also will use programming in a new third year module. With sufficient buy in from other members of staff I believe that the programming will be used throughout.

> "In summary, I am impressed with the thoroughness and conscientiousness planning that has gone into MA1003. The innovative methods employed by Vince are to be congratulated and I anticipate that Spring semester will be a great success and suitably challenging but rewarding for our students.
>
> There are some aspects for further consideration and reflection as outlined above, namely: group membership/inclusivity, group contributions and equitable workload/marks, the ordering of the week 1-6 lectures, inviting external speakers from across different industries in weeks 7-11, and reflecting on ways in which this module can be built upon for years 2 and 3 and discuss within the School as required.
>
> In closing I simply can't speak highly enough of what Vince is now achieving in his teaching within the School, resulting from continued reflected practice and exposure to methods and literature throughout PCUTL. It is truly awesome to witness and if I might have helped even in some small way during his journey so far, that is incredibly gratifying. May he long continue to be an ambassador for innovation in teaching and learning, helping his colleagues be inspired too, continue to reflect on his own teaching and evolve practice as necessary, and ultimately to create further learning opportunities to benefit our students."

I have addressed the issues raised by Paul in this summary above, so here will simply at this point thank him for his encouragement and assistance throughout this process and in particular for spending the time on writing such an extensive, detailed and helpful peer review report.

References

[1] Alison Halstead and Lynn Martin. Learning styles: a tool for selecting students for group work. *International Journal of Electrical Engineering Education*, 39(3):245–252, July 2002.

[2] Sandy Hilton and Fred Phillips. Instructor-assigned and student-selected groups: A view from inside. *Issues in Accounting Education*, 25(1):15–33, February 2010.

[3] David Kember and Carmel McNaught. *Enhancing university teaching lessons from research into award-winning teachers*. Routledge, London; New York, 2007.

[4] Mark Lejk, Michael Wyvill, and Stephen Farrow. A survey of methods of deriving individual grades from group assessments. *Assessment & Evaluation in Higher Education*, 21(3):267–280, 1996.

PCUTL peer review: Description of feedback mechanisms

Vincent Knight

1 General discussion about feedback

I have chosen to make feedback the focus of this peer review.

I practice a pedagogic approach based upon a flipped classroom approach. This approach ensures a continuous feedback loop between myself and my learners.

In Figure 1, a diagrammatic representation of a flipped classroom is given, showing that contact time is spent continuing to construct the learning of the students and also allowing me to obtain and importantly give feedback as to their ongoing development.

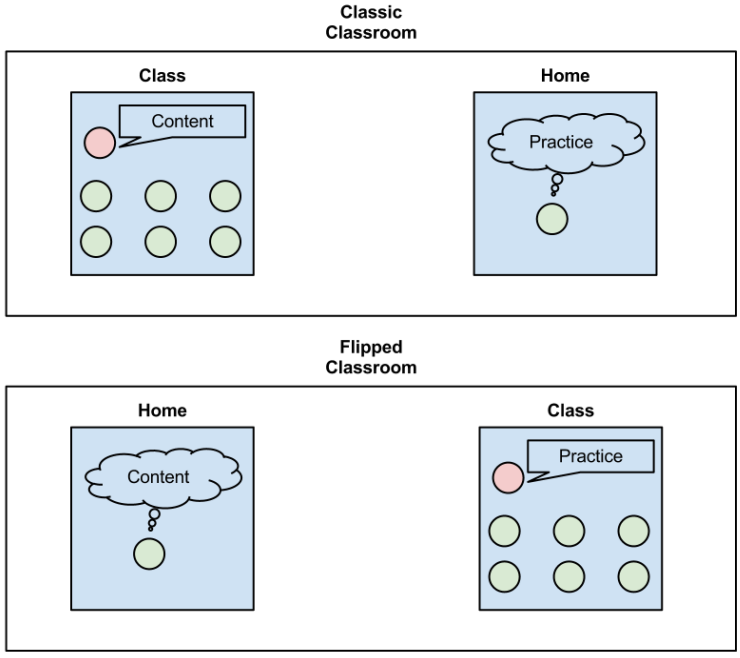

Figure 1: A diagrammatic representation of a flipped classroom

I will return to this aspect in the next section as feedback and flipping classrooms is a major aspect of a new module (core first year module) I am running for the first time. However I thought I would also discuss some traditional feedback mechanisms I continue to use.

Figure 2 shows some written feedback I have given to students in the past (the entire class test is attached). This was feedback given for a programming class test for MAT013. In the feedback I point out the errors made by students and what would have needed to have been done to obtain a better mark.

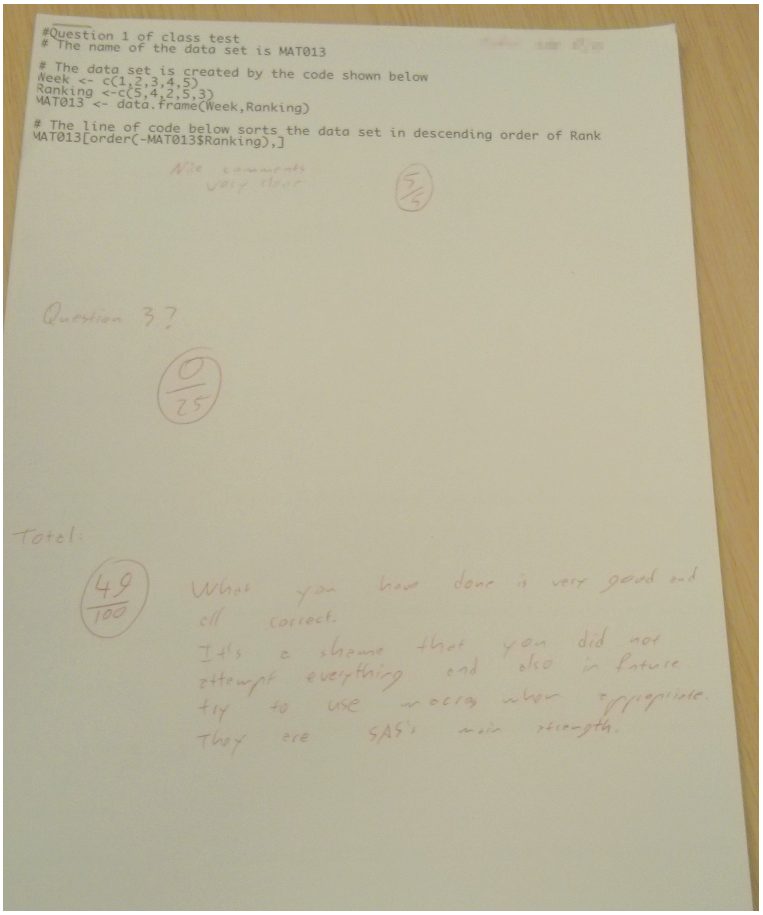

Figure 2: Some written feedback

In the next section I will discuss a new module: MA1003 which has been the main focus of my PCUTL portfolio, concentrating on the feedback aspects of the module.

2 Discussion about Computing for Mathematics

This new module is designed using a completely flipped pedagogy. Students obtain content for a particular topic prior to the lecture on that topic. This content is delivered using a combination of written lab sheets and videos. An example of this can be seen here: `http://drvinceknight.github.io/Computing_for_mathematics/LabSheets/Week_02.html`.

Figure 3 shows the content delivery, assessment and feedback for MA1003 (this is in fact only shown for the first half of the module).

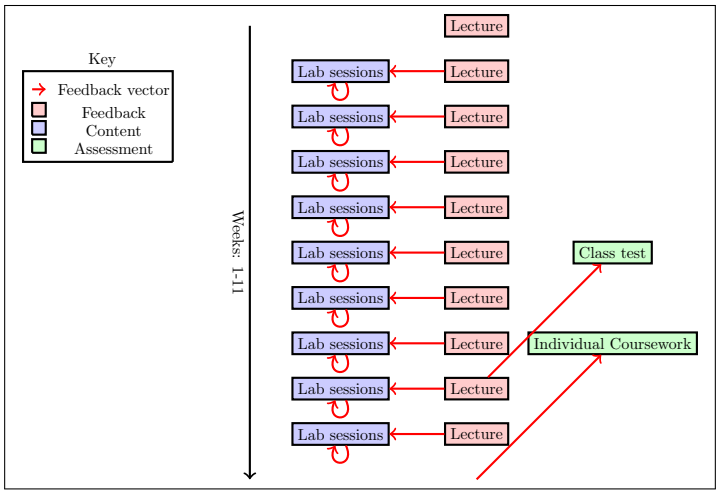

Figure 3: Delivery of content, feedback and assessment for MA1003

There are various aspects of feedback that need to be discussed for the purpose of this peer review:

- **Feedforward**

  First of all, the flipped approach allows for the videos used to serve as not only delivery content but also feed forward mechanisms as to how to carry out a particular piece of assessment correctly. This video: `http://www.youtube.com/watch?v=7KxOxWC3h78` gives some feedback to students on a previous exercise whilst indicating what they must pay attention to in the current exercise.

- **Feedback in each lab**

  In each lab session tutors use a very 'swift' feedback mechanism called 'tickables'. This allows for the student to get immediate feedback as to whether or not they managed a particular task. This allows the tutors to gain an understanding of what difficulties were common on a given task.

- **Feedback in lecture**

  Gathering information as to what students were having difficulty with allows the lecture to be feedback focused. I address particular aspects that students found difficult.

- **Feedback in Office hours**

  Finally, I have started official use of 'office hours' so that students can seek feedback from me on a 1 to 1 basis.

The above feedback mechanisms not only fit naturally within a flipped classroom but also (thanks to the tickables) allow for each student to have some level (often very brief) of individual feedback on each task every week. I'm not sure that with a class of this size (165 students) that would be possible otherwise.

PCUTL - Module 3:
Response to Peer Review by Phil Anderson

Vincent Knight

1 Summary

"Vince has designed (and is currently implementing) a new module, 'Computing for Mathematics', giving a great deal of attention to the formative elements and feedback. The focus of this PRLT is the feedback mechanisms employed. The module structure is highly innovative with the lectures being very much reactive to the difficulties faced by students in the lab session. This, however, is only one form of feedback in the course. The lab sessions are designed to allow rapid feedback through his 'tickables' approach which, interestingly, acknowledge an informed attempt at a particular element and not necessarily a correct answer. Vince also uses videos to provide direct feedback on the exercises. Finally he has begun to introduce a fixed time when he will be available for students to visit his office for one to one discussion.

The approach taken to feedback here is the most thorough I have seen and meets all of the requirements of Cardiff University's Feedback Policy, particularly in that the feedback is extremely timely, appropriate to the learning, continuous and suited to a wide range of students' needs. The sheer range of feedback opportunities should guarantee that all students will find an approach which meets their needs.

It is a reflection of this thoroughness that this module will inevitably take up a lot of Vince's time since so much of the work is bespoke although this workload will reduce with each new cohort as I am sure many of the issues will resurface every year. The size of the cohort (165 students) also presents scheduling difficulties for the lab sessions (as there are approximately 16 students in each lab session and all must be completed before the lecture)."

I really enjoyed talking about my plans for this module with Phil as he was able to query quite a few of my plans. This led to a great discussion about feedback and pedagogy. Phil's comments about my thoroughness are very much appreciated as it has been a long process of constant reflection and re-evaluation to obtain the module design as it is.

Phil raises a valid concern here about how much time this will take. As the module has been running already I have found it slightly challenging to prepare my reactive lecture although as the course runs in future years I am sure I will be able to better preempt the difficulties of students.

During our discussion Phil raised certain comments and suggestions that allowed me to better

2 Comments and Suggestions

"Vince has clearly considered and planned this module, and in particular the feedback mechanisms, extremely well and I am sure it will be a success. He appears to be committed to the use of flipped classrooms and the benefits that brings in terms of feedback opportunities and

deeper learning. It is refreshing and inspiring to see such commitment to innovative teaching and I applaud both Vince and his school's willingness to take risks (albeit risks backed up by sound pedagogic research) with teaching methodologies.

I suggest that consideration should be given to a few minor points.

Firstly care should be taken to ensure that students do not get bogged down in achieving perfection in the tickables and that they cover the breadth of the work required. This will require the lab supervisors to have a good understanding of the rationale and the ability to communicate this to the students.

The module is designed to cater for students who have no previous programming experience, those who come in with significant experience should still find sufficient work to challenge them. It will be difficult to manage the assessments such that this happens whilst still ensuring that top marks are achievable for all students.

The feedback mechanisms appear quite time intensive for those involved, consideration should be given to introducing efficiencies to this process. Will this naturally occur with future running of this module? Can larger groups be managed in lab sessions? Perhaps if students were not all tackling the same exercises simultaneously an element of peer teaching could be introduced.

