Contextualised Problem-based Approach for Teaching Undergraduate Database Module

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Abstract
In this paper, a new approach has been used in teaching the second year undergraduate database module. The approach is a combination of contextualisation, problem-based approach, group work and continuous formative assessment. The contextualisation ensures the visibility of teaching/learning activities so that students are aware of the values of activities and how they can fit into a big picture. Problem-based approach gives the students tasks/problems to solve before the relevant lecture takes place, hence can better develop effective reasoning processes, independently learning skills and improve motivation and engagement. Group work is regularly used due to the diversity of student backgrounds and level of prior knowledge of certain topics. By having group work, students can learn from each other and easily clarify confusions among themselves before approaching the lecturer. This gives the lecture more time focusing on common issues. Formative assessment has also been used to support teaching/learning activities and to reinforce their understanding. The work in this paper has been evaluated via an end-of-year online module survey. The results show good effectiveness of the new approach, although there are still spaces for improvement.

Keywords
Contextualisation, problem-based Learning, peer teaching and assessment, formative assessment

1. Introduction

1.1 Module and Student Backgrounds
The second year undergraduate database module is a core module for the most of the computing courses at the University of Northampton. This module is the pre-requisite of the final year database module and is one of the co-requisites of the second year group project module, which itself is the pre-requisite of the final year dissertation module. Therefore, student performance on the second year database module has direct impact on other modules and likely their final year degree classification. This module develops an understanding of the process in building database applications, with particular focus on the

underlying technologies, which make database application development possible and efficient.

Students on the module usually have mixed backgrounds. The majority are home and EU students; there are also some international students who usually have special needs with regard to language provision and social support. Even for the domestic students, there is a big variation between HND and BSc computing students in terms of entry standards and prior knowledge of certain topics (e.g., from their A level studies or employment). Those students who have prior knowledge are likely to get bored or be absent when being taught basic database concepts, whereas others might be struggling in understanding them. Moreover, there are also different age groups among those students, some of which are mature students who tend to have better motivation, hence better learning attitude. Furthermore, students enrolled on this module are from different courses, perception of importance of the module is different. There is an impression among the computing students that the database module is more relevant to some courses than others, and some students are even not sure why the module is needed for their course. In such as diverse environment, actively engaging students becomes a very challenging task.

1.2 Introduction to Contextualisation and Problem-based Learning

Contextualised teaching is to put individual topics to be taught into a meaningful and real context rather than to treat them as isolated items. Contextualisation allows the learners to see the big picture and how individual topics fit into the big picture and the relationships between them. This will help the learners easily understand the topics being taught, and to quickly recall them during revision period. During university studies, all teaching and learning activities set for students should be seen as having value and as readily performable. Students should be required to build on what they already know, to be relevantly active, to receive formative feedback and to be engaged in monitoring and reflecting on their own learning (Biggs et al 2011). Teaching and learning activities need to be aligned to the intended learning outcomes that are to be facilitated. The alignment should take place in all activities, including content design and delivery, creation of formative assessment and assignments and examinations, marking criteria, feedback, etc. Contextualisation is to make the learning *visible*, so that students at all learning stages have clear idea about why they are learning the topics and what learning outcomes the activities will lead to.

Contextualisation for the undergraduate database module was not done properly in the past as some students were not sure about the values of certain topics and activities and could not link the topics together. For example, some students often asked the lecturer about the relevance and importance of entity relationship modelling; other questions asked were about the relationships between certain topics; in another word, they could not see the big picture. It can be predicted that when students have such confusion, they could easily get frustrated.

