

A Course Structure to Support Project Based Learning

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Abstract

Institutes delivering programmes using project based learning approaches often provide courses or modules to support the various projects being utilized. This paper presents a pilot study of a course structure which can support project based learning initiatives. The proposed structure is designed around a series of online quizzes and a key component is the use of one-to-one interviews to assess each student's progress through the course. In this pilot study, feedback from the students about the process used was extremely positive and the vast majority of survey respondents indicated that they found that the interviews motivated them to engage with course material effectively.

1. Introduction

Project based learning (PBL) and its variants place emphasis on creating an environment in which students are actively solving problems as a vehicle to drive student learning. Educational research reports that this strategy develops cognitive skills across the entire spectrum, from the lower levels of knowledge and comprehension to higher levels of synthesis and evaluation [1]. In addition students develop transferable and social skills as a result of engaging in team activities and learn to contribute to team performance in an ethical manner.

There are, of course, concerns associated with the delivery of projects within a PBL format. Perhaps the most prevalent, from a curriculum perspective, is the concern that students may not deal with the breadth of material covered within a more traditional learning environment. This can occur because individual students can focus on particular aspects of a project rather than have a global understanding of all aspects.

Another related issue is that of students not having a sufficient level of background knowledge in order to engage with the project effectively from the beginning. While a truly problem based learning (as opposed to project based learning) form of delivery would require the students to identify the gaps in their knowledge and fill those gaps through self-directed study. Many institutions that practice project based learning incorporate the provision of course material that is designed to provide the foundations for students so that they can engage with the project effectively from its initiation [2].

Courses/modules that provide the fundamental knowledge and skills required to engage with more complex problems help alleviate the issues surrounding the breadth of the material covered. They also position students so that they can make progress on a project more quickly within a PBL style of delivery.

This paper presents a pilot study of a structure for courses or modules that can support PBL projects and which effectively encourages student engagement with the course content.

2. Overview of pilot study

The following structure was used to deliver a course on digital signal processing to third year students enrolled on an honours degree programme in electrical engineering.

Students were required to work on a set of online quizzes in a computer lab at their own pace. As they progressed through the quizzes they could gain extra marks by taking part in one-to-one interviews with a course tutor during the lab sessions.

The interview questions were structured in such a way that a student had to have sound grasp of the basics before being allowed to progress to more complex concepts (see section 5 for more details). Each student had access to the interview questions beforehand and could request an interview whenever they felt they were in a position to perform well on a particular topic and in the event that a student couldn't answer a question they could simply retake the interview at a later stage without any penalty.

A survey of students found that the interviews helped to motivate them to engage with the course material with just two of 54 survey respondents indicating otherwise. This finding was supported by informal discussions with students and ad-hoc feedback in which students supported the both the module structure and the interview process, despite it being both a considerable challenge and, at times, somewhat daunting.

The remainder of the paper provides details of the module structure, the interview process and survey results, together with some observations of the authors who were the tutors involved in the module. In addition, a concise review of the how interviews and quizzes are used as assessment tools are provided in sections 3 and 4, respectively.

To briefly summarise the key findings of the pilot study, the structure and delivery of the module proved extremely successful from the perspective of both students and tutors. While considerable time and effort was required to develop a framework to deliver and assess the module, once the framework is in place its delivery is sustainable with relatively low tutor effort.

3. Use of interviews for assessment

One-to-one interviews with students are used relatively infrequently as an assessment technique due to the amount of time to conduct them [3]. However they can provide an extremely useful means of identifying the depth of understanding that a student has gained on a topic as the interview questions can be phrased in different ways depending on the ability of the student. Interviews provide a mechanism to explore topics on wide range of levels and their malleable nature allows the student explain their understanding in ways that they would not normally have access to [4].

The majority of assessments undertaken in third level education are skewed in favour towards those students who have developed good written communication skills. Interviews allow a tutor to tease out a student's understanding of a topic by rephrasing questions to suit the student's ability. Weaker students can be coaxed along and the interview process can be used as means to teach and reinforce key concepts at same time as the assessment is taking place. Stronger students can be quizzed on their understanding at a higher level and they can be encouraged to explore more complex concepts that may be outside the grasp of weaker students.

The interview process offers students who have difficulty with written communication to express their level of understanding of concepts through alternative means. It can allow the student to show their skills and knowledge through practical demonstration and augment written work with verbal explanations. It also allows students express insights that are not typically available through other modes of assessment.

The use of interviews would seem to be particularly appropriate within a PBL style of delivery as it ensures that students gain experience in verbally explaining concepts. This is a key skill for students who are required to participate effectively within groups while working on projects. One potential barrier to implementation of PBL within a curriculum is that students may not feel comfortable with speaking within a group and the use of interviews can provide a more palatable and direct route to developing these interpersonal communication skills.

4. Use of Online quizzes for assessment

Online quizzes have been utilized in a broad range of disciplines to support student learning [5-7]. In [5] it is noted that, amongst educational psychology students, higher use of optional online quizzes correlated with better academic performance, while an analysis of a survey of first year biology students [6] found that 90% of students found weekly online quizzes to be either useful or very useful.