I hope that Vince will have the opportunity to further report on his findings either through module 4 or through a paper reviewing the findings and in particular the student perceptions of the feedback received. "

I appreciate Phil's kind comments and in particular his understanding of my willingness to take risks. Given the amount of research undertaken and the multiple locations of evidence for the effectiveness of my methodologies I do not consider this as risky endeavour (although it would have indeed been easier to use a classical approach). Instead, I feel that I have simply asked myself: 'if I had no preconceptions with regards to teaching and learning how would I deliver this course?'.

Phil's particular suggestions and concerns are all gratefully received:

- Ensuring a sound understanding of what is expected of the students is indeed important. I have to ensure that I communicate not only to the students but also to the tutors. This is something that I have had to deal with during the first few weeks of the course: some tutors had not quite understood what was expected of the students. After a couple of meetings and discussions this has been addressed and I am aware of how to ensure this is all well communicated to the tutors and students next year.
- Catering for students who are very comfortable in the course is something that I have also thought of. Although I am glad that Phil mentions it here as I've been concentrating on evidencing that students with difficulties won't be left behind by my teaching approaches. There are various programming projects that I have put on offer to students through the recommended reading list that contains more advanced books.
- Phil also raises very valid concerns as to the workload issues associated to the tutors. Having larger labs is not a possibility at the moment (due to classroom size in the School of Mathematics) and it is already quite intense for the tutors. Based on my discussion with Phil I will think about the possibility of having extra tutors to ensure that a more efficient process. Peer instruction is already encouraged throughout these sessions: for example if a particular exercise is causing difficulties to students, they are encouraged to work in groups to solve it.
- It is very encouraging that Phil would like to hear of how my delivery works out. I plan on evaluating its effectiveness over a series of years and so will hopefully be able to report on my findings, either informally or through a more formal approach such as a publication.

PCUTL - Module 3:
Response to Peer Review by Peter Burnap

Vincent Knight

> "Vince chose to focus on feedback in the peer review, with a particular emphasis on the flipped classroom pedagogic model that he is using to deliver a new first year module. From a feedback perspective, the flipped model ensures a continuous feedback loop between the teacher and their learners. It moves from content being delivered in contact sessions with practice at home, to the content being studied outside the classroom with structured practice sessions during contact sessions. Context and theory is discussed (as opposed to delivered) in interactive lecture slots."

This was a valuable peer review as Pete has a lot of experience with teaching programming. Given the nature of my module it is more akin to a computer science course than a mathematics course and as such his opinion was appreciated.

> "My first question was whether the students (particularly in year 1) would be willing and able to undertake the understanding of content outside the classroom so that a useful and interactive discussion could take place during the timetabled contact session. The is a clear risk here that some students will not engage with this approach and will struggle. While some students who do not attend lectures still achieve a pass overall by learning from the course notes, one would expect that in a flipped classroom students may not have access to the same type of materials as a traditional lecture. The answer to this question was very interesting. Vince has devised a series of 'tick box' evaluation measures that are very quick to measure. Students are expected to demonstrate their achievement of relatively simple skill-focussed tasks in lab sessions (less than one minute per student) to a lab tutor who ticks the box for this student and records each students achievement on a Google Doc spreadsheet. This is an excellent use of collaborative technology as it allows Vince to get an at-a-glance view of student progress. He showed me the spreadsheet and it is clear to see where the minority of students have failed to engaged. The motivation to engage is that 10% of the overall mark would be deducted for non-engagement with lab exercises. Vince was clear that only extreme non-engagement would result in the loss of 10%. On reflection it may be worth him considering what would happen if one day questions arose as to how the engagement would be quantified i.e. how much do I 'have' to do before I achieve the marks?"

I enjoyed talking over the tickable system with Pete and the incentivisation that he mentions is at the forefront of my concern with this. The point he raises about how to quantify 'engagement' is an extremely important one. I had not considered this until the point was raised by Pete. Currently tutors are told to use their subjective judgement but perhaps in future years I will need to put in place guidelines that would not only help tutors but also be transparent to the students. Furthermore in future years I will be using 2nd year students as tutors and so I think this approach could be helpful.

> "A further question was related to how students who clearly didn't engage were managed. From the spreadsheet Vince is able to identify students who have not engaged during any week/month and send them a targeted email asking them to come and see him to discuss their non-attendance/engagement with the lab tasks. They would then be expect to come and see him during scheduled 'office hours' where he has set aside two hours per week for students (engaged

> or not) to drop in and discuss any issues they are having with the work. So far this has been successful but it is worth considering what would happen if 30-40 students all turned up to his office for this. The office hours are supplemented with an excellent provision of 'feedforward' videos where anticipated problems relating to each 'tickbox' task are discussed and guidance on how to demonstrate achievement of the anticipated learning outcomes of the task. This provides a range of options to students who may or may not want to speak to the lecturer on an individual basis, or who would prefer to work at night etc. It is another example of innovative use of technology in support of inclusive and diverse learning methods.
>
> Thus Vince has provided a range of opportunities for feedback that offer different options to students based on their desired method of interaction. Feedback is given in contact sessions (lectures and labs), and in one-to-one sessions during office hours. Feedforward is also given via video snippets."

Thankfully the numbers for these students are quite low and I seem to be able to manage with both of them through office hours, however I need to entertain the possibility of a large number of students needing assistance. If this occurs I imagine that the students would have a common problem and as such I could possibly take them to a lab and give an impromptu lecture. This is something I need to think about further. Pete's kind words with regards to the videos are also appreciated.

> "One further point on feedback was that of inclusivity of people with impairments. Vince noted that to demonstrate achievement of 'tickbox' tasks, the students need to explain their work to the lab instructor. He found that in one case the student felt uncomfortable and unable to do so, and he quickly identified an alternative method whereby demonstration was achieved by communicating with another lab tutor (not the main lecturer). I have found that the involvement of another tutor who is seen more in a supporting role as opposed to the main lecturer is an important inclusion in an international classroom where, for some cultures, it is not normal for the student to question the teacher. This stems intellectual debate somewhat in a discursive environment so involving an informed tutor can be useful to include these students. "

Pete raises a very important point that I have not been able to address fully in my portfolio so far (I have discussed some issues with regards to inclusivity on socio-economic grounds in the concluding portion of my essay). The one anecdote that Pete mentions I feel was handled well and I have since discussed this with the student in questions and have agreed to carry on with the current arrangement. I have made clear that if the student ever does feel like talking directly to me they are very welcome to. With this question Pete has ensured that I also consider further aspects with regards to disability. In my reactive lectures I try to ensure students stand up and take part in various role playing exercises: I need to be cautious with this if and when students with disabilities affecting their mobility are in my class. Of further concern will be the provision of computing facilities in the case of students that are perhaps blind. I should also ensure I make efforts to include sub titles for my videos in the case of students with hearing difficulties. These are all reasonable adjustments that I will make if and when the need occurs.

PCUTL - Module 3:
Peer Review of Phil Anderson

Vincent Knight

1 General comments

The subject of this peer review was module design. In particular the re-design undertaken by Phil for 'EN2705: POWER ENGINEERING 3' a second year module.

Our discussion began with the fact that Phil has his hands bound somewhat and is not only unable to make changes he wants due to university regulations but also due to accreditation. This is an aspect of course design that I have not had to worry about as there is no accreditation body for mathematics.

Due to these restrictions the changes Phil has planned are to be done in stages.

I will discuss my understanding and opinions on these modifications and conclude with some queries and concerns. Importantly, before beginning I would like to state how impressed I am with Phil's engagement with the underlying pedagogic notions linked to learning outcomes of his module.

2 Linking syllabus to learning outcomes

It seems that EN2705 has evolved over time to a module that (in my non-expert) opinion no longer suits the purpose for which it is designed. Phil presented me with the previous (prior to Phil's modifications) module description and it is quite interesting to see that the learning outcomes do not seem to be matched to the syllabus.

As a result Phil has redesigned the module with an alignment between learning outcomes and syllabus. The result of this seems (to my eyes) to be a well aligned module. Furthermore, the analysis of the learning outcomes in view of Bloom's taxonomy was a great thing to see. It now seems that the course is much more level appropriate.

If I was to voice one minor concern it would be how this now fits in the rest of the programme? Perhaps the slight change of syllabus will have effects on the rest of student progression?

3 Pedagogic theory

Another aspect of Phil's modification includes a great consideration of the variety of learning styles he is likely to come across. In particular I approve of his dissemination of a full set of notes at the beginning of the module. This allows students with difficulties to read ahead in time for the lecture but also students who want to speed ahead to do so.

Further modifications which are in line with my preferences for pedagogic practice include a reduction in the number of lectures and an increase in the number of tutorials.

This has all been very well thought out and Phil should be commended on this modifications being based on sound pedagogic theory and not arbitrary decisions.

4 Further plans

All of the above are the first phase of Phil's planned changes. The second phase is noteworthy and I'd like to spend some time discussing it here. In particular the proposed changes will need to gain approval from the accreditation body.

Phil plans to involve more industrial talks (in his modified course, an industrial talk is given). I was surprised to hear that when this talk was given it increased student engagement. In my experience I have often seen students disengage with anything that is 'not on the exam'. Perhaps this was due to the speaker himself and as such I'd suggest that Phil ensures that if more speakers were to be used that they should be 'good speakers'. I plan on using some industrial speakers in the second half of a module I am teaching and might seek some advice from Phil on the subject.

One final aspect in Phil's future plans revolves around the change of locus of information delivery. Phil suggested the use of videos and/or other means. I commend Phil and fully back this idea. I would just raise a capacity issue related to this plan. Designing videos for this purpose takes a very large amount of time.

5 Suggestions and conclusions

I thoroughly enjoyed this discussion with Phil who seems to have a great number of ideas. Importantly, it seems that a lot of what Phil has decided to do is based on official subject standards: QAA Benchmarks for Engineering. Phil has obviously given thought to 'what it means to be an engineer' and this even led us to a discussion on what would be an ideal assessment. In particular Phil talked about the possibility ('pipe dream') of using portfolios instead of exams. I don't know why but I feel cautious about this. I completely understand that this discussion was hypothetical and so I will continue to talk about this in that vain. I feel perhaps that Phil would face a lot of barriers to implementing a full portfolio style of assessment. Having said that perhaps I am just clinging to 'the way things have always been done' and it is important to constantly question methods of teaching and learning.

There are other barriers of concern that come with certain changes that Phil plans on implementing. In particular I wonder how Phil will balance student expectations and/or the pressures related to the NSS standards expected by the University. This is a difficult balance for us all as educators. Students might indeed 'prefer' certain pedagogic models whilst they are not necessarily the best possible model for them. Evidencing the benefits to the students of any innovative pedagogic model is a difficult task.

Overall I think that Phil is doing a great job with this redesign.

PCUTL - Module 3:
Peer Review of Peter Burnap

Vincent Knight

1 General comments

The subject of this peer review was 'real-time' formative feedback for a 20 credit level 7 module called: Security Techniques. In particular we discussed the 'ethical hacking' aspect of the module taught by Pete.

Pete discussed not only aspects relevant to this portfolio but also some aspects of the module content which I found really interesting!

The MSc program Pete teaches is quite similar to the MSc course on offer here in so much as that it is delivered through intense single day bursts. This in itself brings with it various challenges that I feel that Pete has been able to address very well. I will discuss this in general before giving some suggestions and conclusions.

2 Handling a variety of abilities

Pete is faced with students from a variety of disciplinary backgrounds. As such he has the difficult task of teaching some quite complex computational techniques to some students who have no (or very little) knowledge of communicating with a computer. This draws some interesting parallels with the MSc in OR offered at the School of Mathematics where some of our students do not have basic knowledge of mathematics. We have addressed this through the use delivery of basic knowledge during the induction week of the course. Pete however has addressed this by a careful and timely iteration through basic concepts up until all students are up to speed.

3 Assessment of individual learning

There is a constant and timely feedback loop in real time between Pete and his students, this is mainly achieved through small group discussions after tasks have been completed. This has been very well thought out and furthermore allows for group and peer learning. The feedback is also able to be given on an individual level as Pete ask individual questions to all members of the groups. I have a slight concern as to ensuring that students recognise that this is indeed feedback but I will return to this at the end of this peer review.

4 Disengaged groups

One aspect with regard to the group is the potential for groups who have had their discussion with Pete at the beginning of the session. Chatting with Pete, this is something that has already been considered and he

will be having some further pieces of work for students to not be bored. Perhaps a further possibility would be to encourage students who have finished their work to engage in peer instruction (helping students who have not finished yet).

5 Suggestions and conclusions

One aspect of Pete's planning that I have not discussed yet is how he aligns student expectations with their learning experiences. A session at the beginning of the class involves gathering student expectations from the students in class and comparing these to the ILOs. I think this is a great way of doing things and I will consider implementing something similar in my own teaching.

One final aspect of consideration and relevant to Cardiff University's goals achieving high NSS scores is the importance of ensuring that all the feedback that is taking place throughout Pete's instruction is recognized as such. I think Pete is doing a great job ensuring there is a timely and relevant feedback loop in place. Often though, feedback is interpreted by students as implying some written feedback. Ensuring that students recognise feedback for what it is, is something I suggest Pete considers carefully.