Traditional teaching practice follows the *fill-up-the-tanks* model of knowledge acquisition by teaching the disciplines first, independent of one another, and armed with all that declarative knowledge and some professionally relevant but atheoretically taught skills (Biggs et al 2011). The problem of traditional model is the misalignment of intended learning outcomes, teaching and assessments. Problem-based learning (PBL) gives students with functioning knowledge so that their induction into real-life professional practice is much quicker. PBL reflects the way people learn in real life; they simply get on with solving the problems life puts before them with whatever resources are to hand (Biggs et al 2011). (Savin-Baden

2000) argues that PBL is often confused with problem-solving learning, which simply means setting problems for students to solve after they have been taught conventionally and then discuss them later. According to (Boud 1985), in PBL the starting point for leaning should be a problem, query or puzzle that the learner wishes to solve.

Formative assessment is powerful teaching/learning activity that uses error detection as the basis for error correction (Biggs et al 2011). It is an ungraded assessment and used to assist on-going learning. When formative assessment is used, it is very likely that students will feel free to admit their errors and learn from them. In contrast, summative assessment is mainly used for grading students and the grades are final. Students are unwilling to admit their mistakes, as they fear the assessment outcome. Error is no longer there to instruct, as in formative assessment; error now results in punishment (Biggs et al 2011). Formative assessment can be in various forms such as questions and answers sessions, quiz, short assignment, ungraded class test, peer assessment, etc. Formative assessment and feedback should be used to empower students as self-regulated learners; more recognition should be given to the role of feedback on learners' motivational beliefs and self-esteem (Nicol et al 2006).

In this paper, PBL will be used in combination with contextualisation, group work and formative assessment to achieved intended goals of improved motivation, better engagement and ultimately good learning outcomes.

2. Inquiry-based Project

2.1 Project Rationale

The teaching and learning practice for the module of study in the past followed the traditional *lecture plus practical session* model. Most of the lecture notes were developed from scratch, and several textbooks were used. The previous materials for the lab sessions were not systematic, and were replaced by a well-designed lab guide, which uses examples from a different business scenario. Due to lack of consistent information (examples used from different books), it was difficult for the students to see the big picture of various topics covered in lectures and labs, hence difficult to see the interconnection between them. Because examples were from multiple resources, it was very difficult for students to work on some example and use it for next practical sessions. Instead, students had to implement several examples in order to verify their understanding of certain topics. This discouraged some students from trying out the examples. Contextualisation helps put individual topics into a big picture, therefore the interconnections between the topics can be easily seen by the students, and the usefulness of the topics can be realised.

In each of the practical sessions, the main task was to follow the step-by-step instructions in the lab guide. Most of the students simply followed the instructions to complete the tasks without much thinking. This kind of *spoon-feeding* practice prevented metacognitive activities and affected functioning intended learning outcomes (Biggs et al 2011). When students were asked to solve problems independently, they struggled to come out with solutions. PBL is one of the active teaching/learning methods that can narrow the gap between students doing higher order cognitive activities, as it requires students to question, to speculate, and to generate solutions. (Biggs et al 2011) classifies problem-based learning as a good teaching method as it gets most students to use the level of cognitive process needed to achieve the intended outcomes that the more academic students use spontaneously. Contextualised problem-based approach helps students learn academic knowledge and develop professional skills during the process of solving real-world problems, which will benefit their future studies and employment.

Due to the big diversity of the student backgrounds and prior knowledge of the certain topics, when teaching some basic database concepts, it was very difficult to get the same level of engagement from all students. Also, some students thought they understood some topics that they learnt before, but actually they were not able to do the related tasks due to different level of difficulty. In PBL, the students are given problems to solve before the lecture takes place, hence likely pay more attention to what confused them; for those who have prior knowledge about the topics, this approach tests their real understanding.