Online quizzes offer many benefits over their paper-based counterparts; some key ones are listed below:

- Easy/wide access
- Facility to provide quick feedback
- Easy reuse of quizzes
- Allows multiple attempts
- Automatic corrections

Kibble [5] explores the use of unsupervised online quizzes as means to provide formative assessment in a medical psychology programme. The paper explored the impact of offering 'course credit' to students as an incentive to utilise the quizzes. In the first instance no credit was offered and it was observed that there was a high correlation between optional participation and higher end of semester summative assessment grades. Subsequently credit between 0.5% and 2% was offered as an incentive; [5] notes that while the participation increased as a result there was evidence of widespread inappropriate use of the unsupervised quizzes.

The use of unsupervised quizzes are appealing to both students and staff due to the flexibility they offer and the low-cost of their implementation after initial setup. The difficulties with inappropriate use of such quizzes is acknowledged with the result that particular focus will be placed on quizzes which require a basic process to be applied; one in which it would be easier for a student to simply learn the process rather than copy from a colleague. It was also felt that the quizzes should generally contain a number of variables which could easily be randomised to allow for a large amount of variability in each questions answer; although the process to determine the answer would be the same, or similar, in each case to promote sharing of knowledge between students.

The pilot study presented here uses unsupervised online quizzes extensively. The issue of inappropriate use of such quizzes is dealt with by interviewing students on their understanding of concepts as they progress through the quizzes.

5. Course details for pilot study

The course deals with introductory material related to digital signal processing (DSP) and is delivered in year 3 of a four year honours degree programme in electrical engineering. The focus of the course is to ingrain fundamental skills and knowledge associated with digital signal processing which can then be applied to more complex problems. There is little emphasis placed on developing significant problem solving skills within the course, rather a focus is placed on developing key competencies that would be required in order to solve more complex DSP problems at a later stage in the programme. It is worth mentioning that the programme consists of a suite of courses/modules which focus on developing group-based and problem-solving skills throughout its four year duration.

There is a follow-up course in year 4 which deals with more advanced DSP techniques and the authors have been responsible for delivering both DSP courses for the past four years. This has allowed the authors observe improvements in student understanding gained from modifications introduced in year 3.

Continuous assessment forms 40% of the overall module mark and is comprised of two key components: completion of online quizzes and one-to-one interviews. The remainder of the module mark is determined by a 3 hour open book exam and a half hour online exam.

The module is delivered over a 15 week period with a front-loading of student effort during the first 4 weeks to allow students partake in an industry based work placement initiative. During these first 4 weeks students attend four hours of lectures and four hours of computer lab sessions where they work on practical signal processing problems. The problems are presented within a Virtual Learning Environment (VLE) and are mixture of short multiple choice style questions; calculation style questions; and problems that involve more substantial student effort but typically would require no more than 2 hours to complete. Students work on these online problems at their own pace and can continue to work on them for the 15-week period in an unsupervised setting. During the first 4-week period students were encouraged to help each other work on problems within the computer laboratory and students who were able to assist others were rewarded with additional marks (see Table 1).

The VLE also contains over 10 hours of video tutorials with each video being typically 15 minutes duration. The videos are focused on individual concepts which are reinforced and presented to the students in a unified way during lecture sessions. Students frequently review the videos during lab

sessions in preparation for the problems and assessment interviews.

The videos and course notes played an important role during module delivery as they allowed tutors focus entirely on assessing students' ability rather than on explaining concepts during lab sessions. Over the course of the module a number of students commented that access to course material, i.e. video tutorials and online notes, was a particularly useful feature of the module. They felt that if they were having difficulty with a concept or online problem then the necessary resources were readily available.

6. Interview process

There are 8 interview topics each containing interview questions/criteria which are related to learning objectives associated with that topic. Each topic is then divided into a subset of interview criteria that a student must be able to deal with in a single sitting before being awarded any credit. The example provided in the following few paragraphs illustrates the process.

One of the interview topics deals with "filtering signals" and both the student and the tutor have access to the following list of interview criteria.

Table 1. Interview criteria for the topic 'Filtering Signals'

Level	Criteria
Level 0 0%	Unable to complete all of level 1
Level 1 40%	Explain low-pass, high-pass, band-pass and band reject filters. Design and implement a filter using built-in Matlab functions. Explain the term normalised frequency.
Level 2 70%	All above plus: Explain the terms passband, stopband, transition band, passband ripple and stopband attenuation. Design a minimum order filter to meet a filter specification.
Level 3 85%	All above plus: Explain the advantage/disadvantages between FIR and IIR filters. Explain the differences between chebyshev, elliptical and butterworth filter designs
Level 4 100%	All above plus: Deep understanding - able to engage in discussion easily without prompting and/or evidence of having assisted others with this topic

Each student is initially placed at level 0 (see Table 1) indicating they have not yet completed the criteria associated with level 1. In order to complete a level the student must meet all of the criteria associated with that level in one sitting; if a student is unable to demonstrate the knowledge/skills and satisfactorily meet the criteria listed then the interview is terminated and no marks are awarded. A

student can only request an interview related to a particular level once all the lower levels have been completed and there is no limit to the number of interview attempts that a student has on a particular topic, with the only constraint being the time limit of the lab session.

