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Additional Information:

- This is a conference paper.

Metadata Record: https://dspace.lboro.ac.uk/2134/13312

Version: Accepted for publication

Publisher: © South African Society of Engineering Education

Please cite the published version.
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Using Parallel Enquiry-Based Interventions to Engage and Motivate Engineering Students.

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Abstract

Engineering degrees are predominantly taught by highly skilled engineers and scientists but, like most discipline experts, relatively few of them are ever exposed to significant pedagogical training. The concepts and understanding of what motivates and engages students are generally understood but seldom put into practice. Nevertheless, engagement and retention are becoming increasingly important topics as the demands and expectations of UK students are increasing in line with the much higher tuition charges that are the result of recent government changes in the funding of Higher Education. Furthermore, the mind-sets of twenty-first century students are often mismatched with the expectations of their lecturers, who tend to assume intrinsic career motivation and blame poor performance on a lack of drive or ability. The challenge for universities is to enhance the acquisition of knowledge and skills by providing motivators, beyond that gained by the award of marks.

This paper describes an innovative year-long module for first-year mechanical engineering students, which embraces competitive challenges, student-centred learning activities, problem solving, creative design and skills workshops. The activities sit alongside and provide motivators for the unaltered, traditionally taught engineering science curriculum. The concept has been developing for three years and anecdotal evidence had suggested there were positive benefits, so an independent evaluation was commissioned; funded by a small grant from the UK Higher Education Academy. The evaluation used a mix of qualitative and quantitative methods of enquiry and demonstrated that such interventions can not only inspire students but also help to create improved inter-student and staff-student relationships.

Introduction

The transition to higher education is often difficult and it is known that “Effective transition can help to improve rates of initial retention and ongoing success.” (Thomas, 2009) A survey of first year students’ expectations by Cook and Lackey (1999) found that freshers (first year undergraduates) generally expected their learning experience would not differ greatly from secondary school. Persisting expectations of ‘teaching’ rather than ‘learning’ in an environment that expects and requires learner autonomy can lead students to disengage with study and fall behind before that autonomy is fully developed. Couple this with uninspiring traditional delivery of scientific facts and we have a powerful recipe for failure or withdrawal.

The Higher Education Academy surveyed a large number of students who had withdrawn early from UK universities (Yorke & Longden, 2008). The report cited poor quality of the learning experience as one of the major reasons and this is defined for us by the students own perceptions. Some pointed to their sense of isolation. For many, this was associated with large-scale lectures that allowed little, if any, interaction with academic staff or fellow students. Some commented on the impersonal nature, the difference between University and secondary school (high school) styles and the presumption that lecturers expected students to adapt instantly to their mode of delivery. Others commented on the lack of opportunities to make friends on their course or of intimidating or unapproachable staff. These comments were unsurprisingly negative given that the survey was of students who had already left their courses.
It was the realisation that young people arrive at university with very a different attitude and range of abilities to those of their forebears and that universities need to adapt to their changing needs that drove the movement for change at Loughborough University. When students do not respond and depart or fail, traditionalists are tempted to blame the students’ lack of dedication or ability so there would have to be some changes in the staff approach as well. The ideas described here are founded in the widely known constructivist educational theory where learners are invited to construct knowledge for themselves, become actively involved and learn how to learn while they learn. This paper describes some of the successes and growing pains that have accompanied the experiment and seeks to evaluate the initiative’s worth.

**Revised First-Year Curriculum**

Five years of work within the Wolfson School of Mechanical and Manufacturing Engineering at Loughborough University, trialling a number of engagement initiatives, have resulted in significant changes to the first-year curriculum and the inclusion of a new ‘active learning’ module specifically designed to address issues of engagement. The new development sits alongside a largely unchanged curriculum and embraces the idea that the most effective learning takes place when students are motivated. In ‘When Teaching becomes Learning’ (2007), Sotto wrote that motivation is already present in learners but it is a matter of creating situations that enable learners to become actively engaged and to use these experiences to reinforce the necessary fundamental knowledge and skills to support the science. This is more easily said than done but it follows that an effective environment for learning is one where students are truly connected and having fun. According to Malone & Lepper (1987) there are four basic factors needed for intrinsic motivation to occur during a learning activity. They are challenge, curiosity, control and fantasy (encompassing the emotions and the thinking processes of the learner) and these are the features that transform learning into a game. These were the basic principles upon which the EPPS module was built.