The group discussion has been used for two main reasons: i) based on the author's past experience, not all students like asking the lecturer questions, particularly in a big class; small groups encourage them to express themselves, therefore enable better engagement; ii) in a lab session, the tutor has limited time on each of the students. Group discussion gives students a sense of involvement and helps them correct most of the mistakes; therefore the tutor could make better use of the limited lab time. This approach results in good efficiency and productivity. Peer teaching and assessment provides a structure and framework for discussions about quality of work, and helps student to become critical about their own work and the discipline-related body of knowledge (Hinett 2002). During the discussion, better students can help others clarify confusion, making themselves feel helpful; teaching others also makes them understand the topics better. With regular formative assessment, students are assessed on how well they meet preset criteria, where they were before, where they are now and what they need to get a high grade. With proper guidance from the lecturer and discussion with their classmates, the learners will eventually be able to solve the problems themselves, and their confidence will be built, and expectation of success will follow. When the learners see the value of what they are learning and the possibility of success, according to the expectancy-value theory (Feather 1982) they will automatically have intrinsic motivation, which drives deep leaning and the best academic work (Biggs et al 2011).

2.2 Aims and Objectives

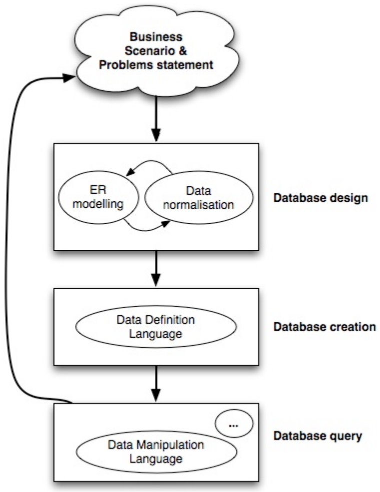
The aims of the work in this paper are to use contextualised problem-based learning to increase motivation, improve engagement, promote metacognitive activities in learning this module, and therefore to achieve better learning outcomes. The main objectives of this paper are as below:

Increase motivation - contextualisation makes students believe what they are going to learn is useful; problem-based learning helps them develop useful skills to solve the real-world problems. When students know they can be successful, their motivation will automatically follow.

Improve student engagement and encourage metacognition - peer teaching and assessment improves student engagement; PBL encourages more metacognitive activities.

Change students' perspective on what they have learnt - contextualised problem-based learning makes students feel they have learnt something useful from their own perspective. It reflects the phenomeno-graphic approach (Prosser et al 1999), which states that it is important to change the learners' perspective on how they see the world and how the learners represent knowledge. When the learners' perspective changes, it will likely lead them to higher order levels of understanding.

The new approach is part of the transformative reflection practice. The multi-stage process of *reflect→plan→apply→evaluate* will always be applied for continuous improvement in future teaching/learning activities.



3. Project Implementation

3.1 Contextualisation

In the module specification, there are four main topics that need to be taught: entity relationship (ER) modelling, data normalisation, creation of databases, SQL, etc. Building a relational database for a given business scenario and answer some important business queries is a chain of process. From Figure 1, it can be seen that when a scenario is given, a database design can be built using ER modelling, data normalisation, or the combination of them. The model can then be used for database creation (either manually or using existing software tools). The creation of relational database and data input can be done using Data Definition Language (DDL). Finally, the database can be queried based on business requirements using Data Manipulation Language (DML). All these steps are essential, and they are very closely related. In the past, the topics were taught separately, the relationships between them were not emphasised, although significant amount of time was spent, quite a few students were still struggling to understand them and even not sure why they need to learn them. One typical example was that several students asked me why they needed to learn ER modelling. The author was told that they thought the ER diagrams (ERD) were just academic practice, which was of little use in solving real problems. To help them understand the relationship, at the beginning of each of the topics, some time was spent telling how each of them fits in the big picture and how important they are. When the importance of the topics is addressed, motivation will follow.

3.2 Problem-based Learning

Students were given problems (in the form of gobbets) usually before relevant lectures took place. Students had one or two days to read the scenarios and to think about the questions. According to (Johnstone 1976), concentration during a one-hour lecture is only about ten to fifteen minutes; if this short period is used to focus on something confusing, it will be more efficient. With the questions in mind, students usually paid more attention in the following lecture to what confused them. They were given plenty of time to ask questions to clarify the confusion. The lecture gave students necessary knowledge to solve the problem and in that sense became a facilitating session. For each of the problems/topics, a list of common issues from previous years was also given, so that students can learn from others' mistakes. The common mistakes were also used on blackboard as comment repository for assignment marking and student feedback.