VK - Module 3 Supplementary materials

Vincent Knight

There are a large quantity of teaching materials, lesson plans and other documents relevant to this portfolio as such I include the urls here.

1 Lesson plans

I have written lesson plans for every week of the first semester of MAT1003:

- Week 1: `http://drvinceknight.github.io/Computing_for_mathematics/Lesson_Plans/Week_01.html`
- Week 2: `http://drvinceknight.github.io/Computing_for_mathematics/Lesson_Plans/Week_02.html`
- Week 3: `http://drvinceknight.github.io/Computing_for_mathematics/Lesson_Plans/Week_03.html`
- Week 4: `http://drvinceknight.github.io/Computing_for_mathematics/Lesson_Plans/Week_04.html`
- Week 5: `http://drvinceknight.github.io/Computing_for_mathematics/Lesson_Plans/Week_05.html`
- Week 6: `http://drvinceknight.github.io/Computing_for_mathematics/Lesson_Plans/Week_06.html`
- Week 7: `http://drvinceknight.github.io/Computing_for_mathematics/Lesson_Plans/Week_07.html`
- Week 8: `http://drvinceknight.github.io/Computing_for_mathematics/Lesson_Plans/Week_08.html`
- Week 9: `http://drvinceknight.github.io/Computing_for_mathematics/Lesson_Plans/Week_09.html`
- Week 10: `http://drvinceknight.github.io/Computing_for_mathematics/Lesson_Plans/Week_10.html`

2 Lab sheets and handouts

All the lab sheets can be found here: `http://drvinceknight.github.io/Computing_for_mathematics/`.

3 Videos

There are links to all the videos for the course from the above page but they can also be found here:

- Week 2: http://www.youtube.com/playlist?list=PLnC5h3PY-znwZCtyKG1UQASpZ9mRkEIJo
- Week 3: http://www.youtube.com/playlist?list=PLnC5h3PY-znxclcsx-JIwgFqGTXMdItOH
- Week 4: http://www.youtube.com/playlist?list=PLnC5h3PY-znyEYYOnDbQHq1PUuNgbhdD3
- Week 5: http://www.youtube.com/playlist?list=PLnC5h3PY-znwesme9fiK-kZZ-DUOJF9l_
- Week 6: http://www.youtube.com/playlist?list=PLnC5h3PY-znyytHl2YQjE41o-TdfewmKr
- Week 7: http://www.youtube.com/playlist?list=PLnC5h3PY-znz1cih4_2b7QvVZaqPnE7m4
- Week 8: http://www.youtube.com/playlist?list=PLnC5h3PY-znzwLePTdmDWDCKJse3omJe5
- Week 9: http://www.youtube.com/playlist?list=PLnC5h3PY-znzOZOAOVo6k_b-zDxjBr-x4
- Week 10: http://www.youtube.com/playlist?list=PLnC5h3PY-znygZ2rYNaX7_8j2Duwh58cK

4 Group presentation

The group presentation slides can be seen here: https://docs.google.com/presentation/d/138OJ4Y_xFMyLEKWDxF3uHgZ1YAkzKXObQnGlvFBTVF4/edit?usp=sharing.

A video of the group presentation can be viewed here: http://www.youtube.com/watch?v=soUWEQUVYzg.

Understanding the perceptions and factors that influence student engagement with formative assessment in mathematics education.

PCUTL Module 3 Group Project

September 2013

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1 Introduction

Assessments are an integral part of the student experience in HE, mostly as a means to both judge academic performance and monitor student learning in HE and both QAA (QAA,2011) and Cardiff University (Cardiff University) developed specific documents for assessments . Cardiff University Assessment Strategy in the very first line highlights how the purpose of assessments is to help staff and students to monitor and improve learning.

While QAA Assessment Strategy focuses mainly on summative assessments (whose first purpose is to monitor learning), in our project we have decided to put our attention on formative assessments. Whilst summative assessments award a grade, i.e. a judgement on performance formative assessments can be used to monitor learning/the attainment of ILOs etc. Both types can be used to monitor learning in some sense, but the clear distinction is that the summative one results in a grade that is used to judge student performance (Irons, 2008)

Formative activities play a key role in learning mathematics. Practising through solving problems and trying things out without pressure are essential to develop mathematical and computational skills and to gain new knowledge by applying the theoretical notions and techniques introduced during lectures to specific cases. This is especially true for formative exercises that students are often offered as part of their non-contact time activities.

A plethora of studies at all stages of education and across a broad spectrum of disciplines support the view that formative assessments are beneficial for student learning (see, for example, the seminal work of Black & Wiliam (1998) who conducted a thorough review of the literature on the subject). Yet, we have routinely observed in our teaching and discussion with colleagues that very few students actually engage in formative activities outside the classroom. One of the primary reasons is the so-called hidden curriculum (Snyder, 1971), where students tend to focus their study on what is assessed, or, rather, what they perceive the assessment system to require. Hence, students use their time strategically and are ‘selectively negligent’ in avoiding content that they believe is unlikely to be assessed (Gibbs & Simpson, 2004-05). Even worse, students can become less willing to devote non-contact time to study for things that do not contribute to the final mark or if they perceive they are not getting any reward for engaging in those. As a result, an appreciable number of students seem to bunch all their learning hours together in the time immediately preceding the final exam, which naturally does not lead to same type of learning both in terms of quality and future retention compared to the type of learning that occurs if a student engages with coursework consistently throughout the term (see Gibbs & Simpson, 2004-05, and the references therein).

The quick fix for the lack of student engagement in formative activities would be to make them summative with some formative intention, e.g. through the provision of feedback. However, if we rely too much on assessment to motivate our students to work it can potentially lead to surface learning approaches. While the importance of motivation to engage in formative activities is widely acknowledged, it can only be partly cultivated by the lecturer; for the most part, motivation to engage in learning should come from within the students and their aspirations for their future. Besides, part of our goal as academics is to help students develop the capacity to act autonomously in a self-regulated manner (Yorke, 2003) and formative activities can be viewed as a means towards attaining this goal.

This project reviews some of the literature on formative assessment and reports on a study into students' conceptions of assessment in mathematics through a questionnaire administered to students in the Schools of Engineering and Mathematics which generated a large statistical sample with over 200 respondents. By gaining an understanding of their preferences, the ultimate aim is to best inform our teaching practices and assessment strategies so that more students engage with formative activities.

2 Methodology

A questionnaire (shown in full in appendix 1 and in screenshot in figure 1) was designed using Google Drive Forms which could be administered online and take approximately 5 minutes to complete. Students from all years and schemes of study in the Schools of Engineering and Mathematics were invited to complete the form anonymously by email (following ethical approval from both schools). Respondents were invited to enter their email address into a prize draw for a £20 Amazon voucher in order to encourage participation.

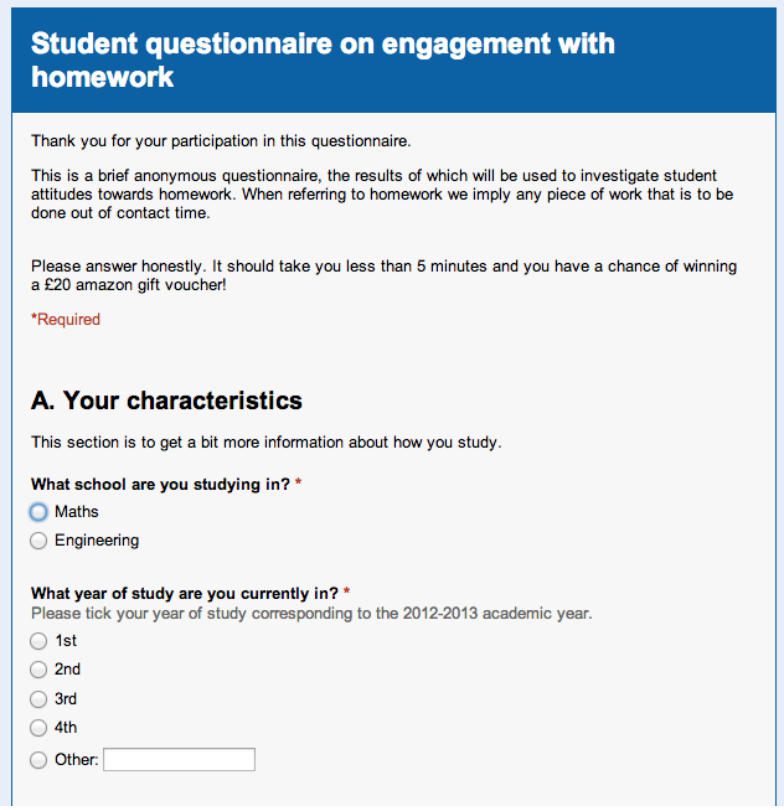

Figure 1: Screenshot of the questionnaire on Google Drive

The form was divided into 4 sections. Section A was designed to elicit details of the student and their characteristics with regard to homework (or work during non-contact hours), in particular the amount of time spent on these activities.

Section B questioned the students on their attitudes and perception of homework. The rationale behind this section was twofold. Firstly, to gain understanding of the students' perceived

benefits from completing non-contact time activities. Secondly, to try to discover the motivating factors required to engage the students in homework. All questions in this section were answered on a Likert scale ranging from strongly disagree (1) to strongly agree (5).

The questions in section C focused on highlighting the attitudes towards formative homework activities and once again were designed to discover the motivations required for engagement.

Finally section D contained 1 question inviting the student to select a single element from a list that would make formative homework activities most appealing.

3 Results and Analysis

3.1 Responses and distribution

The data file contained 205 responses to 28 questions asked to students from the schools of Engineering and Mathematics. The responses were equally distributed between the two schools with the distribution shown in figure 2 across the years of study. To allow for a certain level of comparison between the schools, it was decided to consider all Masters (MENg and MMath) responses as 4th year courses and also to not consider the MSc and Foundation respondents (not coherent across schools).

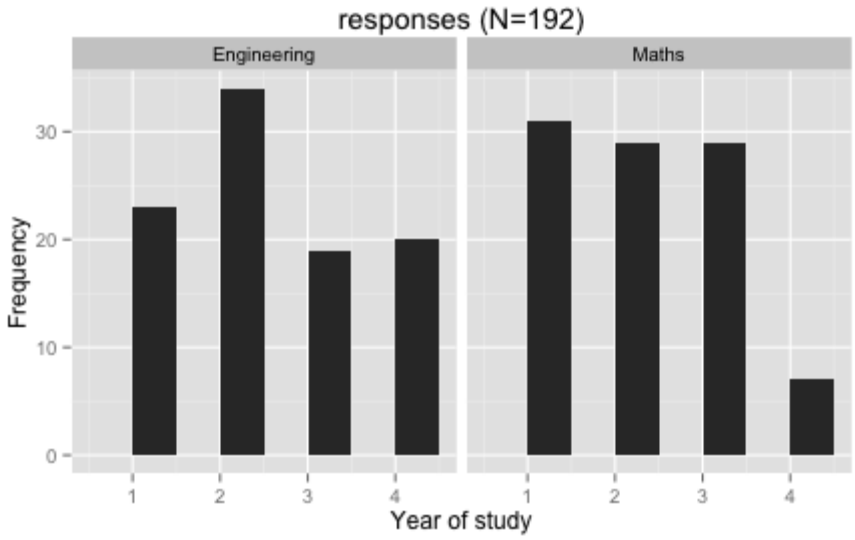

Figure 2: Distribution of responses between schools and years of study (MSc and Foundation not displayed)

The distribution across the years of study is a good representation of the real distribution of students in the School (e.g very few MMath students, and reasonable uniformity for years 1, 2 and 3) increasing the likelihood of the results offering a fair picture of the perception of all students in the two Schools. Results on perceived academic performance also mirror the distribution of degree classification which further increases confidence that this a representative

sample

The data and analysis presented below is a subset which is relevant to the discussion and conclusions later in this report. The complete data set is available digitally and will be distributed with this report.

3.2 Correlation between variables

An initial correlation investigation was carried out in an attempt to identify any statistically significant relationships between responses to questions which could be represented as numeric variables (for example, the school is not considered), shown below.

```
##  [1] "year"
##  [2] "average_self_study_hours"
##  [3] "self_described_academic_performance"
##  [4] "compulsory_hw_completion_percent"
##  [5] "non_compulsory_hw_completion_percent"
##  [6] "completing_hw_led_to_an_improvement_of_final_mark"
##  [7] "completing_hw_helps_understanding_material"
##  [8] "more_likely_to_do_hw_if_marked"
##  [9] "more_likely_to_do_hw_if_counts"
## [10] "more_likely_to_do_hw_if_aware_of_time"
## [11] "more_likely_to_do_hw_if_timetabled"
## [12] "more_likely_to_do_hw_if_mcq"
## [13] "more_likely_to_do_hw_if_was_going_to_recieve_feedback"
## [14] "more_likely_to_do_hw_if_linked_to_employability"
## [15] "more_likely_to_do_hw_if_past_exams"
## [16] "non_marked_hw_is_helpful"
## [17] "more_likely_to_do_non_cumpolsory_hw_if_peer_assessed"
## [18] "more_likely_to_do_non_marked_hw_if_they_were_shorter"
## [19] "more_likely_to_do_non_marked_hw_if_would_improve_overall_performance"
## [20] "more_likely_to_do_non_marked_hw_if_to_be_done_before"
## [21] "more_likely_to_do_non_marked_hw_if_online"
## [22] "mostly_care_about_mark_received"
## [23] "adequate_feedback"
## [24] "hw_helps_identify_strengths_and_weaknesses"
## [25] "more_likely_to_do_hw_if_group"
```

The result of this analysis is conveniently represented graphically with the correlogram shown in figure 3.

