Delivering Manufacturing Technology and Workshop Appreciation to Engineering Undergraduates Using the Flipped Classroom Approach.

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Abstract

Delivery of manufacturing technology and practical workshop based work, on undergraduate engineering courses that engage the learners, is challenging. The paper presents an experimental method of workshop delivery using the ***flipped learning*** *approach, a pedagogical model in which the typical lecture and homework elements of a course are reversed. Video lectures are viewed by students prior to class. In-class time can be devoted to exercises, projects, or discussions as in this case. Learners were asked to observe three Audio Visual clips in preparation for class. The objective was to determine whether the flipped classroom approach can enhance the learning experience, through better engagement with the students, compared to conventional classroom-based learning. The level of student participation and level of success have been established by means of feedback questionnaires from more than 100 participants and peer observation. The results are encouraging and demonstrate that this approach is favoured by the students.*

Key words: Engineering Education, Teaching and Learning strategy, Flipped Classroom, Engineering Curriculum Design, Undergraduate Engineering Courses

1.0 Introduction

1.1 Background

Manufacturing technology and workshop appreciation forms a core module for undergraduates in Engineering and Technology studies. Hence, the module is introduced at an early stage of students' Higher Education studies. A proportion of undergraduate students join degree courses with a good grounding in the practical or vocational aspects of the engineering degree gained through apprenticeships or higher national vocational Business and Technology Education Council (BTEC) qualifications. The BTEC Level 3 Extended Diploma is equivalent to a secondary school leaving qualification and vocational qualification taken in England, Wales and Northern Ireland.

The qualification is organised and awarded by the Edexcel examination board within the BTEC brand and it is equivalent to Advanced Level subjects. The UK government's website detailing such qualifications and their equivalence can be found at the following link:
https://www.gov.uk/what-different-qualification-levels-mean/overview

Engineering degree courses at The University of Huddersfield attract students from diverse educational and training backgrounds which can vary from school leavers with GCSE (General Certificate of Secondary Education) Advanced level subjects, international school leaving certificates/diplomas or baccalaureate to mature apprentice trained or experienced students. GCSE Advanced level subjects is the common route of entry by UK school leavers, into University undergraduate courses.

1.2 Challenge

The challenge and motivation of this work lies in educating such undergraduates in manufacturing technology so that they are able to gain a wide appreciation of technology as pre-requisite knowledge and understanding to deal with practical design problems. This rationale applies to all engineering students irrespective of their core engineering discipline (Automotive, Mechanical, Energy, Design etc.), as they all have an association with manufactured goods and the processes involved in making them. The subject of manufacturing technology should therefore be taught effectively. It forms an important part of the curriculum and is clearly defined in terms of learning outcomes within the UK Standard for Professional Engineering Competence (UK-SPEC). Engineering Council website accessed November 4 2015. The standard can found at the following link.
http://www.engc.org.uk/engcdocuments/internet/Website/UK-SPEC%20third%20edition%20%281%29.pdf).

The UK-SPEC is based on the demonstration of key competences and is the UK Standard for Professional Engineering Competence. It describes the Science and mathematics, Engineering analysis, Design, Engineering Practice competences in the economic, legal and social, ethical and environmental context, that have to be met in order to attain Engineer status at either Technician, Incorporated or Chartered level.

2.0 Structure of delivery of the subject and rationale for changes

Currently the Manufacturing Technology and Workshop Appreciation module is a 20 credit module delivered at foundation level, over a period of one academic year. This involves 24 hours of lectures, 36 hours of practical, workshop based work, and approximately 140 hours of unsupervised study (as a recommended guideline).

Students attend lectures that cover a wide array of manufacturing technology topics and a series of practical day-long workshop practice sessions. Some of the lectures are intended to underpin knowledge gained during the workshop practice sessions. Learning from the lectures is structured such that students acquire a broad knowledge of manufacturing by *remembering* (facts, definitions and terminology) *understanding* (differences in processes and their relevance to the manufacture of disparate products or artefacts) and *applying* to design assignments – in accordance to Bloom's taxonomy and verbs, as revised by Anderson (2002).

Bloom's Taxonomy was created in 1956 under the leadership of educational psychologist Dr Benjamin Bloom in order to promote higher forms of thinking in education, such as analysing and evaluating concepts, processes, procedures and principles, rather than just remembering facts (commonly referred to as rote learning). Bloom's taxonomy is most often used when designing educational, training, and learning processes and it makes reference to three learning domains: Cognitive-knowledge, Affective (attitude or self) and Psychomotor (skills)-the UK-SPEC is based on Bloom's taxonomy.

Referring to Bloom's taxonomy, it is evident that understanding and applying in Manufacturing Technology and Workshop Appreciation module, are reinforced through the practical sessions which also give students the opportunity to develop their psychomotor skills. This also helps build their confidence in attempting practical hands-on craft type work that they may require in future and also inspire the students, thus also addressing the affective domain.

The combination of lectures and practical sessions are designed to complement each other. Students enjoy being engaged in the practical sessions as they are learning by doing, which forms an important aspect of engineering education. The importance of class based learning can be underestimated by learners.

The challenge for the educator is to maintain a high level of interest through various means. When describing manufacturing processes, visual stimulation during the lecture is important in order assist the learner in the learning process. This can be achieved

through use of graphical illustrations and still photographs. Case examples, as well as a collection of DVD or short demonstration films also help further understanding. Wider possibilities for such demonstrations are becoming ever more available through the advent of material available in the public domain such as YouTube and appropriately vetted and approved websites, as well as other online learning material.