3.3 Group Work

The problem based approach was also used in group work, which was regularly used for two reasons: 1) as mentioned in the Section 1, students on this module have very diverse backgrounds and different prior knowledge of certain topics, therefore, group work seems ideal in such a situation; 2) some of the topics in this module such as ER modelling and data normalisation are, especially at the beginning, confusing, the author has encountered all sorts of mistakes from students. Group work took place during practical sessions, students were asked to form small groups of two to three students randomly as suggested in (Yamane 2006) to avoid gossip or discussion of off-tasks. They were asked to perform the tasks first on their own, when finished, they needed to compare the answers and convince the group members. After short group discussions, most groups could come out with a good answer; occasionally, all groups made a common mistake that was usually due to insufficient explanation of the topic in the lecture. In that case, more time was spent on the particular topic.

3.4 Formative Assessment

Formative assessment was regularly conducted by peer assessment and tutor assessment. One of the main advantages of formative assessment is that students are not afraid of admitting mistakes in front of the lecturer or a big class or in a work to be graded. Peer assessment is very informative, based on the observation, students were usually not afraid of admitting mistakes. In the practical lab session, the tutor usually walked around and checked whether the students understood the topics by asking them questions. Doing the informal conversation, most of the students tended to ask questions, which otherwise might not be asked in a big class. Continuous formative assessment consolidated students' understanding of different topics and improved their confidence.

4. Project Evaluation

4.1 The Student Survey

The new approach used for teaching the module was evaluated at the end of the academic year via online module survey. According to experience in the past, the more questions in the survey, the less responses students made. Since the survey was done after all assessments, students were less likely to respond to the survey actively. To encourage more responses, there were only ten questions in the survey. All questions except the last one were multiple choice questions (MCQ) with scale 1 to 5, representing strongly agree to strongly disagree, respectively. The questions were carefully designed to get students' feedback on different aspects of the module in a way similar to those used in national student survey (NSS).

4.2 The Results

The survey form was active for three days, and during the time twenty-seven out of sixty students responded, which is considered a good sample. In this section, the evaluation results are analysed to see the effectiveness of the new approach. The response to question 1 (refer to Figure 2) shows that about 60% of the students considered the module is intellectually challenging, slightly less than 20% of them did not share the same impression. This response reflects the diverse student backgrounds mentioned in Section 1.1. The second question is about teaching style. From Figure 3 it can be seen that 63% of the students believed the traditional style (*lecture plus lab session*) was suitable for this module whereas 29% of them had opposite view. The figure suggests some changes in teaching style are required and it is one of the reasons of this paper.

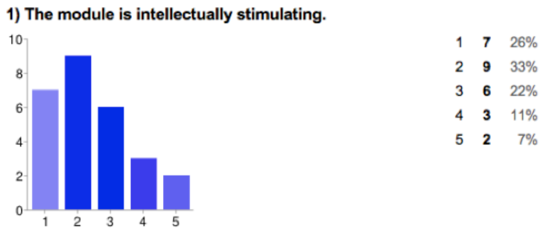


Figure 2. Responses to survey Q1

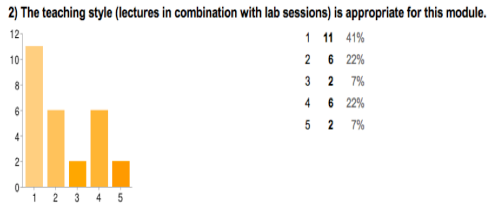


Figure 3. Response to survey Q2

As mentioned earlier, the problem-based approach together with group work have been introduced for this module, particular in the lab session. Figure 6 shows that 66% of the students believed that the problems given in the lab sessions were challenging, whereas 19% of them needed more challenging tasks. Due to the diverse backgrounds this is expected, and will be solved by adding more challenging tasks for more competent students. From Figure 4 and 8, it can be seen that some students were quite happy (60%) about the group discussion to solve the problems among themselves in lab, however, the group work resulted in less involvement from the lecturer, which around 30% of the students seek direct help from. These two figures verify each other, and the textual feedback in Figure 11 confirms the conclusion. In the future, perhaps the lecturer should participate more in-group discussion to give students perception of involvement.