**Module Activity Descriptions**

The new module entitled ‘Engineering Principles and Professional Skills’ is delivered throughout the first academic year and accounts for 20 credits (in the UK, full-time undergraduates must study 120 credits per year). The module is built around four student-centred ‘enquiry-based’ assignments (EBL) of different styles and duration and a programme of appropriate skills workshops. There is also a 1-hour per week lecture programme to provide connectivity and, in some cases, give information; there is no formal examination. The projects are highly active and the major project attracts industrial sponsorship. Details of all the student-centred activities are listed in Table 1.

**Table 1. Team Based Assignments**

<table>
<thead>
<tr>
<th>Duration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBL-1 1-day (8 hours)</td>
<td>Competitive Design and Make using simple materials</td>
</tr>
<tr>
<td>EBL-2 1-day (8 hours)</td>
<td>Business Start-up Game</td>
</tr>
<tr>
<td>EBL-3 3-weeks</td>
<td>Vehicle Systems Research Project – create a video documentary</td>
</tr>
<tr>
<td>EBL-4 13-weeks</td>
<td>Competitive Design and Manufacture project – Mechanical Handling</td>
</tr>
</tbody>
</table>

The module has a strong association with the School’s personal tutoring scheme. On arrival, the intake of approximately 150 students is split amongst 24 academics who are designated as personal tutors and who meet with their tutor group of typically six each week. Personal tutors have traditionally provided pastoral and general academic support but enthusiasm for the system has historically been patchy and strong bonds were rarely formed between staff and their tutor group or between the tutor group members themselves. By linking the competitive activities to these groups, we hoped to generate a stronger sense of ownership and camaraderie and to include the staff member wherever possible.
### Table 2. Skills Workshops

<table>
<thead>
<tr>
<th>Topic</th>
<th>Duration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teambuilding and Resource Management</td>
<td>2 hours</td>
<td>Practical exercise</td>
</tr>
<tr>
<td>Library Skills</td>
<td>2 hours</td>
<td>Practical exercise</td>
</tr>
<tr>
<td>Understanding Learning styles and study skills</td>
<td>2 hours</td>
<td>Practical exercise</td>
</tr>
<tr>
<td>Plagiarism</td>
<td>1-hour</td>
<td>Practical exercise</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>2-hours</td>
<td>Competitive Robotics exercise</td>
</tr>
<tr>
<td>Basic Workshop Skills</td>
<td>2x2-hours</td>
<td>Hands-on workshop training</td>
</tr>
<tr>
<td>Engineering Measurements</td>
<td>2-hours</td>
<td>Practical Laboratory</td>
</tr>
</tbody>
</table>

The small group ‘skills workshops’ listed in table 2 run alongside the student-centred assignments and are timetabled as appropriate across the year: these are activities integrated into the programme, and each one is repeated several times until the whole cohort has taken part.

The teambuilding exercise in week 1 helps to form these teams which have generally begun to function by week 5 which has been designated ‘project week’. EBL-1 and EBL-2 are day-long exercises in tutor-teams during this special week when all lectures and tutorials for other modules are cancelled: it was decided to introduce this break from didactic delivery in the fifth week of the first semester to encourage and excite students who were settling to lectures but evidently starting to become unmotivated and inert. Aside from the fixed activities, this week allows freshers some time to reflect and, perhaps, catch up on other tutorial work.

A short lecture programme provides the glue to integrate all the activities together and provide timely information and necessary background knowledge for the project work but the overriding philosophy is that of student-centred learning where groups are challenged to find out for themselves, so lecturing is kept to a minimum in this module.

### Analysis of the Effectiveness of Change

**Methodology**

Conventional end-of-module feedback is obtained routinely for all modules in the School of Mechanical and Manufacturing Engineering; quantitative data are optically read and free text comments are summarised by the module leaders as a developmental process. Feedback relating to the EPPS module was scrutinised for the academic years 2008/2009 and 2009/10.

A web-based survey was made available to students on the module in the academic year 2009/2010 to discover their opinions about the different elements of the module and to determine their levels of engagement.