Several publications, over recent years, have scrutinised established teaching and learning methods, such as Euchner (2014). Progressive methods of teaching and learning are being introduced (see e.g. Salmon, Nie and Palitha 2010) along with disparate delivery methods (Clifton and Mann 2011; Holmes and Gardner 2008; Gupta 2008).

Building on current research and authors' experience in delivering Manufacturing Technology and Workshop Appreciation module, a single topic from the module syllabus has been selected for delivery using this flipped classroom approach. The objective is to establish whether the cohort of students perceive that they are benefiting from an improved learning experience and whether the experience is a more enjoyable process due to greater interaction.

2.1 Reinforcing knowledge in a standard classroom and laboratory approach

The selected topic for the experimental session, which forms a small part of the module, was addressing cutting tool materials used for manufacturing applications, particularly within a machine shop environment and in the wider manufacturing industry. Knowledge and understanding gained by self-directed, followed by workshop sessions where students are actually witnessing and applying the use of such materials in machining processes. Such knowledge is also applied in future design exercises in which the learner is required to consider the ease of manufacture of designed artefacts.

Good practice has been established by the presentation of review questions once a subject has been covered, including the demonstration films. Review questions offer multiple choice answers which are directed at students at the will of the educator (learners are therefore aware in advance that they may be individually asked to answer questions). This serves several purposes:

1. Maintain the attention of the learner who may be called upon to answer questions
2. Provide the learners with a flavour of what they can expect in an end of year assessment in the form of a timed examination.

3. Provide an opportunity to emphasise some critical issues of the topic covered with key discussion points.
4. Structure the learning session such that some humour is included. This can be achieved by offering a selection of possible answers from possible or probable to ridiculous ones.

Guessing is discouraged through the request of rationale behind the given answer or through a process of elimination such that the given answer is justified. This also helps build an aspect of analysis when reviewing Bloom's learning outcomes (Anderson and Sosniak 1994). In examinations, incorrect answers receive a negative score therefore discouraging students from guessing their way through questions associated with topics. Figure 1 illustrates how the majority of current or more traditional sessions are divided. These roughly comprise of one third delivery using PowerPoint slides with illustrations and text. The other two thirds of the session are divided (but not always equally) between audio-visual (AV) demonstrations and review questions. In the flipped classroom approach, students are asked to observe relevant and recommended AV prior to attending with prepared questions. This primes them prior to the scheduled session thus accelerating the learning process.

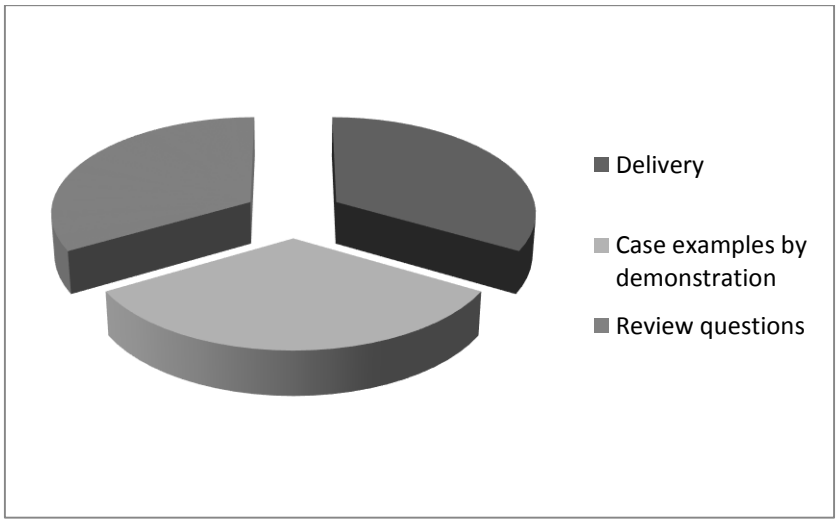


Figure 1 – Example of how a session is currently delivered. There can be a time variation between each of the three aspects (delivery, case examples by demo DVDs and review questions)

2.2 Educational material

The learning material includes PowerPoint slides augmented with detailed notes were developed by the author over the last twenty years. A number of reference sources were used which were also recommended to students for further reading such astwo well established and classic text books in the subject area by S Kalpakjian and S Schmid 2006, Manufacturing Engineering and Technology 5th edition, ISBN 0-13-148965-8 and DeGarmo's 2013 Materials and Processes in Manufacturing, ISBN 978-0-470-87375-5.

Audio visual material was carefully selected by the author through what was judged to be suitably educational and available in public domain through the world wide web.

The lecture based material provided to students includes a copy of the PowerPoint slides supplemented by an attached script. The learner is encouraged to make further notes around the slides that provide the main visual aid for the subject covered. Such notes along with the provided script allow for a valuable source of information when it comes to revisiting the subject matter later. Students are also encouraged to purchase one of the recommended text books which will be used as a reference beyond the duration of the module. This is also a source of reference for further student learning.

2.3 Workshop exposure

The workshop exposure forms the practical aspect of the module where students are given the opportunity to develop their psychomotor skills. It is important in that it provides a fundamental appreciation in working safely and the development of skills required for the operation of machine tools. These will consist of lathes, milling and other machine tools. Students are made aware during the class based sessions that in the wider world of manufacturing, a plethora of complex machines exists.