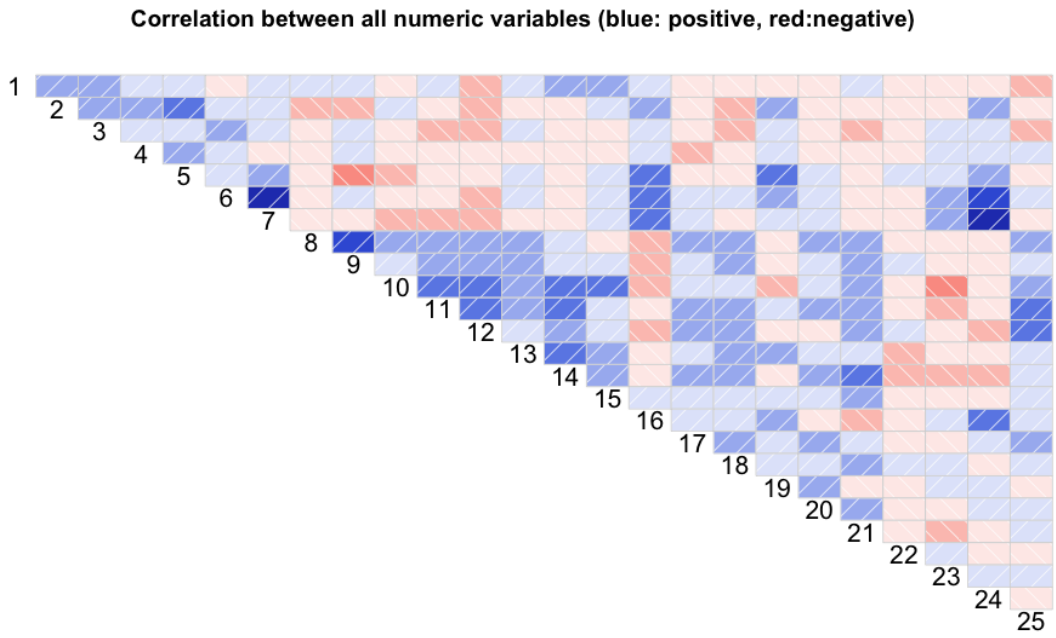

Figure 3: Correlogram of numeric responses to questionnaire

Blue shading represents a positive correlation and red shading, a negative correlation. So for example we see that variables 6 and 7 are positively correlated. Recalling the variables this is to be expected as it is shows that students who agree/disagree with the statement "homework leads to better understanding" also agree/disagree with the statement "homework helps with obtaining a better mark".

In the the remainder of this section we will investigate whether or not correlations observed on the correlogram are statistically significant. The significance of correlations are tested using two well known coefficients. The Pearson Correlation Coefficient (r) has a value between -1 and +1 where 1 is a perfect positive correlation, -1 a perfect negative correlation and 0 no correlation. The p-value tests the null hypothesis, i.e. the probability that the correlation between variables was coincidental. A p-value of less than 0.05 (5%) indicates that correlations are statistically significant.

Correlation between variables 6 and 7:

A positive correlation coefficient of 0.561 with a p-value of 2.2×10^{-16} shows that students who feel that homework helps with marks will also feel that it helps with understanding and importantly vice versa. An immediate implication of this is the need to encourage students to understand the relationship between understanding and marks as well as homework and understanding.

Note that these two variables are also correlated to whether or not students feel that homework helps identify strengths and weaknesses. (Correlation between 6 and 24: $p = 1.24 \times 10^{-4}$, $r = 0.52$; Correlation between 7 and 24: $p = 3.71 \times 10^{-16}$, $r = 0.54$)

Correlation between variables 8 and 9:

A correlation coefficient of 0.4952 with a p-value of 2.9×10^{-13} again shows a significant positive correlation between whether or not students are more likely to do homework if it is to be marked and if it counts towards their final mark.

Various other observed correlations were considered but none were found to be statistically significant.

3.3 Correlations with student profile

In this section particular attention was given to the following statements:

1. Non marked homework is helpful to me;
2. I mostly care about the mark received;
3. I am more likely to do homework if it is linked to employability;
4. I am more likely to do homework if it is to be done before a lecture on the subject;
5. I am more likely to do homework if it is to be done in groups;
6. I am more likely to do homework if it contains past exam questions;
7. I am more likely to do homework if it is to be peer assessed;
8. I am more likely to do homework if it can be completed online.

Responses to the above were considered against various dimensions which profiled the student.

1. Year of study;
2. School of study;
3. How good I consider my academic performance to be;
4. I feel that the feedback I have received has been adequate;
5. How many average hours a week I spend self studying;

3.3.1 Non Marked homework is helpful to me

This statement is quite an important one as positive responses indicate that students are aware that non marked homework has a positive effect on their work. The mean score for this statement was 3.3854 indicating a slight trend towards a positive result.

The distribution against school of study is shown below (the mean value is shown in red):

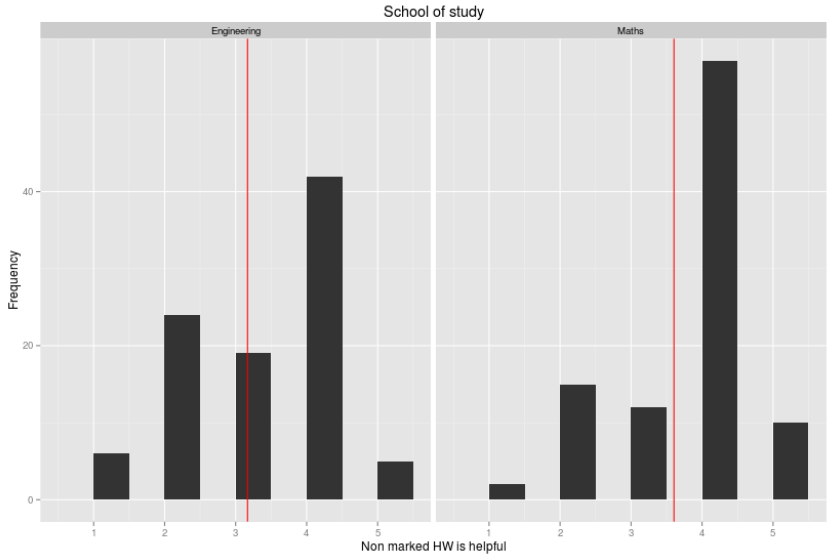

Figure 4: Non marked homework is helpful to me by school

We see that students from the School of Mathematics seem to find non marked homework slightly more helpful (an average of 3.6042 versus 3.1667). This difference is statistically significant (as the Kruskall-Wallis test gives a p value of 0.0026).

There is only one further factor that seems to affect this (in particular the year of study or academic performance seem to have no effect): the amount of time that students spend on self study (figure 5). It seems that the response increases with the amount of time spent self studying. This is confirmed to be statistically significant with a p-value of 0.014. The perceived adequacy of feedback does not have an influence on this parameter.

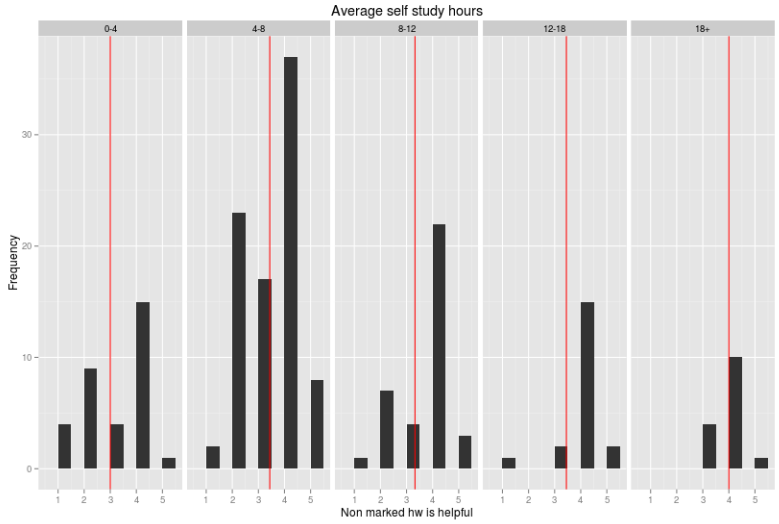

Figure 5: Non marked homework is helpful to me by number of hours of self study

A difference was identified between schools of study (with students from the school of Mathematics finding homework more helpful than students from the school of Engineering). Further analysis (Figure 6) shows that there is a significant difference between between Maths 2nd year students and the rest (p-value of .02). Students find homework less helpful in their second year. Interestingly this is also the year of the mathematics degree scheme during which students have less summative assessment.

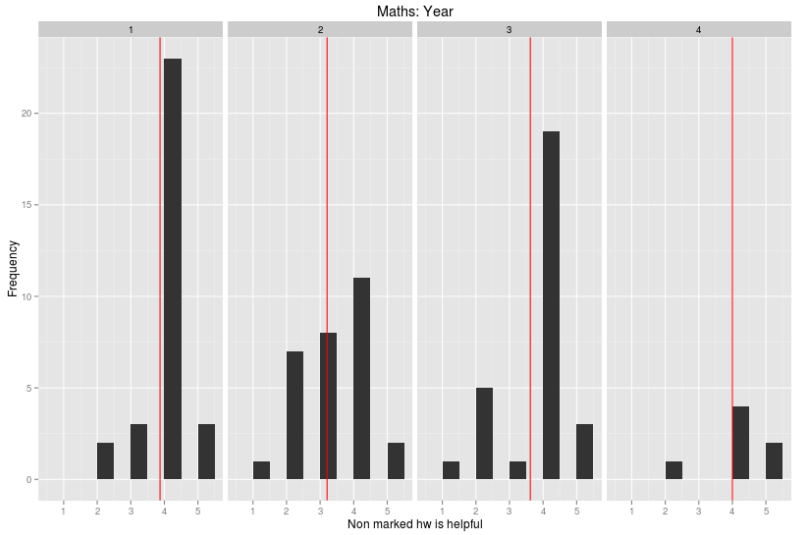

Figure 6: Non marked homework is helpful to me by year of study for Maths students

To summarise:

- Student opinion does not change across years (slight difference for Mathematicians);
- Student opinion does not change across perception of feedback;
- Student opinion does not change across academic performance;
- Students who spend more time self studying find homework more helpful.

3.3.2 I mostly care about the mark received

This statement is motivated by the general perception that students care more about a mark than about feedback. A mean score for this question of 2.78 is inconclusive and the responses to this question to not seem to be significantly affected by any of the dimensions considered.

3.3.3 I am more likely to do homework if it is linked to employability

The current landscape of student interests in education and a growing call for employability skills to be embedded throughout the curriculum led to the inclusion of this question which gave a mean score of 3.33.

The distribution of the responses separated by each school is shown in figure 7.

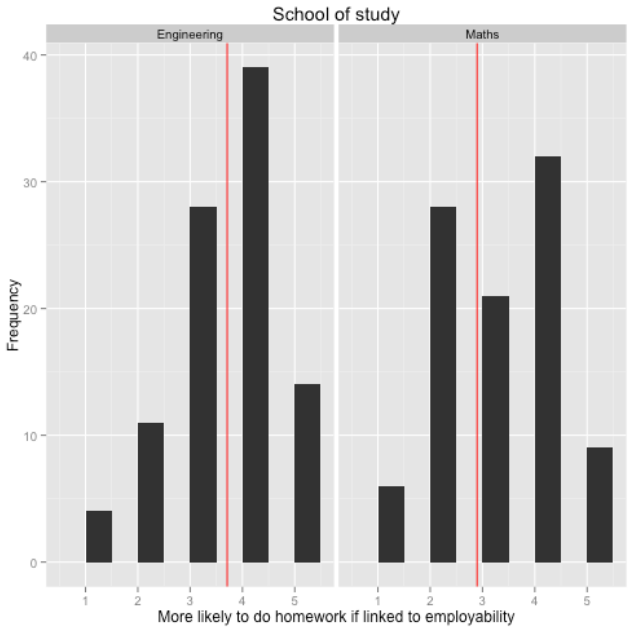

Figure 7: I am more likely to do homework if it is linked to employability by school

A statistically significant difference between the schools, p-value of 2.5×10^{-7}, becomes apparent (a bi-modal response is seen for mathematics students with some claiming that employability is less likely to make them participate in homework).