Student focus groups were undertaken during the academic year 2010/2011 with second year undergraduates who had completed the EPPS module during their first year. The outputs from the focus groups provide qualitative data relating to student engagement with the module, perceptions of the module whilst undertaking it and a reflective opinion from the second year perspective. The focus groups were led by research staff who are independent from the School.

Semi-structured interviews were undertaken with staff who initiated the first year curriculum changes, staff who were conscripted to help with the module and personal tutors who may have observed a change of attitude in their personal tutees. All participating members of staff and students were guaranteed anonymity.
**Conventional module feedback**

Towards the end of each module, during a timetabled lecture or tutorial session, generic questionnaires are circulated to all attending students. These questionnaires pose questions with multiple-choice ‘Likert’ scaled options for the answers relating to module content, teaching facilities and teaching quality; in addition there is space for students to write comments. It is the random qualitative comments made by the student that are of particular interest here.

In the academic year 2008/2009 there were 62 (51%) completed questionnaires received and in 2009/10, the return rate was slightly higher at 90 (64%). These included a relatively large number on which additional comments had been added (32 in 2010) which suggests a generally interested cohort. The feedback form also asked for comments to be given on how the module could be improved. The written feedback was very positive, in general, with students repeatedly commenting on the Interest they gained by ‘real’ experiences and the enjoyment they gained from the tasks.

Some students wrote strong praise for the module: one said “a superb module and really puts your engineering minds to work” while another wrote “very interesting and a great learning experience”. Some individuals, however, disliked one or other of the elements and several suggestions for improvement were made but the only consistent criticism concerned timing with some project work occurring around exam times. Following this feedback, minor changes were made to the module for the academic year 2010/2011. Of interest amongst the quantitative section were the 82% positive response to the question “Is the module appropriate for the degree Programme?” and 85% positive response to “Is the module interesting and stimulating?” 70% also agreed that the module had developed their understanding of engineering but 30% were neutral.

**Web-based survey**

The online survey was made available midway through the academic year to current students and sought to determine their opinions of the team-based work while they were undertaking it. The response rate was 53% (76 students). Again, there were both multiple choice and free text questions but, unlike the end-of-module survey where standard questions are used for all modules, these questions were specifically devised for this evaluation.

Comments received indicated that students welcomed the enquiry-based learning and teamwork approach; furthermore, the module successfully encouraged students to meet with and engage with their personal tutors. Prior to this initiative, the longstanding personal tutoring scheme had been patchy at best. The module provides impetus for tutor meetings and the questionnaire enquired how helpful students had found their personal tutor for the EBL3 project: 72% of students responded positively, with 10% describing their personal tutor as ‘enthusiastically helpful’. The group work tasks undertaken during week 5 of semester 1 were described as enjoyable by 76% of the respondents and 80% felt that the group work improved their communication skills.

Students reported that they appreciated being able to “work as a team” and that the projects had enabled them to “bond as a team”. One elaborated; “It allowed team dynamics to really flourish, highlighting everybody’s role in the team well, which should prepare us better for the major project [EBL4]”. Another respondent wrote about being taught to “work better as a team and become better friends as a result.”

**Student focus groups**

During the 2010/2011 academic year three focus groups were run, each comprising of four student volunteers from the second year of the mechanical engineering programme. These students had taken the EPPS module during their first year of study. The participants had entered university immediately after taking ‘A’ Levels in Maths and Sciences, after a gap year or after successfully completing the Loughborough University Science and Engineering foundation course. All participants seemed genuinely interested in the evaluation being undertaken and were keen to speak of their personal experiences of the module.
Interestingly, all of the students had extremely good recall of the module content and made very similar comments about the module. These comments fell into two categories; the group work proved to have been very popular, however, participants felt that some of the lectures were rather boring. They spoke positively of “working on real problems with other people.”

Built into the module is the necessity for students to contact their personal tutors. Participants were asked to explain how they felt about making contact with their personal tutor at the commencement of their first year and whether or not they felt differently about contacting him or her later in the year. None of the students expressed anxiety about contacting their tutor at any time. Gratifyingly, there was considerable praise for personal tutors, for example, “Perfectly approachable, not condescending – a hands on approach, I certainly feel able to go and talk to him”.