During workshop activities, comprising of a total of 36 hours, hand tools are used as part of the practical work for the manufacture of a simple engineering artefact. The students are exposed to the effective use of CNC machine tools and appreciate their application in an industrial environment.

3.0 An experimental delivery method of a flipped learning approach

The flipped classroom is a relatively new pedagogical method which employs audio-visual lectures, problems and active group-based problem solving activity. It represents a combination of set of learning theories. The rise of the flipped classroom has been

researched by Bishop J et al, who attribute the rise of the flipped classroom approach to the advent of technological movement that has enabled 'the amplification and duplication of information at extremely low cost'. The flipped classroom approach entails both inside and outside classroom activities. The classroom activities tend to be more interactive compared to traditional lectures. Experiences and required resources for such a method of delivery in engineering have been described by researchers such as Rossiter (2014).

Bates and Galloway (2012) have studied and reported on the approach of the flipped classroom in a large group enrolled on an introductory physics course.

The students engaged in the learning process described in this paper are all enrolled on the module described in section 1.1. The complete group is involved and observed. The longer term objective of this research is to gauge and quantify, by means of changes in examination performance. It is hoped to achieve this by monitoring and comparing performance between subjects covered using the flipped class approach and those covered by more traditional means.

Because of observed students' engagement with visual aids (VA) material during the class, it was proposed that current delivery method be altered to make further use of short demonstrations available within the public domain, particularly on the website YouTube. Students have expressed a willingness to view educational material prior to class and are also better prepared for more interactive engagement during class activities. Such short clips can follow a verbal explanation of a process and accompanied by running commentary by the tutor. The aim is that visual impact short clips will deepen understanding more than a description with simplified diagrams. Simplified diagrams serve the purpose of putting a concept across but can often also cause confusion thus raise questions by the learner.

Students are often keen to explore such resources outside the timetabled class, particularly with direction and guidance. Such resources carefully selected by the tutor for showing during class, are important because upon delivery of a subject through the imparting of knowledge, students are inclined to form a visual perception of a process which can lead to further curiosity of the subject especially if only a partial understanding is formed. Curiosity in a subject after class delivery is regarded as good because it is a positive sign of stimulation for further learning. The audio-visual demonstrations serve to satisfy this curiosity and also clarify any misconceptions that

the learner may have had regarding the context in which the process is applied in practice.

The principle of restructuring delivery of sessions is easier to achieve with certain topics than others. It also relies on the availability of relevant short clips. Bite sized chunks of videos offered within the YouTube environment implies that several short videos from differing sources can easily be accessed. This has proven to work in the delivery of nursing practice education as reported by Clifton and Mann (2011). By similarity, Engineering and Manufacturing education encompass vocational subjects that can benefit in similar ways of delivery for teaching and learning.

An experimental method offers the opportunity to assess the flipped learning approach. We can then quantify the outcomes by comparison to a usual method of delivery. This may be done by means of questionnaires directed at the students. By firstly selecting just a few (no more than three) video clips, students shall be asked to view these online, prior to the scheduled class. They will also be requested to come to the session with a question based on the viewings. Some of the raised questions may be listed for everyone to see and therefore form focus points to address for discussion. Clarification or explanation of queries may be made on reflection of the delivered session (which will also include short video clips with commentary, explanations and expansion where necessary). Godwin (2007) reports that group discussions stimulated by using YouTube in the classroom environment can lead to deep learning on the subject as well as a critical evaluation in information literacy.

The longer term research question is whether learners can achieve improved examination results in the subjects delivered by this revised approach of delivery and can they subsequently achieve a higher level of learning.

3.1 Educational Framework

Past experience was a motivation for the experimental session; students often comment on technically inspiring things they have observed either on TV or online.

Manufacturing technology is a visually stimulating subject that can now appear very ‘bland’ if described with words and simple sketchy illustrations. This is particularly the case now when learners have been exposed to educationally rich ‘Discovery’ channels and online sites that are freely available. Author’s experience indicates, and is substantiated by Biggs (2003), that greater learner participation is a recipe for improved learning success. Some prior knowledge, even when limited, can further improve the

knowledge acquired during the delivery session, by providing a basic foundation by better utilising the time during the teaching and learning session. This can be further substantiated through an appropriate educational theoretical framework or frameworks. Theoretical Frameworks are 'formulated to explain, predict and understand phenomena' (Swanson 2013). They can also be used to challenge and extend existing knowledge, within limits of the bounding assumptions, University of Southern California, Research Guides, accessed November 4 2015.
http://libguides.usc.edu/content.php?pid=83009&sid=618409).
Lev Vygotsky's Theoretical Framework on Social Learning Theory has been identified, Educational Technology 547, Learning Theories Website, accessed November 4 2015, http://jan.ucc.nau.edu/lsn/educator/edtech/learningtheorieswebsite/vygotsky.htm).
Social Learning theories help us to understand how people learn in social contexts (from each other) and how teachers act as facilitators to construct active learning communities (Vygotsky, L.S.; Hanfmann, Eugenia; Vakar, Gertruda; Kozulin, Alex, 2012).