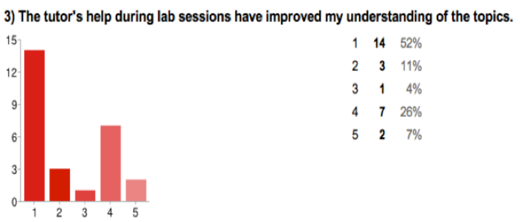


Figure 4. Responses to survey Q3

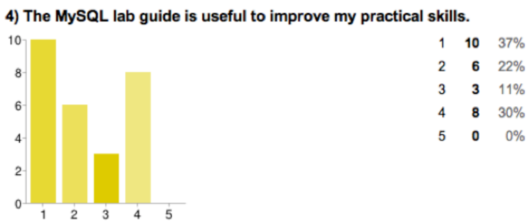


Figure 5. Responses to survey Q4

Question 6 of the survey asks students if they feel the knowledge from the facilitating lectures is enough to solve the problems. 66% of them felt very positive (refer to Figure 7), but students (26%) felt negatively. The reason for this is unknown, it could be due to insufficient explanation of the topics during lecturing, or some students were poor applying the theory to solve practical problems, therefore more problem solving examples should be given. From the response of the last survey question (refer to Figure 11), the latter is more likely to the case.

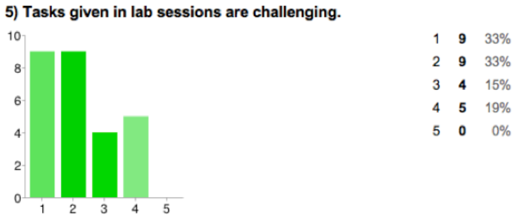


Figure 6. Responses to survey Q5

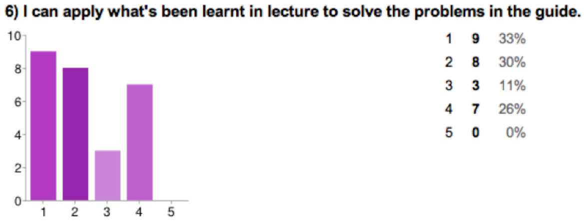


Figure 7. Responses to survey Q6

In this module, a comprehensive MySQL lab guide has been used to improve the students' practical skills, particularly the Structured Query Language (SQL) skills. As the instructions are very detailed, therefore it tends to be more independent work. The lecturer usually checked the students' progress by completion of the tasks. Figure 7 shows that 30% of the students did not think the guide was very helpful. It might be due to the guide is so detailed (step-by-step), completion of the tasks in the guide did not really help the students solve difficult problems independently. The reason remains to be investigated.

Questions 8 and 9 are about assignment marking criteria and feedback. The majority (over 60%) of the students (Figures 9 and 10) were happy, but some students (less than 20%) were still not very happy. This needs to be improved in the future.