Week 5 of semester one is a lecture-free period. Instead of lectures the students undertake two group work assignments, to accommodate all the students the assignments need to be repeated – each student attends for two full days. The students all welcomed this break from the traditional lecture/tutorial format at a time when they felt their workload was building up and did not experience any difficulties in returning to lectures in week 6. However, their feelings about the actual activities they participated in were varied. A selection of the comments made is shown below:

“The break was good; we could use one this year ... it gave me a chance to catch up on work”. “Returning to lectures in week 6 wasn’t a problem – I just got straight back into it.”. “The group car work was fun. The SimVenture business game was quite good fun too, it’s a fun game with real life lessons”. “The activities were a bit naff”.

In addition to ascertaining whether or not students had found particular components of the module enjoyable and pertinent to their studies the focus groups were questioned about whether they had learned anything about how they learn. With the exception of one student all participants felt that the module had contributed to their understanding of how they learn. Comments made included:

“I’ve realised that for me it’s easier to learn if I’m doing it rather than just sitting in a lecture being told how to do it.”

Students detailed three aspects of the module that they found to be particularly useful. The most cited elements were the major project and in particular ‘their week in the manufacturing workshop’, the project management experience and the group working experience: of this one student commented; “I was put in a group with total strangers, some of them were hard to work with which was difficult but I learned to get on with it.”

Finally, participants were asked for their current opinions of the module, looking back as second year students. The consensus of opinion was that they have a greater appreciation of the module now than when they were undertaking it during their first year. The following comments capture all that was said in the three focus groups.

“When we were doing the module I can remember in week 5 enjoying making the buggy but thinking what’s the point of this. Now looking back [I] would like to do another day like that.” “I think it’s good to change the routine a bit and it’s beneficial to be working as a team, you need to cooperate. Team based things like that are good.” “Thinking back I believe that the group work taught me to voice my opinions but I didn’t realise that at the time. Without the first year module I may not have been so vocal this year.” “Much better than at the time, my main memory of it is the final project, which was the best. I didn’t learn as much from the other tasks though and I wouldn’t cart around chasing marks again because I think the module is designed to help us develop skills that are difficult to measure. It would be great if we could have a similar module in our second year.”

Staff Interviews

Individual interviews were undertaken with six staff who are personal tutors and staff who are involved with delivery of this module.
Interviewed members of staff who are personal tutors to EPPS students were asked whether they perceived that this module had had any impact on their tutees. The replies were all positive and indicated that they had a better relationship with their tutees than was previously the case.

“Now I see them more as a group, I used to probably have it half and half as group and individual sessions. I probably have more group sessions now just because of the group activities”. “I facilitate and act as a bit of a motivator for the team”. “I equally provide, in some instances, technical input which may be a little bit beyond their experience at that time so that I can assist them in moving forward and if I’m honest also trying to engender a bit of esprit de corps within the teams so that they actually have a desire to achieve”. “Sometimes, particularly at that stage of their development here they need help to glue together”.

Personal tutors who are not directly involved with delivery of the module were asked whether or not they were aware of the module content and the aims of the module. All of the interviewed members of staff are aware of the overall module content, if not the detail, and the aims of the module.

“I obviously only interface with a fairly small part of it, the part to do with my personal tutees, so some of the exercises the students work with their personal tutors but there is a lot of the module where the personal tutor doesn’t work with their tutees and obviously those parts I don’t know anything about. “Obviously [the module leader] sends through material on it as well so when we were actually getting involved I had a quick look at the module [VLE site] just to see what sort of context we were supposed to be working in”.

Members of staff were asked to describe their initial feelings about the module. All staff, whether they were directly or indirectly involved with the module, replied with positive comments.

This is an expensive game [undergraduate study], we are going to be seeing changes in the customer requirements and clearly the secondary education system has adapted to exam driven achievement, and interpersonal skills etc., are neglected to some degree so I think that’s why I’m positive on this”. “Yes, very much so and I couldn’t understand any staff not being”.

Members of staff who were directly involved with some aspect of the module delivery were asked to comment on their initial feelings about being involved. These were staff who had participated in the week 5 activities. Again, all responses were favourable. “I’m happy to be involved with the module and contribute to it. I’m keen to develop engineers”.