Consequently, teachers can create a learning environment that maximises the learner's ability to interact through discussion (discussion of AV case studies and demonstrations in this case), collaboration (group viewing and creating questions prior to scheduled classes) and feedback (through addressing questions in class as points of discussion thus eliminating incorrect answers by reason – a form of formative feedback). In Vygotsky's framework this is discussion-based learning using Socratic Questioning Methods where the teacher or instructor manages a Socratic dialogue that promotes deeper learning (Hake 1998).
Vygotsky also recognized that learning always occurs and cannot be separated from a social context, therefore the essence here is to encourage learners to be inquisitive by identifying processes discussed in class with everyday artefacts. Through deeper understanding the learner can acquire the knowledge to challenge traditional methods of production by proposing alternatives. In Bloom's Taxonomy this is the Application, Analysis and Evaluation stages in the Cognitive Process Dimension (Krathwohl 2002).

4.0 Timing and evaluation

Delivery of the experimental session took place during the first academic term 2014/2015. Time was allowed to select a suitable subject topic with adequate online

resources. Evaluation of the session was by peer observation of teaching. This can therefore be compared to delivery of more usual sessions for the same module. The primary means of feedback was an evaluation questionnaire given to students to complete immediately after delivery. The Harvard University, Program on Survey Research Tip Sheet on Question Wording was used as a guide to formulate the questions for the questionnaire. This can be found at the following link,
http://psr.iq.harvard.edu/book/questionnaire-design-tip-sheet (last updated November 17, 2007)

Feedback was also taken in the form of informal discussion. Students were well placed to express their preference of delivery method as they were able to compare to a more usual delivery style of the same module, but for different topics.

4.1 Delivery

The subject topic for delivery was - materials used for making cutting tools in the manufacture of components ('Cutting Tool Materials' – see figure 2). This was chosen partly due to the availability of AV material on the web. It also forms an important topic within the module that students can find interesting if presented in an appropriate manner. The availability of good quality and interesting material prior to such a flipped learning approach to teaching and learning is important yet not always entirely possible. After some time was spent exploring the web for suitable material, three links on YouTube were identified. These were as follows:

Recommend AV viewing 1: This covers six popular Cutting Tool Materials and lasts 7.5 minutes. It offered a short introduction to the subject which would hopefully lead to the desire to view a more thorough and comprehensive viewing of the next recommended viewing. Students were directed to the following link, which was embedded in an email sent to each student enrolled on the module,
https://www.youtube.com/watch?v=1K2_zb9kQ-8

Recommend AV viewing 2: This forms part of an extensive collection of the BBC Technical Studies series. Now available in the public domain, it remains highly educational. The only anticipated drawback with this clip was its duration of 24 minutes, which may exceed the time some students are prepared. The given link was,
https://www.youtube.com/watch?v=GVLP-IXPEt0

to dedicate prior to class, despite recommendation by the tutor – this was something else to be established from the experimental session.

Recommend AV viewing 3: This covers two Super-Hard cutting tool materials and is of short duration of 1.6 minutes. The given link was,

https://www.youtube.com/watch?v=tpXd5Dds27w

The students were notified by email, the week prior to delivery, to view the three AV clips. They were also informed during class the week prior to delivery and reminded by a follow-up email the day before delivery.
The total time involved in viewing the three AV links was 33 minutes and it was recommended that they view all three in order that they attend prepared with questions. The aim was that the delivery sessions would develop in to a more interactive session than usual, through pre-prepared questions that would lead to greater open discussion and dialog.

Learners were given a copy of the slides to be presented. Additional supplementary notes were added to the Virtual Learning Environment (VLE) prior to the session, enabling student access to detailed information as covered during the lecture. Although the lecture started in the usual manner with an introduction to subject followed by scope of the session, it gradually became increasingly more interactive than usual. This was because, in anticipation of prior knowledge, it was possible to direct questions to the learners which would sometimes go beyond the reciting of basic knowledge but more to establish their understanding. Questions can sometimes be aimed at testing the students' ability to deduce answers through reasoning based on known facts. This would indicate that within the learners' cognitive domain they are acquiring Knowledge, Comprehension and certain Application (see figure 3). In order to satisfy the underlying criteria for the higher order of cognitive domains a number of multiple choice questions were composed, each offering a range of possible answers ranging from plausible to the ridiculous. These offered discussion points through breaking down, comparing, differentiating, distinguishing, identifying, relating etc. (*Analysis*), prior to explaining, interpreting, justifying, summarising, supporting (*Evaluation*), in compliance to Bloom's verbs. The higher order domains are observed in figure 3. The ability to create

is anticipated later with more practical experience when students are placed in a working environment.

Figure 2 - The Subject topic (introductory slide) that was covered during the experimental teaching and learning delivered session

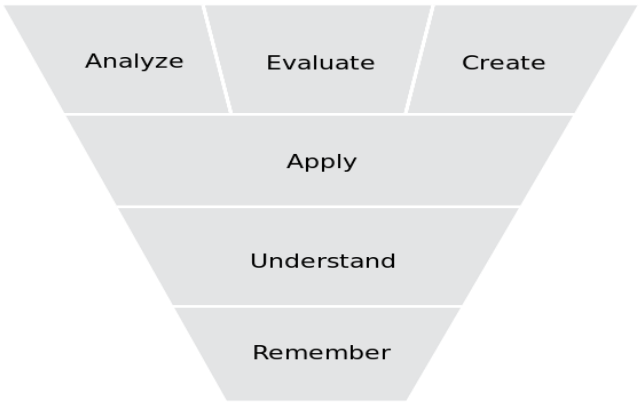


Figure 3 – Categories in the cognitive domain of the revised Bloom's Taxonomy (Anderson 2002).