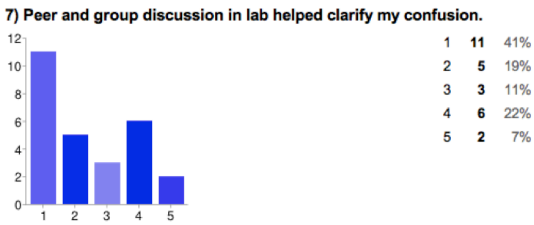


Figure 8. Responses to survey Q7

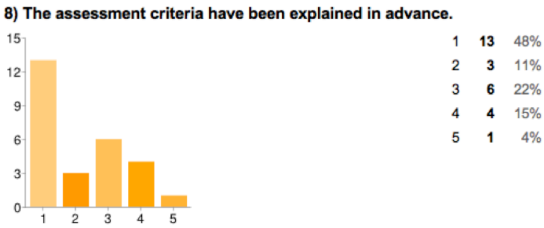


Figure 9. Responses to survey Q8

Overall, for all questions, about 60% of them agreed or strongly agreed on the current practice and about 20% disagreed and the rest had no strong opinions. Since the survey was conducted after the examination (which has high weight (60%) of the module assessment), which, the author believe, had high impact on the survey results. To eliminate such an effect, it might be a good idea to choose more suitable time to conduct surveys in the future.

5. Discussion

During the evaluation, the author noticed that although the problem-based learning worked well for some students, it did not work well for others. Barrows in (Barrows 1986) argues that in order for PBL to work well, two things need to considered: 1) the degree to which the problem is structured. In another word, the level of difficulty should be decided carefully and all the information needed to solve the problem should be provided. If the problem are too difficult or there is insufficient information available (supplied by the tutor or on other resources), it will demotivate the students from trying it; 2) the extent of tutor's direction towards the solution. The tutor needs to have the right level of involvement/direction, so students will not be leave to solve the problems on their own. The response to the last survey question suggests that the direction from the tutor was insufficient, and this should be improved in the future.

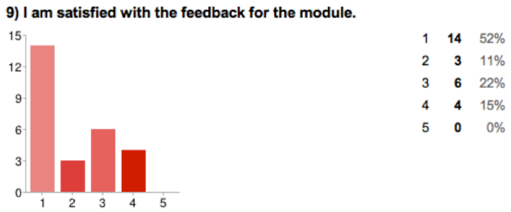


Figure 10. Responses to survey Q9

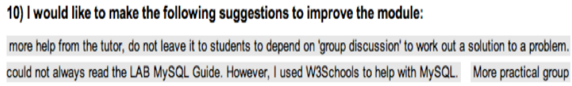


Figure 11. Responses to survey Q10

It has also been observed that ownership is essential for PBL to work well. The ownership comes from strong motivation. As described earlier in this article, contextualisation ensures *visibility* of the values of all teaching/learning activities. According to the motivation theory (Biggs et al 2011), when students see the values of the activities, and can expect success when engaging the learning tasks, motivation will follow. Therefore, contextualisation and PBL is a good combination for good teaching/learning.

6. Conclusions

The paper applies a new approach for teaching/learning second year database module. This module is a core module of most of the undergraduate computing courses and serves as the pre-requisite or co-requisite to other modules; therefore performance of this module has big impact on the overall studies. Students on this module usually have very diverse backgrounds in terms of possession of prior knowledge, age groups, social and cultural differences, etc. These factors make it difficult to have a right balance for all students; as a result engagement was usually poor. To promote good engagement and achieve indented learning outcomes, a combination of contextualisation, PBL, group work and regular formative assessment has been used in teaching/learning the module. Contextualisation ensures *visibility* of values of the tasks, hence can improve the motivation, which is the key success factor for PBL. Group work allows students to learn from each other and clarify confusions among themselves before approaching the lecturer. Good students can learn better by helping the peers and will not be bored. It also spares the lecturer's time to focus on common issues. Formative assessment has also been regularly used to reinforce understanding of the topics.

The work in this paper has been evaluated via an online module survey. There are some positive results (about 60% of the students agreed or strongly agreed on the new approach), however, about 20% of the students who responded negatively to the new approach, therefore there are still some spaces for improvement. The new approach is part of the transformative reflection practice. The multi-stage process of *reflect→plan→apply→evaluate* will always be applied for continuous improvement in future teaching/learning activities.

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