No other factors seem to affect students responses to this statement.

3.3.4 I am more likely to do homework if it is to be done before a lecture on the subject

This statement is in line with certain constructivist teaching methodologies which include flipped classrooms. The mean response for this question was 2.87 with the distributions by school shown in figure 8.

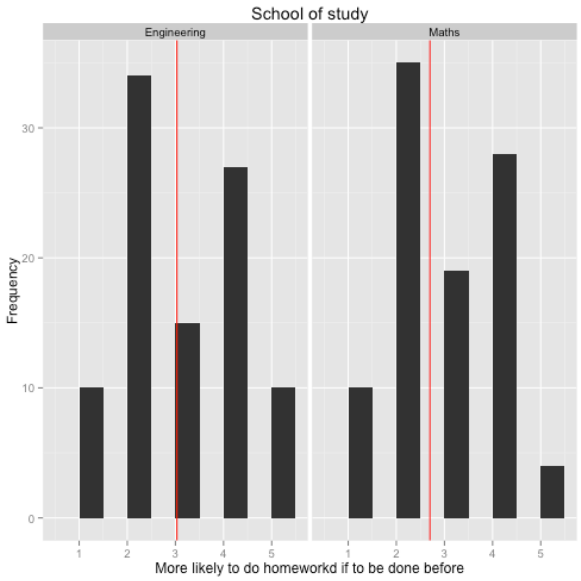

Figure 8: I am more likely to do homework if it is to be done before a lecture on the subject by School

We see that engineering students seem slightly more likely to do homework before lectures on a subject (with a p value of 0.0492 on the Kruskall-Wallis test) but further analysis failed to reveal anything of significance.

3.3.5 I a more likely to do homework if it is to be done in groups

The emphasis on group work is investigated through this statement. The mean score of 3.39 indicates a tendency that students are more likely to do homework if it is to be done in groups. This trend is not uniform across the years of study.

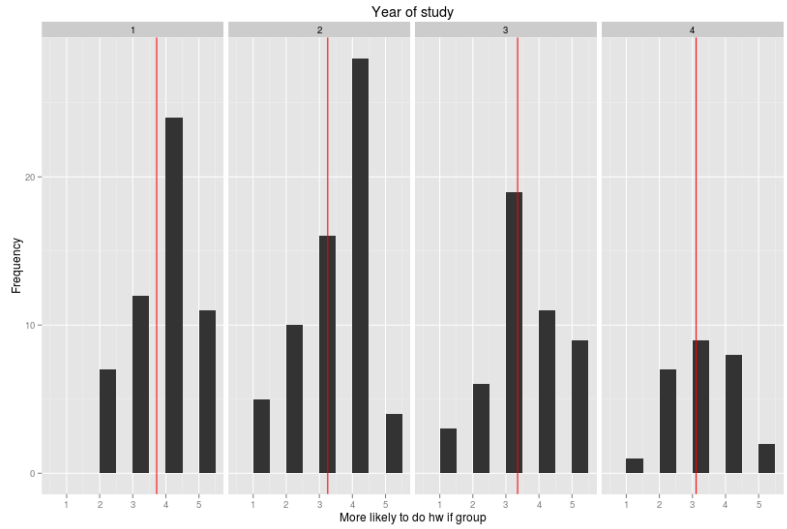

Figure 9: I am more likely to do homework if it is to be done in groups by year of study

There is a statistically significant difference between year groups (a p value of 0.0422) and a further multi criterion test shows that there is a difference between year groups 1 and 4 showing that as students progress through their education they become less favorable to group work. There seems to be no difference for this particular aspect with regards to school of study however, self described academic performance does have an effect (a p value of 2.1174×10^{-4}) as shown in figure 10. A further multi criterion test shows stronger students are less likely to want to work in groups.

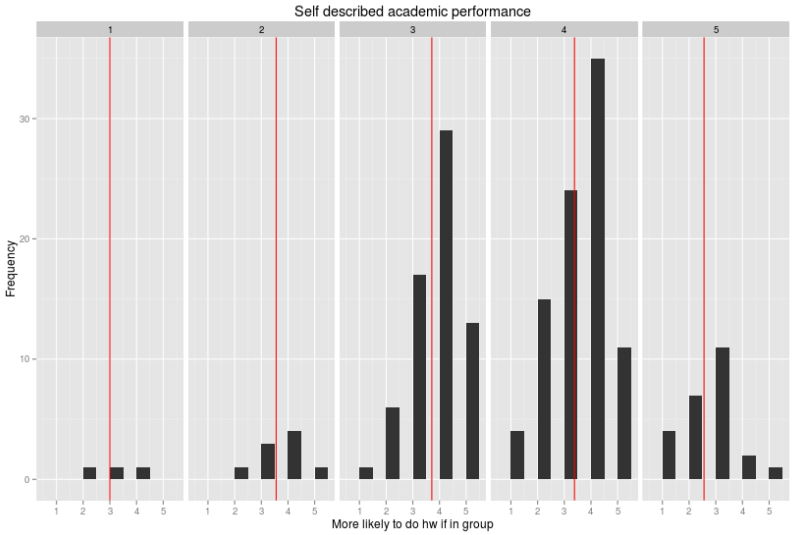

Figure 10: I am more likely to do homework if it is to be done in groups by self described academic performance

In summary:

1. Stronger students are less inclined to want to do group work;
2. Students in later years do not like group work.

3.3.6 I a more likely to do homework if it contains past exam questions

It is often assumed that students 'work to the test'. A mean score of 3.95 seems to indicate that this is indeed the case. There is a very slight (but significant: p value of 0.0066) tendency for later year students to attach more importance to the exam.

No other significant effects were noted.

3.3.7 I am more likely to do homework if it is peer assessed

A mean score of 2.27 seems to indicate that students are less likely to see the benefits that are recognized in some educational literature. When considering schools it can be seen that engineering students are slightly more receptive to peer assessment as shown in figure 11 (p value of 0.0034)

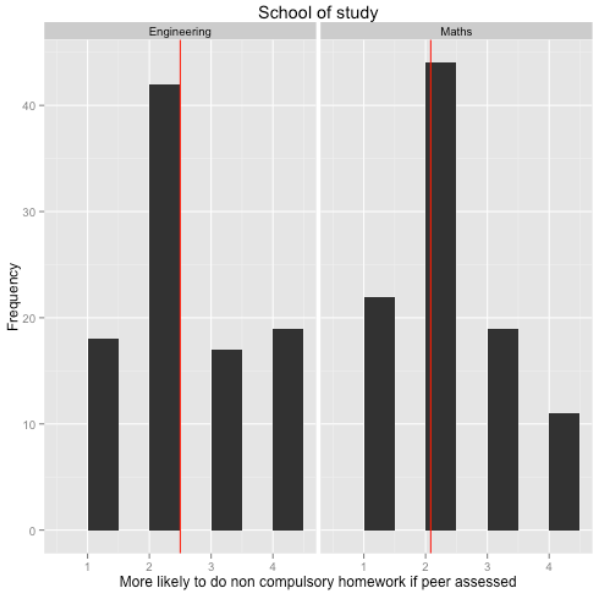

Figure 11: I am more likely to do homework if it is peer assessed by school

Furthermore it can also be concluded that students who spend more time self studying are less inclined to want to use peer assessment, figure 12 (p value of 0.0034)

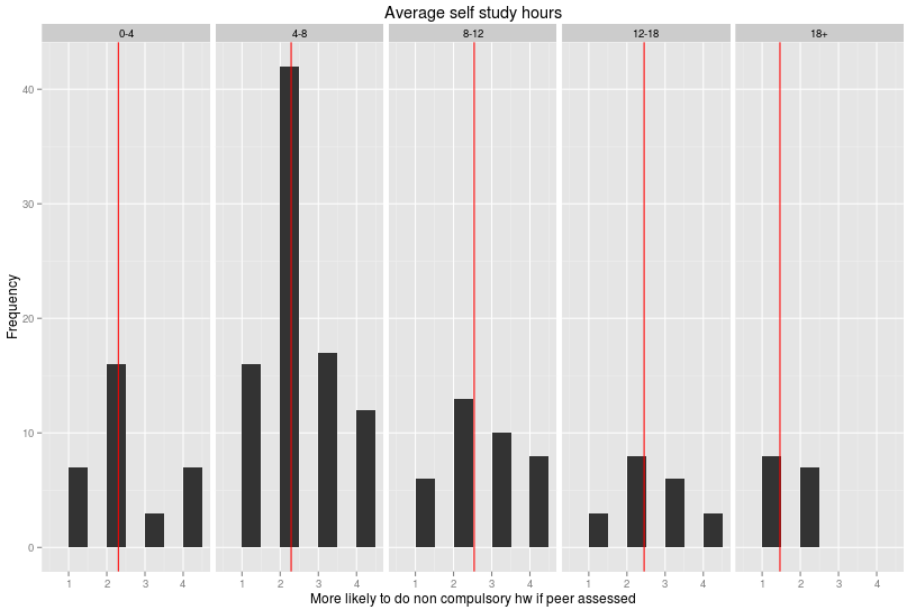

Figure 12: I am more likely to do homework if it is peer assessed by average self study hours

Interestingly, there is a statistically significant effect (p value of 0.0128) which shows that students who like group work are more likely to want to be peer assessed, figure 13.

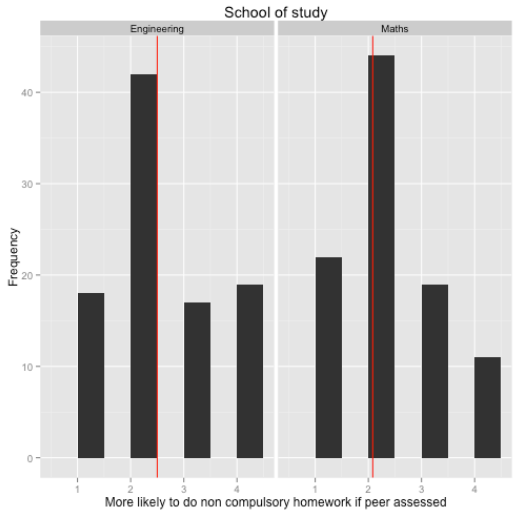

Figure 12: I am more likely to do homework if it is peer assessed by group study preference and school

3.3.8 I am more likely to do homework if it can be completed online

This last statement considered in this study aims to evaluate the attractiveness of the use of modern e-learning resources. With a mean score of 2.651 it would seem that students are not that encouraged by online resources. A significant difference is to be seen between the schools however (p value of 5.7961×10^{-6})

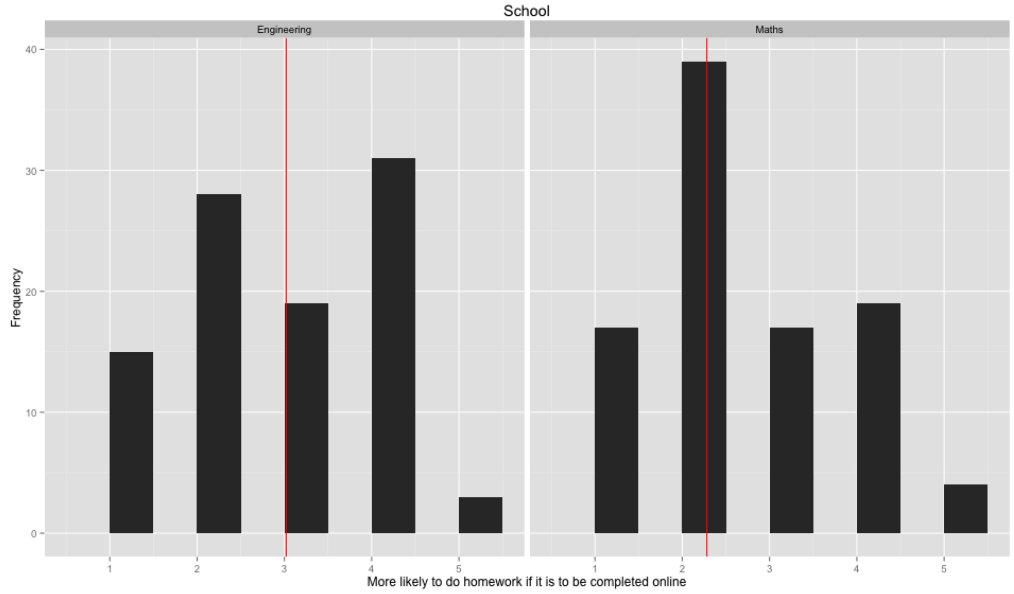

Figure 13: I am more likely to do homework if it is to be completed online by group study preference and school

3.4 Most influential factors in engaging with formative activities

Section D of the questionnaire asked students to select a single element that would make NON-MARKED and/or NON-COMPULSORY homework most appealing. The distribution of responses are shown in figure 14.