5.0 Evaluation

What remained to be determined at the end of the session was whether the learners felt that they had:

1. Gained a greater depth of understanding by prior viewing of the AV material, compared to not having done so.
2. Had enjoyed and benefited from the session through certain prior familiarity with the subject material, than if they hadn't viewed it.
3. Had they enjoyed the increased level of interaction during the session.

The means by which to establish the answers to these questions was by a feedback questionnaire, consisting of 10 questions. A copy of the questionnaire is included in the addendum of this paper and the analysis by students' selected answers to the given questions is also detailed.

The theoretical basis of the questionnaire was to establish the actual number of students that were willing to view the recommended material prior to class (and how much of it) and then to hear their views as to whether they had perceived to have gained from the overall learning experience. One of the longer term research questions is whilst students may indicate that they enjoy the flipped classroom approach to teaching and learning, do they actually benefit to a greater extent than a more conventioanal diatactic teaching approach. Question 7 was included to establish the students perceived relevanance of content, to their course. Questions 8, 9 and 10 were included to enable the quantifiacation of participation and to palce a value to the number of students who desired for more sessions to be delivered in this manner.

5.1 Summary of findings, analysis and conclusions from feedback questionnaire

A total of 104 questionnaires were returned by the students that were present in the experimental delivery session. All students on the module took part so there was no selection at this stage of the research. The purpose of the questionnaire was to determine the effectiveness of the flipped learning approach, as perceived by the students and to verify this as part of on-going research. The first question was to establish the proportion of students that attended and prepared for class by having watched the AV material. Of the sample group 51% had watched all three viewings, 30% had only watched some of the three viewings and 19% hadn't watched any of the viewings (see chart 1 in figure 4). Analysis of these results are detailed in the proceeding sections. The response rate indicated that students are willing to dedicate some time to watching the recommended AV as part of prior learning, but not the entire thirty minutes that was

required for viewing all AV material. This was further confirmed when the respondents were asked to provide reason.

5.2 Students who partially viewed the recommended AV material

Reasons why only 30% of the class watched some and not all of the viewings were identified by further questions and explanations on the questionnaire. Of the 30% respondents who admitted watching part of the viewings, almost all (29%) claimed to have watched only the two short AV viewings lasting 7.5 and 1.6 minutes (a total of 9.1 minutes duration). The reasons claimed were:

They were too long and I didn't have time or didn't want to dedicate the time outside lecture time to view all three and/or lost interest.

This was the response of most students who hadn't viewed all of the recommended viewings, despite the longest, of 24 minutes duration, being of most educational value as was indicated to the learners.

Students commented that they were under the impression that they didn't have to view all three viewings. A false claim as they weren't given any indication that this was the case.

Question 3 of the questionnaire was aimed at establishing whether the learners considered prior viewing worthwhile as a learning enhancing experience. 81% of those that watched some or all of the viewings claimed it was worthwhile, whilst 19% were unsure. None of the responses claimed an outright 'NO'.

Asked whether more class sessions should be planned like this by taking the approach of recommended prior viewing, 81% responded with a definite 'YES', 17% were 'UNSURE' and 2% responded with a 'NO'. This is graphically represented by **chart 4** in **figure 4.**

Over half of these respondents considered the session to be more interactive, more informative and more interesting than usual, partly due to prior viewing. This indicates that overall, students favour this method of delivery because, they claim that it enhances their learning experience.

5.3 Students who didn't view any of the recommended AV material

Nearly 1 in 5 students or a total of 20 (19%) had not viewed any of the recommended AV viewings prior to the class. Although not entirely surprising, we wanted to identify the reasons by including question 2 in the questionnaire.

The reasons cited for this, as given by the students, included:

'I forgot'

'They were too long and I didn't have time or didn't want to dedicate the time outside lecture time'

'Looked at my email too late'

'Were not interested'

'I didn't know about it'

'Didn't think I had to'

'Already knew about the subject matter'

This would indicate that most of these students have an apathetic attitude to learning and their responses relating to their learning experience, in which comment is invited on an enhanced learning experience, is invalid. Their responses were on whole, indifferent and they failed to participate as interactively as other respondents who had prior knowledge. This was clearly indicated in their feedback.

5.4 Students who viewed all of the recommended AV material (see chart 3, figure 4)

Over half (51%) of students had viewed all of the recommended AV viewings. This committed them to over 30 minutes of their own time, prior to the class session. Their views and feedback with regard to their learning experience are important as they provide us with greater integrity of the outcome of the experimental delivery method due to this being a better informed sample group than the remainder.

Nearly all the group (52/53 or 98%) had claimed that they benefitted more throughout the session by having viewed the AV material before than if they hadn't. One respondent was unsure. Yet when asked whether more classroom sessions were preferred to be organised and delivered like this, a fewer number (43/53 or 81%) responded positively with a definite yes and 9/53 or 17% were unsure. 2% said no **(see chart 4, figure 4).**

5.5 Evaluating participation of learners

32% had participated by either direct interaction with the tutor or a peer during the session (either by expressing an opinion, replying to or responding to a question). This is high considering that the group size was in excess of 100 students and the timetabled session of 1 hour. The remainder 36 (68%) claimed that they just listened. None claimed to have lost interest. This was probably due to the size of the whole group.