In addition to their first thoughts, members of staff were asked to detail their feelings about the module at the time of the interview and whether their attitude had changed since they first became involved and if so what had influenced this change. All but one of those interviewed had been involved with the module for more than one academic year. Members of staff whose attitude had not changed were asked to explain what it was that convinced them the module was an effective approach, an ineffective approach or why they were unable to determine its effectiveness.

All interviewees cited favourable feelings towards the module at the time of interview and in one case the response reiterated the comments that were made by the students in the focus groups.

“Well I’ve talked to my tutees quite a lot about how they feel about it, because that’s more important really, and they’re very positive. I get the impression that they find it a very useful exercise and it’s also a nice break for them from the academic work but they keep stressing that it’s not just a bit of fun and that they do think they’re learning”. “…they have lots of small niggles about things but generally they’re very positive. I’m supportive as well, I think it [the module] has good aims and it generally succeeds”. “…there are ways that it can be improved but …. it is growing and evolving”.

None of those interviewed had changed their opinion of the module since their initial involvement with it. “The module is an effective approach; the students are engaged, keen, happy and competitive”. Personal tutors were asked whether or not they had noticed a change in attitude of their personal tutees since the introduction of this module and if so what the changes were. Responses to this question were a mixture of yes and unable to say, for example:
“Yes, I think they bond together as a group a lot better. …. I think that’s probably the biggest difference”. “Unable to say – I’ve only had personal tutees after this module was introduced”.

The perceived advantages and disadvantages, from a staff perspective, were investigated.

Advantages:   Students working together in a group environment. Breaking down barriers, between staff and students. A better focus for personal tutors to work with their students. Excellent staff time utilisation.

Disadvantages:   The module, particularly Week 5 and the major project in semester 2 is labour intensive for staff. Some interviewees reported no disadvantages.

Finally members of staff were asked if they perceived any benefits or hindrances to student development that could be associated to this module. None of the staff interviewed perceived there to be any hindrances. The following benefits were mentioned:

The opportunity for students to interact. To gain a basic understanding of business and technology. To get them going more quickly. The break from lectures as their work is beginning to pile up. The fun aspect. The valuable experience of group work, early in their course.

Conclusions
Members of staff and students, who were interviewed for this evaluation, view the module as having a positive effect on both student engagement and the development of student group working skills. It was also established that, since the introduction of this module, there had been an improvement in the working relationships between personal tutors and their tutees. Where personal tutors were only visited reluctantly in the past, many students now appear protective about their own group and certainly much keener to ask their tutor’s advice. The introduction of project work into the first year has excited students and unhelpful barriers are being broken down. The role of personal tutor has been extended and we now have tutor-groups competing in the project activities with senior academics taking a keen interest in their group’s successes and providing helpful feedback to develop and improve the learning activities.

The fact that the module exists alongside conventionally taught engineering science modules meant much less disruption than a complete reorganisation would have required and it allows those academics who have been schooled in convention to continue with what is familiar to them. Furthermore, the two curriculum aspects are mutually supportive. The EPPS provides learning skills, demonstrates real applications and encourages engagement with the course and the profession, while the conventional modules add depth, scientific knowledge and mathematical skills that help to reflect on and explain the outcomes of some of the project work that often doesn’t go quite as planned but still provides a substantial learning experience: learning through mistakes.

There were some less favourable comments made by students concerning small individual elements of the module, for example, some disliked one or other of the actual tasks and the marking structure for particular topics (particularly when they had scored badly), however, these perceived shortcomings were not deemed to jeopardise the effectiveness of the module. By far the most common criticism gathered from all survey methods concerned the timing of events and clashes with revision periods etc. With such a large group and the need to operate all the activities several times over on a rota basis, this seems inevitable. Overall, the students considered the benefits of the module vastly outweigh any shortcomings. The module is still in its infancy and is being developed and improved each year and some of the perceived shortcomings have already been remedied.

Finally, there were strong correlations of opinion regarding the benefits of the module between the staff and students who were interviewed and also with the information on the module feedback forms and from the online student survey. All research methods strongly supported the earlier anecdotal evidence that was instrumental in initiating the evaluation project.
References

Acknowledgements
This project was kindly funded by the Higher Education Academy of the UK, Engineering Subject Centre, Loughborough.