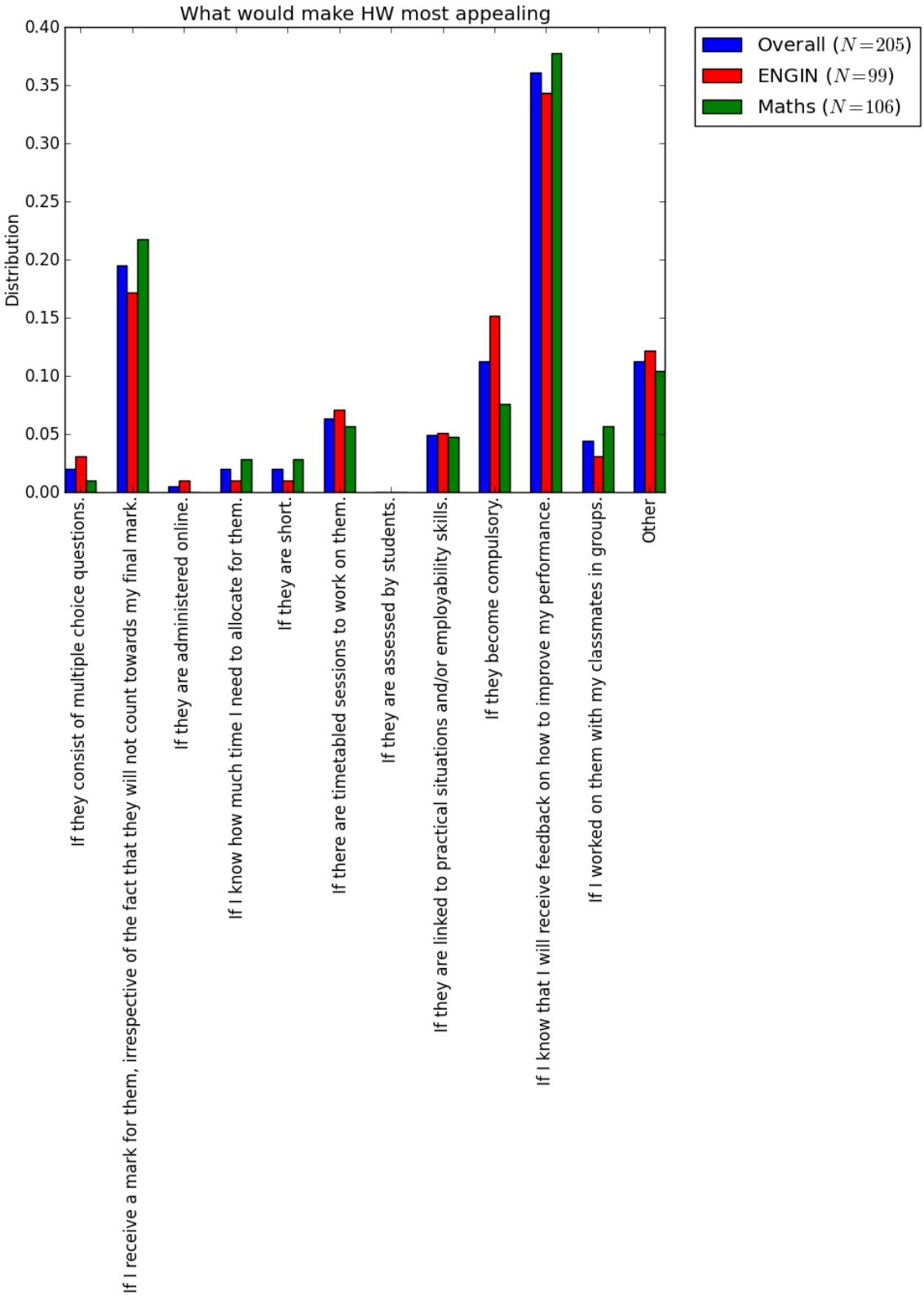

Figure 14: Student responses to "what would make homework more appealing"

4 Discussion

4.1 Interpreting Data

A more detailed data analysis of the data analysis reveals several interesting and original findings. However, it is important to first make clear the limitations of the study. The questionnaire was designed to elicit student perceptions of formative assessment in an effort to further understand the motivating factors to their engagement. The results do not necessarily imply that the methods which score strongly will be the most effective in improving the learning experience, but merely indicate student preferences. Moreover, we should also acknowledge the possibility that some students may have no familiarity with certain assessment methods. Secondly, despite the rigorous statistical methods employed in determining the significance of correlations care must still be taken in ascribing causal links.

4.2 Feedback and Formative Assessment

The role of feedback as a fundamental part of promoting student learning (QAA). In particular feedback is a key element in formative assessment (Sadler, 1989), since, as Yorke (2003) suggests, the basic principle of formative assessment is to `contribute to student learning through the provision of information about performance'. More specifically, feedback should provide students with an indication of their progress in relation to achieving the intended learning outcomes, where they need to put more effort to troubleshoot their performance to enable them to attain the expected level of learning (Nicol & Macfarlane-Dick, 2006; Irons, 2008).

The overwhelmingly positive effects that feedback has on learning compared to other aspects of teaching has been reported in the work of Black & Wiliam (1998). This is also reflected in our survey, where a large proportion of students is favourably inclined towards formative feedback. Nevertheless, while providing our students with plenty of quality feedback is highly desirable, it can become unrealistic when teaching large classes and the lecturer is solely responsible for this task. Hence one of the major challenges in feedback provision is managing the whole process so that the lecturer's workload is not dominated by creating feedback. Besides, a related important issue has to do with the timeliness of feedback: if feedback provision takes a long time, it can become ineffective, especially when students have moved to new material and feedback is no longer relevant to their ongoing studies, thus becoming unlikely to be acted upon (Gibbs & Simpson, 2004-05). More importantly, no matter how much effort is invested in providing feedback, it is not always the case that students benefit from feedback, especially if it is not constructive and explicit, if it is not understood by the students, if it does not provide students with an opportunity to enter into dialogue about their feedback, if it is not appropriate (e.g. providing positive feedback irrespective of the quality of the work), if it is provided merely to justify the mark the students are given and, lastly, if students do not use feedback to enhance their learning (see Irons, 2008, and the references therein). All these suggest that if providing students with feedback is indeed feasible in terms of workload, it is crucial to ensure that what

will provide will actually enhance student learning and enter into a dialogue with our students about the kind of feedback they would like to receive. Besides, once feedback is provided, it should be the students' responsibility to decide what to do with it.

The findings of this study seem to indicate that for the students in the schools of Engineering and Mathematics their engagement in formative homework activities is not influenced by feedback. This can be attributed to the way mathematical skills are assessed. Undeniably, conceptual and procedural knowledge are critical in mathematics learning (Baroody et al. 2007; Star 2007), but apparently greater emphasis is placed to assess procedural knowledge (Star 2005). Thus, feedback commonly comes in the form of identifying errors in calculations or faults in the approach undertaken and rarely identifies specific developmental needs for the student to address, losing some of its value once model solutions are provided.

A possibility could be to use the problem-solving structure of mathematics assignments to provide feedback through students' group discussions on the solutions.
Also, the use of the students themselves to provide feedback on formative assessments is an attractive alternative and warrants further discussion inside our Schools and across Cardiff University. These ideas, however, could face resistance from students which will be covered further in the later section on social learning.

The value of feedback is significantly enhanced if it is timely. When teaching large groups providing feedback before the focus of the teaching has moved on to another section of the curriculum can be difficult. The notion of the flipped classroom whereby home study takes place before the contact time teaching creates a situation where feedback can be provided in a more timely fashion. The student response to this approach did not deliver a clear indication of its value with strong positive and negative responses however there was a statistically significant difference between schools with Engineers appearing more . This is perhaps influenced by their experience with homework being given on previously learnt mathematical techniques which will be useful in upcoming classes.

4.3 Marks vs feedback

The students that participated in our survey had mixed views when they were asked whether they were interested more on the marks they are given rather than the feedback they receive. We found that a large number of students was more interested in receiving marks, which resonates with previous research on the subject (see, e.g., Gibbs & Simpson, 2004-05; Irons, 2008, and the references therein). Gibbs & Simpson (2004-05) argue that 'students can tackle assignments that are intended as learning activities so as to maximize the marks they obtain rather than maximising the learning achieved from engaging with the assignment'. When marks are absent, research has shown that students shift their focus to the feedback they receive in order to gauge their performance and read feedback much more carefully (Black & Wiliam, 1998) and this makes it more likely to use it to guide their learning. However, while it is tempting

to only provide feedback in formative work, it is important to communicate to our students the pedagogic benefits of feedback, because the absence of marks might make the formative activity less appealing to students who favour marks as a means of monitoring their progress and the degree of attainment of the learning outcomes.

This is also linked to the findings related to exam questions where a clear trend is evident showing that students become more motivated by tasks that are directly linked to their summative assessments as they progress through the years of study.

4.4 Social Learning

The responses regarding the perceptions of group working activities show clear divisions in the cohort surveyed. Giving students the option to work in self-selected groups is perhaps one of the easiest measures to implement in formative assessments and it has the added benefit of reduced marking in case a group submission is allowed. More importantly, students with different learning preferences (solitary vs group work) can engage with the activity. However, it could be problematic if there are disparities in the quality and amount of contributions from each group member. At the same time, we need to acknowledge that students who would not have otherwise engaged with the activity will have the opportunity to learn through the interactions with their peers.

Peer- and self-assessment can be a solution to cope with marking and providing feedback to a growing number of students. Drawing from related research in the literature, Gielen (2007), identified a number of benefits of peer assessment for students:
It can be used indirectly to increase social pressure on students to put more effort into the assignment.
Students receive feedback on time and it is sometimes perceived to be more understandable compared to the feedback they receive from the lecturer.
Peer assessment can be used as a tool for learning. Apart from learning by being exposed to different perspectives and ideas, students develop their abilities to understand and appreciate the usefulness of feedback.
However, there are also a number of important caveats associated with peer assessment: it can increase student stress levels due to the aforementioned peer pressure (Pope, 2001); it presupposes student engagement with the activity so that not only a handful of students out of a whole cohort participate; it will not function properly if students are not persuaded that this activity is also for their own benefit and it is not merely passing work from the teacher to the students; if students do not take the process seriously, they will not make an effort to offer quality feedback or it is also possible that students are not competent enough to offer feedback (see MacDonald, 2004-05; Sluijsmans & Prins, 2006).

Peer assessment in mathematics and engineering is perhaps more straightforward to implement, since marking is based on more or less objective criteria compared to, say, more

subjective judgements one must make when assessing an essay. It has been largely successful in a case study presented by Forbes & Spence (1991), where the authors made peer marking a course requirement for an engineering module without the marks contributing summatively. They found that students performed better than what was achieved previously, when the lecturers were doing the marking. These promising results indicate that even though peer assessment is a welcome development, at least when it comes to the workload of a lecturer, it requires a lot of preparatory work to address all the aforementioned pitfalls and takes considerable briefing, training and rehearsal if they are to be effective (Brown, 2004-05).

One of the most interesting findings presented here is the perception of social learning activities. In particular for those who spend long periods in non-contact time study. If we assume that this group represents the most engaged and motivated students then their apparent dissatisfaction with activities such as group working and peer assessment requires further attention. The literature shows clear benefits of these types of activities. However, if the students with the greatest understanding of the subject area are excluding themselves from these opportunities then their value becomes limited. This raises the question of what incentives could be provided to encourage their participation. Principal amongst these will be demonstrating the benefits of such activity through clearly communicated learning outcomes which focus on transferable skills vital for graduates.

Students also perceive the usefulness of social activities to decrease as they progress through the year groups. If we also consider that a similar pattern is displayed with the interest in exam type questions then a picture of a student who becomes more focused on their own performance begins to build. Again it is interesting to compare this with the group discussed above who fit this profile in all years of study i.e. highly focused on individual performance and blinkered as to the wider benefits offered by social engagement.

4.5 Computer-based assessment

The participants in our study had mixed views about computer-assessed assignments. Even though there seemed to be no general trend regarding their preferences about multiple choice questions (MCQs), an important difference arose when students were asked about the appeal of online formative activities. Engineering students tended to prefer online formative assessments, whereas maths students tended to favour them less. This could perhaps be indicative of a different degree of integration of computer use in the Maths and Engineering curricula with Engineering having recently been trialling online assessments for first year maths courses. Online homework would also necessarily focus on the final answer instead of the single step in the reasoning. Therefore small mistakes in computations would end giving a very low score. Moreover proof-type questions would require a huge amount of time, if completed online. Whilst this could be envisaged as penalising both groups it is understandable that maths students would have stronger negative connotations towards this approach.

It is important to emphasise that even though MCQs and online assessment tools are relatively easy to administer and assess once a carefully created question bank is available, this type of formative activities can be used primarily as a diagnostic tool to test the understanding of key principles and is not appropriate for testing high-level cognitive learning.

MCQs could therefore be used alongside traditional problem sheets in order for students to self-assess the understanding of key concepts and identify problem areas before attempting the problem sheets.