5.6 Subject matter and relevance to the course (see chart 6, figure 4)

79% considered that it was and 21% were indifferent. None thought it was irrelevant.

5.7 Comparison with usual method of delivery (see chart 5, figure 4)

Of the 53, 83% had agreed that the session was better than usual delivery due to increased interaction between learner and teacher (or amongst peers) and that they considered the session more informative and interesting due to prior viewing. 13% thought it was no different and 4% were indifferent.

5.8 Should future subjects within the module be delivered like this? (see chart 7, figure 4)

74% responded with a positive ‘yes’, 2% with ‘no’ and 24% wanted some more sessions like this but not all future sessions. This is conclusive that the learners benefitted from the flipped learning experience.

6.0 Conclusions and Future Work

It is evident that whist students are prepared to dedicate time for prior learning in preparation for class, this time is limited to less than 10 minutes for a fair proportion (30%) whilst 19% are unwilling for various reasons, including apathy and time constraint. Even of the 30% of students that had prepared with up to 10 minutes of viewing, over 80% considered this to be a learning enhancing experience. 98% of these students thought that future topics within the same module ought to be delivered in a similar manner due to the learning benefits.

A small minority of the group (less than 20%) have an apathetic attitude to learning in that that they were merely prepared to attend timetabled sessions and be informed without a will to participate in an interactive manner or even to undertake some prior

preparation. The experimental delivery has been worthwhile in verifying an enhanced learning experience for learners.

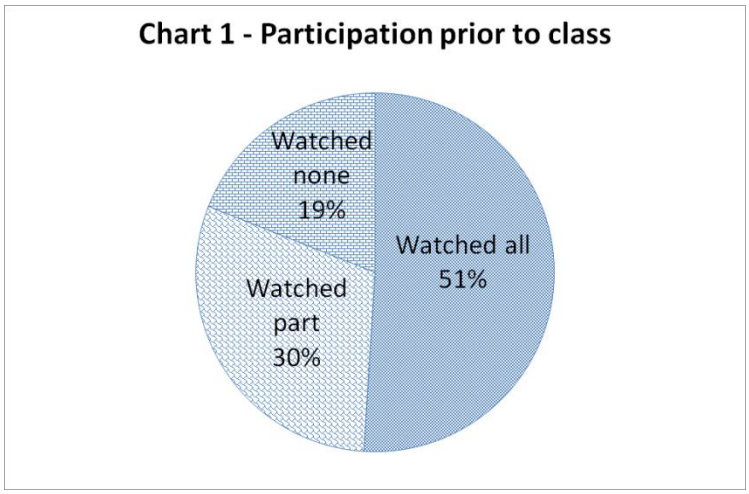
More sessions should be organised and delivered in this manner though not all sessions. This should be down to the discretion of the educator and be based on subject and topic. It also depends on availability and quality of material. The group size in this case was large enough to limit the number of learners that interacted in class. It is anticipated that delivery to smaller groups would results in greater engagement by in-class participation. In order to further this work, a similar experimental delivery is proposed within another School for a science based subject. A similar questionnaire will be issued in order to compare results and attitudes across both subject groups.

It is proposed that other future work is to encompass the following:

1. The context of the flipped learning approach will be applied to other subject areas within engineering in order to evaluate and quantify its effectiveness and importance in the teaching and learning process.
2. Having designed and implemented an experimental session to include prior engagement with teaching material, we now feel compelled to incorporate similar delivery for other topics which may prove effective to a greater or lesser extent and report on this.
3. Whilst the outcome of this experiment was evaluated using feedback questionnaires analysing student engagement with new material and, most importantly, student performance under time constrained examination, the improved performance requires quantifying. This can be achieved by presenting students with a significantly greater number of questions covering more than one topic, delivered in a similar ‘flipped classroom’ method as has the topic detailed in this paper.
4. A greater number of valid data samples are therefore required in order to evaluate the validity of improved performance, an important aspect of future work. The experiment will be repeated during the current academic year over a number of suitable topics as part of the on-going research. The results of the examination will provide quantitative data to evaluate whether the flipped classroom will results in improved overall examination scores and higher pass rate.

5. To report on comparisons in flipped learning techniques such as pre-sessional AV and podcasting.

At this stage, the measure of success is a qualitative one which is established through the carefully selected questions that have been presented to the students for feedback. The longer term research question and objective is whether we can verify and quantify a greater level of learning through the flipped class approach. The means of establishing this is by monitoring examination scores in particular subject topics, where the delivery method has been flipped classroom approach.