Since approximately 16 students are present in a computer laboratory and these students could hear all interviews that were taking place, tutors would vary the way an interview was conducted, particularly if they got the sense that responses to interview questions were being ‘memorized’ rather than ‘understood’. As an example, the question “What is a low-pass filter?” would often receive the response “it’s a filter that removes low frequency content from a signal”. In order to ensure that this phrase was understood the tutor might ask the student to explain what he/she meant by ‘frequency content’ or to illustrate the concept of a low-pass filter with a sketch.

For each topic the criteria associated with Level 1 represented the minimum set of knowledge/skills that the student would require in order to put this grouping of knowledge and skill to practical use. In the filtering signals example, it can be seen that the student cannot get any credit for only knowing the basic filter types (low-pass, high pass, etc.), he/she must also be able to demonstrate an ability to filter a signal, which also requires knowledge of normalised frequency.

Structuring the topics into different levels is designed to focus the students on the fundamentals before dealing with more complex concepts and encourages a broader understanding of the entire module content. This is in contrast with a typical written exam in which students can often perform well with deep knowledge of a just a few selected topics.

7. Survey results

The course has been delivered in the manner described above for the last two years and both cohorts were invited to participate in an anonymous online survey. The survey participants were presented with the following three questions:

- Did the interviews motivate you to engage with the course topics? *Yes (significantly) / yes (to an extent) / no*
- Did the online quizzes help develop your understanding of the course topics? *Yes (significantly) / yes (to an extent) / no*
- Would you like to see more modules organised in the same way? *yes / no*

Participants provided responses by selecting one of the options shown in italics after each question

above. Students were also invited to provide additional comments on the module as an option.

There were 39 students in the current cohort, of which 27 responded to the survey, while 27 of 57 students in the previous year’s cohort took part.

Table 2. Survey responses of current cohort

Did the interviews motivate you to engage with the course topics?		
<i>Yes (significantly)</i>	70.37%	19
<i>Yes (to an extent)</i>	25.93%	7
<i>No</i>	3.70%	1
Total		27
Did the online quizzes help develop your understanding of the course topics?		
<i>Yes (significantly)</i>	48.15%	13
<i>Yes (to an extent)</i>	51.85%	14
<i>No</i>	0.00%	0
Total		27
Would you like to see more modules organized in the same way?		
<i>Yes</i>	77.78%	21
<i>No</i>	22.22%	6
Total		27

Table 3. Survey responses of previous year’s cohort

Did the interviews motivate you to engage with the course topics?		
<i>Yes (significantly)</i>	44.44%	12
<i>Yes (to an extent)</i>	51.85%	14
<i>No</i>	3.70%	1
Total		27
Did the online quizzes help develop your understanding of the course topics?		
<i>Yes (significantly)</i>	51.85%	14
<i>Yes (to an extent)</i>	44.44%	12
<i>No</i>	3.70%	1
Total		27
Would you like to see more modules organized in the same way?		
<i>Yes</i>	62.96%	17
<i>No</i>	37.04%	10
Total		27

8. Discussion

The original motivation for the use of interviews was to deal with the potential issue of inappropriate attempts of unsupervised online quizzes [5], whereby students could answer questions correctly even though they might not fully understand either the question or the solution they provided. This might occur, for example, if a student was to blindly copy a colleague’s approach to a particular problem. The survey responses indicate that the interview process had the desired effect in this regard.

The use of interviews has additional benefits. Firstly the style of interview can be adapted to suit the ability of the student; weaker students can be prompted and stronger students can be given the opportunity to provide insights which are not typically available through other modes of assessment. This method therefore allows for the assessment of a broader range of cognitive ability [8]. The interview process is also well aligned with the notion of developing students' verbal and interpersonal communication skills, which is one of the drivers for utilizing project based learning.

Another positive feature of the structure used is that students are encouraged to focus on the fundamental core competencies before attempting to engage with more complex concepts. Students cannot request an interview on complex concepts until they have demonstrated competency with the fundamentals. The authors consider this to be an important feature which is often lacking with other assessment approaches, including written examinations and group-based project work.

The results of the survey also indicate that the students found the structure of the module useful as they would like to see the approach adopted within other modules. This could be interpreted as meaning that the students found the module relatively easy but through informal discussions the authors got the sense that they appreciated they were developing useful skills and knowledge of a relatively high difficulty.

One significant issue with the course structure presented is the significant time required to develop material such as online quizzes, video tutorials and notes. Tutors were in a position to focus on assessment, using interviews, as a result of such material being available and this is seen as being a key component for the successful delivery of the module in the manner described. However, as more and more online resources become available this barrier will be reduced and the proposed structure will become increasingly feasible.

9. References

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