Noteworthy is also a modified type of MCQ testing, which was introduced by Garner-Medwin (2006) as a means to encourage students to think more carefully about questions by differentiating confident responses from lucky guesses. Moreover, despite the technological advances which led to the development of more sophisticated online assessment tools for mathematics (see, for example Pitcher et al., 2002; Barr et al., 2012), research on the efficiency of online testing produced mixed results (see Jenkins, 2004-05; Sim et al., 2004, and the references therein), which suggests that the design of formative activities of this type is highly non-trivial and one needs to ensure that they are fit for purpose.

4.6 Most influential factors in engaging with formative activities

The responses shown in figure 14 clearly identify two significant areas which the students surveyed felt would provide the greatest motivation to completing homework. FIrstly if they received a mark for the work which reinforces the conclusions from section 4.3 whereby students utilise marks to self assess their progress.

The largest response however was for “if I know that I will receive feedback on how to improve my performance”. This finding reflects those of the National Student Survey and the guidance from the University. However, the statistical analysis performed on the data from the previous sections of the questionnaire showed that the dimension “I feel that the feedback I have received has been adequate” did not correlate with any statistical significance to any of the responses considered, which indicates that the perception that feedback is important is not deeply held.

5 Concluding remarks

5.1 General Conclusions

Formative assessment is essentially assessment for learning. It is a developmental activity that helps students monitor their own progress, but also identifies problem areas to be addressed both by the students through additional effort and study and by the lecturers by informing their teaching practice.

However, if students are to become independent, lifelong learners, they must learn to take full responsibility of their learning and develop the capacity to self-regulate their learning as they progress in their studies, thus becoming less reliant on teachers to evaluate their performance (Sadler, 1989). This gradual transition to self-reliance requires the necessary support so that through feedback and formative activities students develop the necessary self-monitoring skills

to evaluate the quality of their own work. Hence, it is no surprise that a large number of the students who participated in the survey indicated that the provision of feedback could motivate them to engage in formative activities.

Students who participated in the questionnaire indicated that they are not particularly willing to embrace innovative approaches to assessment despite the abundance of studies which highlight their benefits to learning if administered properly. This can be attributed at least in part to their reluctance to engage in types of assessment they are not familiar with or think they will take more time (Gibbs, 2006). Moreover, such alternative formative assessment methods could be of different format compared to the summative assessment (e.g. MCQs compared to a typical problem-based written examination), which is likely to make formative activities less appealing, since they may be perceived as being unhelpful in preparing them for the final test.

Apparently, the diversity of student responses indicates that it might be idealistic to expect to develop a single assessment methodology that appeals to every student, so some diversity in formative activities is preferable in order to engage a larger number of students with different learning preferences. Gibbs & Simpson (2004-05) and Irons (2008) propose a framework that can be utilised in the development, design and implementation of formative activities and how these can be integrated in our teaching practice, which can be briefly summarised as follows: the formative assessments take appropriate learning time and encourage students to study the things we wish them to learn; the tasks engage students in productive learning of an appropriate kind; the objectives, assessment criteria and how the activities contribute to learning are made explicit; feedback is provided often enough, on time and in enough detail and focuses on student performance and on actions under their control and not on the students themselves; feedback is acted upon by the students. Above all, we need to be realistic of the workload involved in the implementation and administration of such activities, the amount, quality and timeliness of feedback that can be realistically provided as well as the degree that such activities can provide opportunities for enhancing student learning.

5.2 Engaging students in formative activities

The key findings of this study can be finally summarised in a series of recommendations to engage students in formative activities.

1. If we wish to utilise the students' current perceptions of formative activities then the focus should be on social learning exercises in the early years with a shift toward individual activities in later years which are strongly linked to summative assessments.

2. If, as educators, we have strong feelings on the use of certain learning opportunities such as group working or peer assessment then we have to demonstrate their efficacy in order to challenge student perceptions.

3. The optimal solution will clearly vary by individual student and flexibility of approach in terms of the range of formative activities on offer.

4. Highly engaged students need further encouragement to engage in group activities if these are to be part of the core values of the degree scheme.

5. For contact-time intensive degree programmes such as Engineering formative activities could be considered as a timetabled activity in place of traditional contact time.

6. The belief that personalised feedback is the most significant factor in student satisfaction may not be as deeply held as is widely understood. Further study into the nature of feedback required is warranted before committing to practises of time consuming individual responses.

References

Baroody, A. J., Feil, Y., and Johnson, A. 2007 An alternative reconceptualization of procedural and conceptual knowledge. Journal for Research in Mathematics Education, 38,115–131.

Barr, N., Milne, S. & Neve, P. 2012 Contextualizing formative assessment in mathematics and statistics. The Higher Education Academy, STEM .

Black, P. & Wiliam, D. 1998 Assessment and classroom learning. Assessment in Education, Principles, Policy and Practice 5 (1), 773.

Brown, S. 2004-05 Assessment for learning. Learning and Teaching in Higher Education 1 (1), 81–89.

Forbes, D. & Spence, J. 1991 An experiment in assessment for a large class. In Innovations in Engineering Education (ed. R. Smith), pp. 97–101. Ellis Norwood.

Garner-Medwin, A. R.. 2006 Confidence-based marking: towards deeper learning and better exams. In Innovative assessment in Higher Education (ed. C. Bryan & K. Clegg). Routledge.

Gibbs, G. 2006 Why assessment is changing. In Innovative assessment in Higher Education (ed. C. Bryan & K. Clegg). Routledge.

Gibbs, G. & Simpson, C. 2004-05 Conditions under which assessment supports student learning. Learning and Teaching in Higher Education 1 (1), 3–31.

Gielen, S. 2007 Peer assessment as a tool for learning. PhD thesis, Katholieke Universiteit Leuven.

Irons, A. 2008 Enhancing learning through Formative Assessment and Feedback. Routledge.

Jenkins, M. 2004-05 Unfullfilled promise: formative assessment using computer-aided assessment. Learning and Teaching in Higher Education 1 (1), 102–107.

MacDonald, A. 2004-05 Student self-evaluation of coursework assignments: a route to better perception of quality. Learning and Teaching in Higher Education 1 (1), 102–107.

Nicol, D. J. & Macfarlane-Dick, D. 2006 Formative assessment and self-regulated learning: a model and seven principles of good feedback practice. Studies in Higher Education 31 (2), 199–218.

Pitcher, N., Goldfinch, J. & Beevers, C. 2002 Aspects of computer-based assessment in mathematics. Active Learning in Higher Education 3 (2), 159–176.

Pope, N. 2001 An examination of the use of peer rating for formative assessment in the context of the theory of consumption values. Assessment & Evaluation in Higher Education 26, 235–236.

Sadler, D. R. 1989 Formative assessment and the design of instructional systems. Instructional Science 18, 119–144.

Sim, G., Holifield, P. & Brown, M. 2004 Implementation of computer assisted assessment: lessons from the literature. Research in Learning Technology 12, 215–229.

Sluijsmans, D. & Prins, F. 2006 A conceptual framework for integrating peer assessment in teacher education. Studies in Educational Evaluation 32, 6–22.

Snyder, B. R. 1971 The hidden curriculum. Knopf.

Star, J. R. 2005 Reconceptualizing procedural knowledge. Journal for Research in Mathematics Education, 36, 404–411.

Star, J. R. 2007 Foregrounding procedural knowledge. Journal for Research in Mathematics Education, 38, 132–135.

Yorke 2003 Formative assessment in higher education: its significance for employability and steps towards its enhancement. Tertiary Education and Management 11, 219–238.

Understanding assessment: its role in safeguarding academic standards and quality in higher education. QAA. September 2011.

Cardiff University Assessment Strategy.

Appendix 1: Student Questionnaire

A. Your characteristics

This section is to get a bit more information about how you study.

What school are you studying in?*

- **Maths**
- **Engineering**

What year of study are you currently in? *Please tick your year of study corresponding to the 2012-2013 academic year.

- **1st**
- **2nd**
- **3rd**
- **4th**
- **Other:**

On average, how many hours do you spend self studying per week? *

- **0-4**
- **4-8**
- **8-12**
- **12-16**
- **16+**

Based on your marks to date, how would you describe your academic performance? *

- **Well above average**
- **Above average**
- **Average**
- **Below average**
- **Well below average**

On average, what percentage of COMPULSORY homework assignments have you completed? *

- **0-20%**
- **20-40%**
- **40-60%**
- **60-80%**
- **80-100%**
- **Not applicable**

On average, what percentage of NON-COMPULSORY homework assignments have you completed? *

- **0-20%**
- **20-40%**
- **40-60%**
- **60-80%**
- **80-100%**

- **Not applicable**

B. Your attitude toward homework in general.

This section is to identify your attitude toward homework in general. When referring to homework we imply any piece of work that is to be done out of contact time.

Rate the following statements on a scale of 1 - 5 where 1 is "strongly disagree" and 5 is "strongly agree".

Completing homework assignments led to an improvement of my final mark. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

Doing homework assignments helps in understanding the lecture material. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

Homework assignments help me identify strengths and weaknesses in my knowledge and skills. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

I am more likely to do homework assignments if they are marked. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

I am more likely to do homework assignments if they count towards my final mark. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

I am more likely to work on homework assignments, if I can collaborate in groups with my classmates. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

I am more likely to do homework assignments if I am told in advance roughly how much time they will take. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

I am more likely to do homework assignments if I was given timetabled sessions in which to complete them. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

I am more likely to do homework assignments if they were multiple choice type questions. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

I am more likely to do homework assignments if I knew I was going to receive personalised feedback. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

I am more likely to do homework assignments if they were linked to practical situations and/or employability skills. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

I am more likely to do homework assignments if problems were taken from past examination papes. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

C. your attitude toward optional/non-compulsory homework

This section is to identify your attitudes toward NON-COMPULSORY homework i.e. homework which does not count towards your final mark. Non-compulsory homework can be either MARKED or NON-MARKED. MARKED homeworks are those for which you receive a grade and/or feedback and NON-MARKED homeworks are those for which you receive no feedback.

When referring to homework we imply any piece of work that is to be done out of contact time.

Rate the following statements on a scale of 1 - 5 where 1 is "strongly disagree" and 5 is "strongly agree".
I feel that NON-MARKED homework is helpful to me. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

I am more likely to do NON-COMPULSORY homework assignments if they were assessed by my classmates. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

I am more likely to do NON-MARKED homework assignments if they were shorter. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

I am more likely to do NON-MARKED homework assignments if I knew that it would improve my overall performance. *

- **1. Strongly disagree**
- **2. Disagree**

- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

I am more likely to do NON-MARKED homework assignments if it was to be done before a lecture on the subject. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

I am more likely to do NON-MARKED homework assignments if it could be completed online. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

In marked homework assignments, I mostly care about the mark I receive and not about the feedback I am given. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

I feel that the feedback I receive in marked homework assignments is adequate. *

- **1. Strongly disagree**
- **2. Disagree**
- **3. Undecided**
- **4. Agree**
- **5. Strongly agree**

D. Your suggestions.

This section contains 1 question inviting you to select a single element that would make NON-MARKED and/or NON-COMPULSORY homework most appealing. When referring to homework we imply any piece of work that is to be done out of contact time.
What would make homework most appealing for you? *

- **If they consist of multiple choice questions.**
- **If I receive a mark for them, irrespective of the fact that they will not count towards my final mark.**
- **If they are administered online.**
- **If I know how much time I need to allocate for them.**

- **If they are short.**
- **If there are timetabled sessions to work on them.**
- **If they are assessed by students.**
- **If they are linked to practical situations and/or employability skills.**
- **If they become compulsory.**
- **If I know that I will receive feedback on how to improve my performance.**
- **If I worked on them with my classmates in groups.**
- **None of the above. Assignments should count towards the final mark to be worthy of doing.**
- **Other:**

E. Enter to win!

Feel free to enter an email address which we will use in a prize draw, for a chance to win a £20 Amazon voucher.
Email adress:We will not use your email address for anything else but this prize draw. You can of course choose to not enter anything here.

Add item

Confirmation Page
Show link to submit another response
Publish and show a link to the results of this form to all respondents
Allow responders to edit responses after submitting

Send form

Appendix 2: Peer assessments.

Student self- and peer-assessment have become increasingly popular in higher education (Tan and Leng, 2005). Peer assessments are assessments of students by other students, both formative reviews to provide feedback and summative grading (Bostock, 2001).

Peer assessments are usually used in combination with self-assessments (i.e. each student assesses the work of all the other students and her/his own work as well) to avoid generously marking students being penalised in the overall marks they receive. The idea of using peer/self assessments to provide summative grading is highly controversial (see Tan and Leng, 2005 et al.).

Many studies (see Tan and Leng, 2005 et al.) show that peer/self assessments tend to underrate or overrate and rarely agree with tutor/teachers grates. In particular students who are poorer academically have a higher tendency to inflate their scores when compared to students who are stronger academically. Thus self/peer assessment needs to be used very carefully when providing summative grading. We do not further investigate this problem since, in this specific case, peer assessment is used to provide only feedback by formative grading and comments. Still our findings tend to confirm the danger of the use of peer assessment for summative assignments.