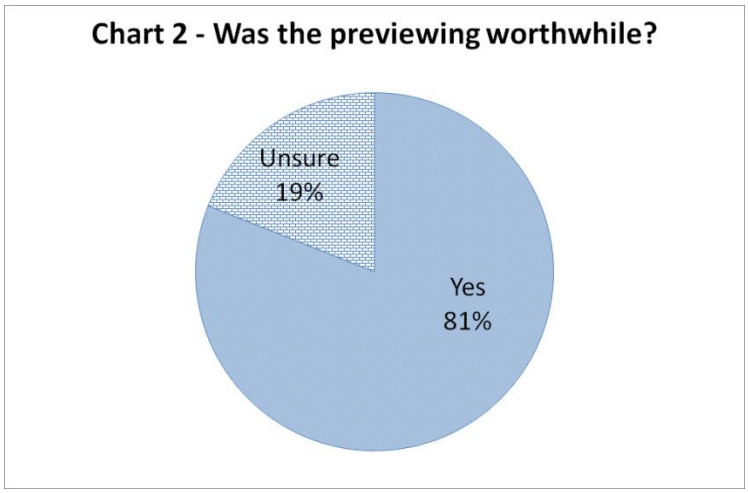
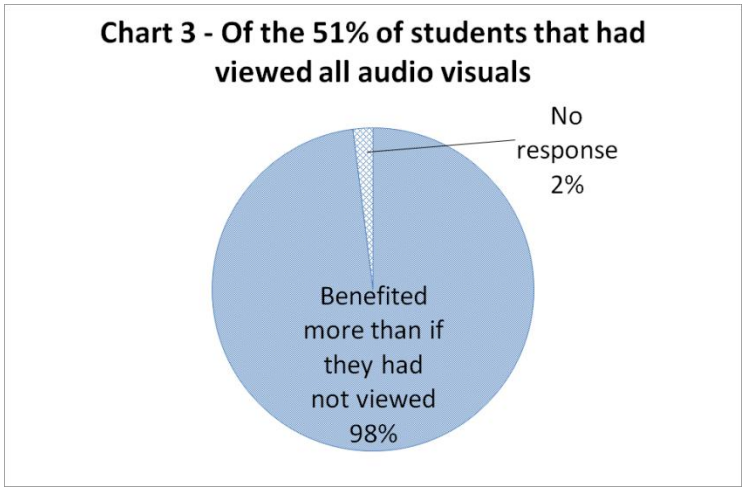


Figure 4 – Charts 1 and 2 indicating the level of participation and value placed in doing so.



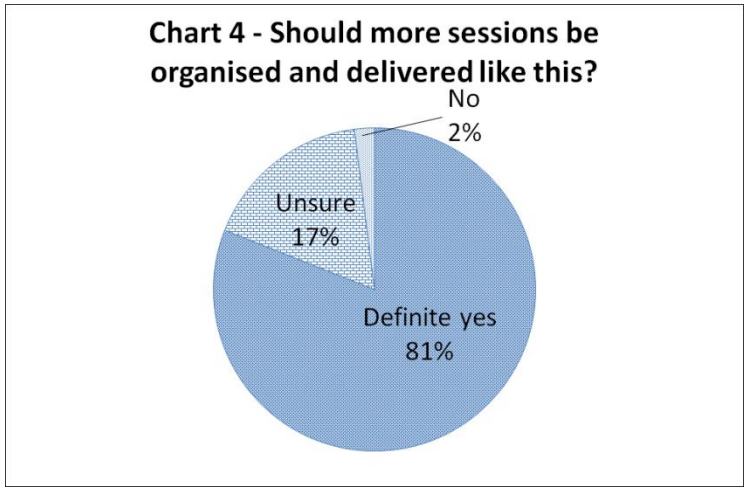
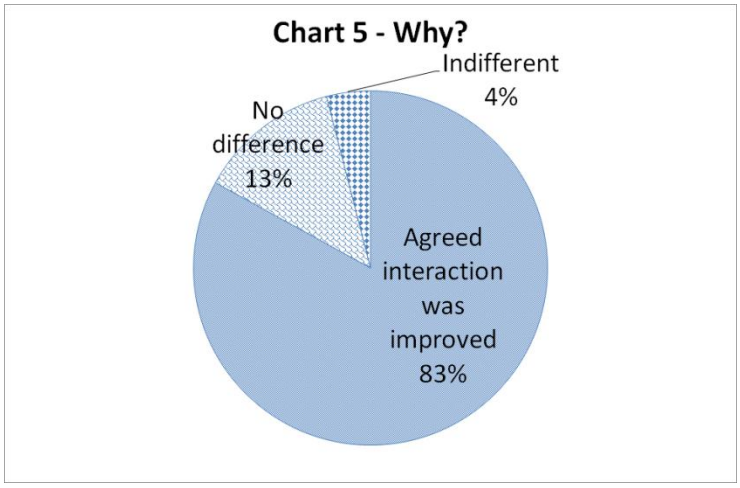


Figure 4 – Charts 3 and 4, refer to the perceived benefit in viewing all AV (by the students) and whether more sessions should be like this.



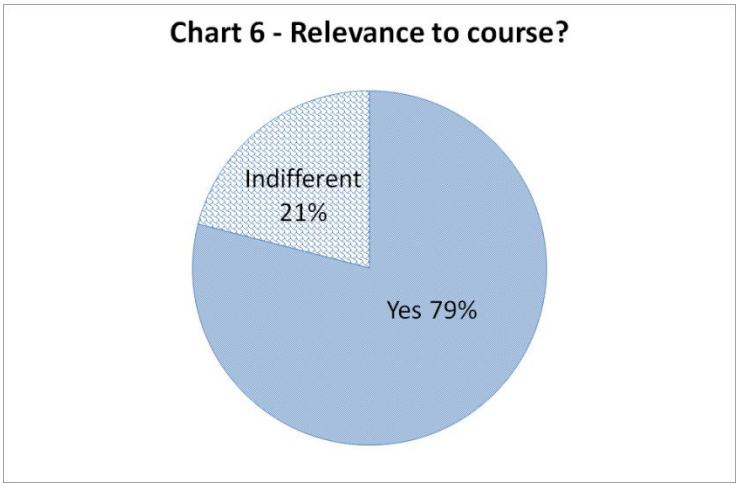


Figure 4 – Charts 5 and 6 refer to the justification for method of delivery and relevance to course, as perceived by the students

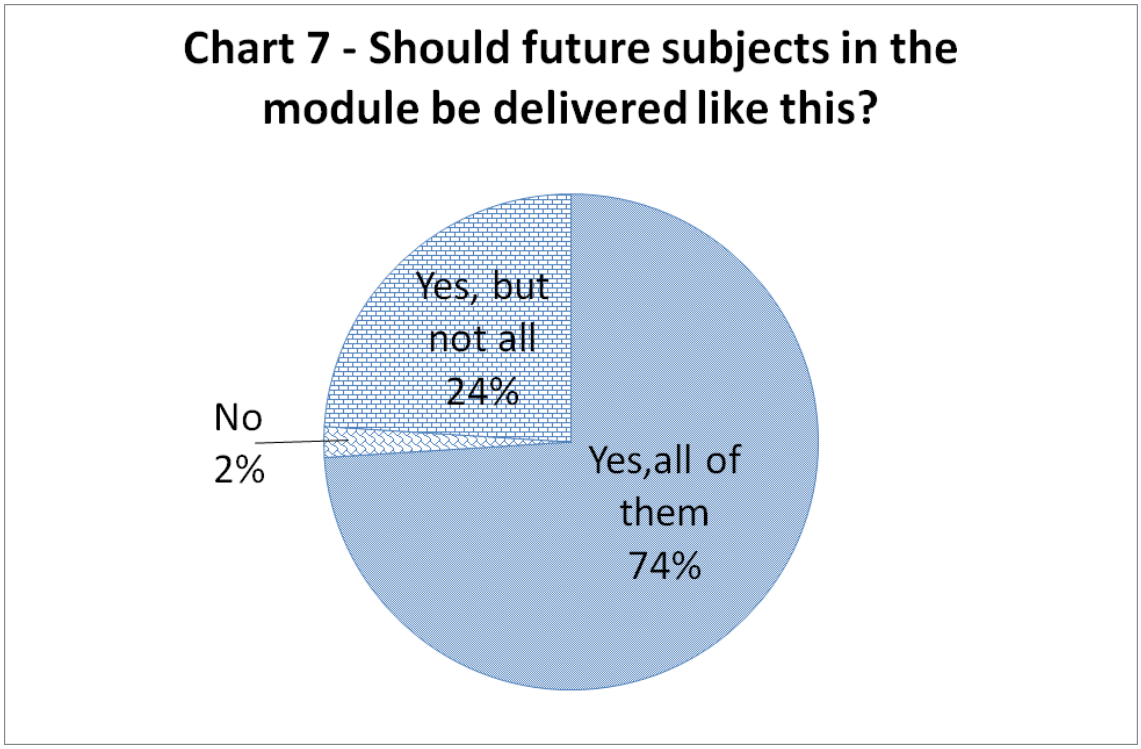


Figure 4 – Chart 7, refers to the response as to whether future subjects should be delivered like this (in the opinion of the students).

Figure 4 – Chart 1 to 7 summarise the findings of this research.

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Addendum

Copy of Questionnaire

Following delivery of the session, please answer the following questions:

1. You were asked to watch three AV clips on YouTube prior to the schedule class. Three clips were given of duration 7.5 mins, 24 mins and 1.6 mins
Which of the following best fits what you did? Tick all that apply

❒ Yes I watched all three fully
❒ No I didn't watch any of them
❒ I only watched some of them, partly or fully
❒ I only watch the short ones (7.5 & 1.6 mins)
❒ I watched part of the longest one

2. If you didn't watch all three clips, what was your reason?

❒ No interest

❒ They were too long and I didn't have time or didn't want to dedicate the time outside lecture time

❒ I didn't think I needed to watch all three as watching was recommended and not essential

❒ Other (Please state)……

3. If you watched any, did you think it was worthwhile watching the recommended viewings prior to class?

❒ Yes
❒ No
❒ Not applicable as I didn't watch
❒ Not sure

4. Do you think you benefitted more during the timetabled lecture session by viewing the AV material, more than if you hadn't?

❒ Yes
❒ No
❒ Not applicable as I didn't watch
❒ Don't know

5. Do you think more classroom sessions should be organised and delivered like this?

❒ Yes
❒ No
❒ Don't know

6. How do you rate delivery of the session in comparison to usual sessions?

❒ Better than usual sessions in that it was more interactive
❒ I found it more informative and interesting than usual sessions, partly due to prior viewing
❒ It was no different to usual sessions
❒ Not sure/indifferent

7. I liked the subject matter, in that I found it interesting and relevant to the module and course

❒ True
❒ False
❒ Indifferent

8. Did you participate in the discussion in any way?

❒ Yes, by asking the tutor a question, or a peer/fellow student
❒ No, I just listened
❒ No, I lost interest

9. Would you like more sessions in this module (lectures only) to be conducted in the same way (by prior viewing or demonstrations)?

❒ Yes

❒ No

❒ Some but not all

Add your comment here (optional)……..

……..

10. If you answered No in the last question, what is your reason?

❒ Disliked having to prepare before class

❒ Would rather be given all the information during class, including AV demonstrations

❒ Other, please specify

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Add your own comments here if you wish

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