Moreover since we are mainly interested in providing formative feedback, we can avoid considering self-assessment.

The benefit of formative peer/self assessments are largely discussed in the literature (Brown, Rust and Gibbs 1994, Zariski 1996, Race 1998 and others). We are particularly interested in the peer assessments as a method to seek feedback by peers and to “own the assessment process” (Bostock, 2001). As a teacher, this is an opportunity to both develop our own marking criteria and reflect on how those same marking criteria assess our own work (e.g. will we feel that these criteria fairly “mark” our effort on the project?).

Moreover according to our questionnaire many students dislike peer assessments while our group could not find a consensus when asked to answer the same question (some of us strongly disagree with the idea of peer assessments, whilst others strongly agreed).

For most of us, as for most of our students, the response was a a-priori judgment since we did not experience peer assessments before. Therefore it is extremely useful to match our a-priori feeling with the reality of being peer assessed.

Methodology chosen:

We decided to use a peer assessment divided into three parts:

-Part A (Peer assessment of product): we implement a classic peer assessment for our project presentation.

-Part B (Peer assessment of process): we run an each-other peer assessment to evaluate our group working skills.

-Part C (Combined final peer assessment marking): we briefly show how it is possible to combine the first two peer assessments in order to get individual marks which would take into account both the value of the project and our personal contribution to the process.

PART A: Peer assessment of the product via peer assessment of the presentation.

There are two main reasons why we have chosen this specific peer assessment method.

- One of the main purposes of assessments is to improve learning through feedback. We

worked on our project using Google Drive, by the use of continuous comments on each other's work. Thus we have already got all possible feedback from each member of the group. Therefore each other peer assessing would not lead to any new constructive feedback.

- Our project is about how students perceive assessments. According to the response to our questionnaire (Question n.20) many students dislike peer assessments. According to some literature (reference), one of reasons of that is students tend to under-mark their peers whenever they misunderstand the real time and effort spent on a task. With this peer assessment-choice we try to put ourselves in a situation as similar as possible to the situation experienced by our students.

Marking criteria and outcome:

We used a modification of the marking criteria developed by the School of Mathematics to assess projects. The main difficulty was to adapt those criteria to a situation when the assessors could assess only by coming to the presentation without reading the report. Therefore the final marking criteria and the weight of each of them look quite different from the original ones. The criteria assessments form will be added at the end of this appendix.
Cohort 21 participants coming to the presentation were given a copy of the marking criteria (see Group Project, Peer Assessment Marking Criteria 1) and they were asked to hand-in the assessment at the end of the presentation. In spite of our effort to involve as much peers as possible, at the end only 4 Cohort 21 participants assessed our presentation. The scores are shown in the following table (being the score from 1 to 6=maximum score).

	Assessor 1	**Assessor 2**	**Assessor 3**	**Assessor 4**	**Mean**
ANALYSIS AND UNDERSTANDING (50%)	5	6	5	6	5.5
ORIGINALITY (15%)	4	5	4	4	4.25
PRESENTATION (35%)	4	6	6	5	5.25
FINAL MARK	4.5	5.85	5.2	5.35	5.225

Comments:	**_____**	Very nice use of stats. very well presented. Good job!	Can you use median to demonstrate the difference of some non-normalise d data.	Some of the graphics were not clear. Your research question may need + be addressed and focused. Vincent knew his data very well.	

Discussion of the results:

If we examine the peer assessments, we can point out some reflections:
1-validity of peer assessments: marks from peers are diverse.
Even if we focus only on the presentation, there is no consensus between the assessors (in fact the scores vary from 4 to 6). This seems to confirm the tendency observed in many studies (Boud and Falchikov, 1989).
2-the comments provided very constructive and useful feedback.
3-a small number of participants decided to engage with peer assessing, i.e. a very poor engagement in the assessing task from our peers. This leads to question ourselves on the difficulties of implement peer assessments in HE: how can we motivate our students to take part in a procedure that we (=teachers in HE) are not willing to do?

Limit of the chosen method: the specific case of peer assessment for group work:

The primary limit of this method is that the work can only be assessed through the presentation, hence the "assessors" will not have the knowledge of the entire piece work.
Another limit is that peer assessments of group work are often used to give individual marks. Academic staff often cannot confidently give the same mark to each member of the group (Loddington 2008). This peer assessment method fails in this point since it does not assess individual contribution to product produced.

PART B: Peer assessment of group working skills.

In thesecond peer assessment each member of the group assessed the others (including self-assessment).
The assessment criteria used, were taken from "Peer assessment of group work: a review of the literature"(Loddington, 2008) and were applied without any modification (see Group Project, Peer Assessment Marking Criteria 2). The scores are summarized in the following table.

	Phil (P)		**Federica (F)**		**Vince (V)**		**Nikos (N)**	
Time management	**P**	**4**	**P**	**4**	**P**	**4**	**P**	**4**

	F 4 V 4 N 5	F 4 V 4 N 5	F 4 V 4 N 5	F 4 V 4 N 5
Problem solving	P 4 F 4 V 5 N 4	P 4 F 4 V 5 N 4	P 4 F 4 V 5 N 4	P 4 F 4 V 5 N 4
Communication	P 5 F 4 V 4 N 5	P 5 F 4 V 4 N 5	P 5 F 4 V 4 N 5	P 5 F 4 V 4 N 5
Reflection	P 5 F 4 V 3 N 4	P 5 F 4 V 3 N 4	P 5 F 4 V 3 N 4	P 5 F 4 V 3 N 4

The total score for each of us has been calculated by total average, e.g.

Phil's score= sum all the score and divide by 16= 4.5

A quick look at the table shows that the peer assessment of the process failed in providing individual score since each member of the group achieved identical overall scores. This can be read as "each member of the group felt that all the other member of the groups equally contributed to the final report produced". It is also worthwhile mentioning that the fact of equally marking each member of the group could be influenced by the professional and personal

relationship between the members of a group and an anonymous peer marking could have provided a different outcome.

PART C: Final grading: combined marks?

Usually any assessment should provide feedback and grading about all the learning outcomes. The learning outcomes of a group project can be usually divided in two groups:
I: learning outcomes related to the project itself (in our case the learning outcome of PCUTL module 3)
II: learning outcomes related to group work developing skills.
In Part A we peer assessed learning outcomes I, since we assessed the task produced via presentation.
In Part B we assessed learning outcomes II by peer assessment each others contributions to the process.
Constructive feedback for each student in a large cohort is a difficult and time consuming task. Loddington (2008) presents different methodologies for determining individual marks (see also Lejk, Wyvill and Farrow 1996) for group work, see in particular the WebPA method: For each question/learning outcome the group as a whole receives a mark, and for each question the contribution of each member of the group is marked by the other group members, and this is used as weight for computing the individual mark for each group member. This method provides a very nice algorithm for mathematicians to play with but it appears over-complicated in particular in the case of formative assessments which are not summative. A similar but easier model to provide an individual mark from a group project can be obtained by combining the mark from peer assessment of the product with the mark from assessing individual contribution to the process (part B). The individual marks coming from part B, once suitably renormalized go to multiply the group mark from part C, providing a different mark for each member of the group. We do not apply this scheme in our case since the peer assess in part B failed in providing different marks for different members of the group. We would nevertheless like to suggest this combined method in situations where there is the intent to use peer assessing to provide summative grading.

References for Appendix B

Bostock, S. 2001 Student peer assessment, in The Higher Education Academy

Brown,S., Rust, C. & Gibbs, G. 1994: Involving Students in the Assessment Process, in Strategies for Diversifying Assessments in Higher Education, Oxford: Oxford Centre for Staff Development.

Boud, D. & Falchikov,N. 1989: Student Self-Assessment in Higher Education: A Meta-Analysis, in Review of Educational Research vol 50 no 4 pp. 395-430

Loddington, S. 2008. Peer assessment of group work: a review of the literature

Race, P. 1998: Practical Pointers in PEer Assessment, in Peer Assessment in Practice, Brown, S., (ed.) (SEDA paper 102) Birmingham SEDA, pp. 113-122.

Root, L. S. Faculty Evaluation: Reliability of Peer Assessments of Research, Teaching, and Service, in Research in Higher Education 26:1 (1987).

Tan, K., & Leng, H.K. 2005. Self and Peer Assessment as an Assessment Tool in Problem-Based Learning.

Lejk. M. & Wyvill, M. & Farrow, S. 1996. A survey of methods of deriving individual grades from group assessments, in Assessments & Evaluation in Higher Education Vol. 21, No 3.

Zariski,A. 1996 Student peer assessment in tertiary education: Promise,perils and practice, in Abbott, J. and Willcoxson, L. (Eds.), Teaching and Learning Within and Across Disciplines, p. 189-200. Proceedings of the 5th Annual Teaching and Learning Forum, Murdoch University, Perth.

Group Project, Peer Assessment Marking Criteria 2

Time management
To what extent were you and your group members prompt at arriving for meetings or group sessions, emailing information, or phoning etc?

1. Very often late
2. Sometimes late
3. Sometimes on time, sometimes late
4. On time more often than not
5. Always on time for all tasks

Problem solving
To what extent were you and your group members active in providing constructive ideas, suggestions, solutions etc?

1. Rarely provided ideas
2.Sometimes provided useful ideas
3. Sometimes provided ideas, some were useful
4. Quite often provided useful ideas
5. Always provided useful ideas

Communication
To what extent did you and your group members keep in touch with each other during the project?

1. Rarely kept in touch
2. Sometimes kept in touch
3. Sometimes in touch, sometimes not
4. Usually kept in touch
5. Always kept in touch

Reflection
To what extent were you and your group members thoughtful about what you were doing (e.g. constructive criticism, open to ideas, seeking out advice)?

1. Rarely acted positively/reflectively
2. Sometimes acted positively
3. Sometimes positive, sometimes not
4. Usually acted positively/reflectively
5. Always positive in this way

Group Project, Peer Assessment Marking Criteria 2

	Score=6	Score=5	Score=4	Score=3	Score=2	Score=1
ANALYSIS AND UNDERSTANDING (Weighting=50%) Mark: …….	- Exceptional understanding and knowledge of the subject and provides a vast and original selection of evidence -Is an outstanding achievement overall and work is of publishable quality	- Demonstrates a clear and accurate understanding of underlying principles and comprehensible interrelations between different results - Is of excellent quality overall with well stated outcomes and considerations of future extensions	- Demonstrate a sound grasp of the underlying principles, techniques and context - Is of good quality overall with sound of outcomes presented	- Demonstrates a satisfactory and general understanding of what was done, though some-what lacking in depth and rigour - Is overall satisfactory with adequate outcomes presented	- Demonstrates shortfalls in understanding in some key areas - Has unconvincing outcomes and overall poor achievement	- Demonstrate very little understanding of what has been attempted, or its relevance - Achieves very little of value
ORIGINALITY (Weighting=15%) Mark: …….	- Leads to innovative results and conclusions - Is of great interest for research in HE	- Presents interesting results and conclusions - Makes a significant input for future research in HE	- Progresses the work well and brings some useful ideas - Presents some new evidences and/or ideas of some interest for research in HE	- Presents the material clearly and satisfactorily - Gives an overall sight on the subject	- Brought little thought on the subject - Conclusion were stated with unclear explanations	- Demonstrates no thought on the subject - Conclusion are inadequate and demonstrate inadequate input of time and effort
PRESENTATION (Weighting=35%) Mark: …….	- Was outstandingly well prepared, well- structured and very easy to follow - Used clear, accurate and appropriate language - Included several difficult or subtle ideas and were explained very convincingly - Made excellent use of time available and of visual aids used - Included perceptive and insightful answers to questions asked by audience	- Showed thorough and comprehensive preparation, and was clearly delivered - Used appropriate language - Included some difficult or subtle ideas and were explained well - Made every good use of the time, and any visual aids - Included clear answers to questions asked	- Was well prepared and delivered - Indicate some minor problems with use of language and/or delivery but these did not cause major difficulties for listeners - Included well-delivered ideas and intelligible delivery -Made good use of time and any visual aids -Included competent answers to questions	-Was adequately prepared and delivered - Included main ideas covered competently - Indicated some weaknesses in time management. Any visual aids were adequately produced -Included answers to some of the questions, but showing a sound of knowledge of the subject matter	- Indicate some preparation and delivery was overall acceptable - Used appropriate language in places, but included some inaccuracies - Included competent explanation of several ideas, if perhaps briefly - Did not make the best use of time available and/or visual aids - Indicated that some questions posed were understood and answered, at least in part	- Was poorly prepared and extremely difficult to follow - Had numerous examples of inaccurate use of language - Lack of explanation of the ideas presented - Made very poor use of the time and any visual aids added little information - Included some answers to questions that provided little evidence of relevant knowledge

We would appreciate your feedback here: