Using Peer-Assisted Problem-Based Learning to Develop Business Systems Analysis Skills: An Experience Report

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Abstract
This paper reports on the experiences of using peer-assisted problem-based learning (PAPBL) in a very large class of postgraduate students for an assignment spanning two complementary modules (Database Technologies and Systems Analysis). Students worked in teams of three. They were provided with a realistic business case study and required to generate data flow diagrams, UML diagrams, a fully normalised entity-relationship model, and SQL code to build the database. All teams were required to provide peer feedback on the draft solutions of two other teams, and in their final submission to explain how (or why not) they modified their work in response to peer suggestions. Each individual student was also required to write a reflection piece about their experience of working in a team and of receiving peer feedback. Additionally, they were asked to complete a survey seeking opinions on how PAPBL helped them to develop study skills, build confidence, make learning more enjoyable, clarify understanding of fundamental and complex concepts, consider and value the perspectives of others, and gain practical skills. Student feedback on the effectiveness of the lecturers in guiding the process was also sought. Quantitative and qualitative findings based on analysis of students' experiences are presented, further backed up by the lecturers' reflections on what worked well and what did not.

Keywords: Peer-Assisted Learning, Problem-Based Learning, Active Learning, Database Systems, Business Systems Analysis, Information Systems Education, Computer Science Education

Introduction

The School of Business & Economics at the University of Galway is globally accredited by AACSB (the Association to Advance Collegiate Schools of Business), prestigiously placing it amongst 5% of business schools similarly recognised across the world. As a result, national and international demand for places on the school's postgraduate programmes in business information systems (BIS) has dramatically increased in recent years. From 2017/'18 to 2021/'22, the number of postgraduate students registered on the school's various BIS programmes rose by 113%. At the level of individual modules, this increase has been most sharply felt by those that are offered across multiple programmes. This paper reports on experiences from two such modules – Database Technologies and Systems Analysis – which saw the number of students increase by 40% and 44% respectively in the past three years.

In 2021/'22, the number of students enrolled on these two modules exceeded 200. This presented the lecturers with an interesting pedagogical challenge: how to create a means of assessment that encouraged students to meaningfully engage with the material (while ensuring adherence to the rules of academic integrity), and also incorporating a mechanism that provided students with timely formative feedback on their work (given the lecturers' constrained ability to handle the volume of queries within a very large class). It was therefore decided to introduce an inter-module project spanning the two modules, using an innovative approach that combined principles of peer-assisted learning (PAL) and problem-based learning (PBL), hereafter referred to as peer-assisted problem-based learning (PAPBL). This paper reports on the students' and lecturers' experiences of using this approach.

Related Work

Problem-based Learning (PBL) is an active learning approach based on the theory of constructivism, underpinned by four tenets: learners construct their own meaning to build knowledge, new learning is founded upon prior knowledge, the process is enhanced by collaborative group-based activities, and the problems to be addressed should be based on realistic scenarios (Cooperstein & Kocevar-Weidinger, 2004).

PBL has been found to be an effective approach for helping students to learn essential skills in business systems analysis and database systems design (Luce, 2000; Richardson & Delaney, 2009; Fatima & Abdullah, 2013; Qotimah & Muslim, 2019). In PBL, the challenges being explored are typically ill-defined with no definitively correct answer. PBL therefore encourages critical thinking and creative problem-solving. PBL is also helpful in developing interpersonal, teamwork, planning and time management skills (Woodward et al., 2010; Hwang, 2018).

PBL may be used in conjunction with peer-assisted learning (PAL), which is defined as: "the acquisition of knowledge and skill through active helping and supporting among status equals or matched companions. It involves people from similar social groupings who are not professional teachers helping each other to learn and learning themselves by so doing" (Salkind, 2008).

PAL has been successfully used in medical education for quite some time and is now a well established approach in that field of study (Glynn et al., 2006; Wadoodi & Crosby, 2002). The reciprocity of educational exchange is one of the key benefits of PAL, as participants scrutinize and influence each others reasoning processes while working towards a shared

goal. In their exploratory study, Wynekoop & Kazuo (2020) found that the use of PAL in a systems analysis class can help students develop critical thinking skills.

As alluded to by Richardson & Delaney (2009), the successful implementation of PBL requires considerable resources. Unfortunately, as class sizes increase in response to universities prerogative to meet funding shortfalls, even the most arduous teachers are struggling to find enough hours in the day to communicate with students. The approach described in this paper aims to remediate this problem by leveraging the potential of PAL to help the students help themselves; that is, peer-assisted problem-based learning (PAPBL).

Although PBL and PAL are very well established approaches within ICT education – especially in areas such as programming, systems analysis, software engineering and database development (Brodie et al., 2008; Alva et al., 2018; Brilingaite et al., 2018) – there are surprisingly few surveys of student experiences in the mainstream academic literature. This paper makes a contribution in this regard by presenting an analysis of quantitative and qualitative data gathered from students, building on prior student surveys conducted by Luce (2000), Sindre et al. (2003), Lavy & Yadin (2010), El-Khalili (2013), Tadjer et al. (2020) and Mitchell et al. (2021).

Study Context and Research Method

This study is based on two complementary modules taken by postgraduate students within the author's institution. One module ('Systems Analysis') introduced students to aspects of requirements analysis, business process modelling (DFDs, UML), and agile methods. The other module ('Database Technologies') covered data modelling, relational database design and SQL. Initially there were 235 students, 199 of whom were enrolled on Systems Analysis and 223 on Database Technologies. For various reasons, 19 students (8%) withdrew along the way, leaving 216.

The two modules ran in parallel during the first semester of the the 2021/'22 academic year, with lectures and on-line self-directed tutorials taking place across a twelve week period. The normal delivery of both modules was affected by restrictions necessitated by the ongoing COVID-19 pandemic, and was further upset by a major cyberattack on the university's systems four weeks into semester that crippled on-campus network connectivity and effectively forced students and teachers to work from home. Because of this, the lectures were recorded and made available on-line to facilitate asynchronous engagement.

The class was made up of 40% females and 60% males, ranging in age from 19 to 51 with median of 24 years. Their nationalities were India (71%), Ireland (17%), China (5%), and twelve other countries spanning five continents (7%). Students came from various disciplinary backgrounds and, because of high levels of demand for places on the programmes, they had strong academic credentials. This diversity of life experience, prior learning and problem-solving perspectives meant that there was a pool of knowledge and talent within the class that could be tapped into for the purposes of peer-assisted learning.

Assessment Design and Administration

The class was broken into 79 groups, randomly selected by the lecturer. No changes to groups were permitted. Most groups comprised three members but a few just had two. 12

groups were enrolled on the Database Technologies module only, 4 on the Systems Analysis module only, and the remaining 63 studied both modules.

The 'Teton Whitewater Kayak' Company teaching case developed by Parker (2003) was selected as the basis of the inter-module assignment. This case is well suited to teaching database design and/or business process modelling. It is sufficiently challenging and detailed, yet leaves enough to students' imagination that they must be creative and evaluate the merits of various potential solutions.

The assignment specification for the Systems Analysis component required groups to produce a functional decomposition diagram (FDD), a context-level and systems-level data flow diagram (DFD), a DFD for any of the first-level processes, a UML use case diagram for any of the main processes, and a UML activity diagram, sequence diagram or state machine diagram for any of process.

The assignment requirements for the Database Technologies component were to produce a logical entity-relationship model (ERM) using any common diagramming notation (i.e. Crow's foot, UML, etc.), a fully normalized relational database schema with explanations of design rationale, and the SQL data definition statements to build the tables and relationships.

A tailored collection of LinkedIn Learning tutorials was made available to students and they were also provided with other hand-picked learning resources specific to the assignment. In addition to a number of lectures covering the relevant material, a dedicated workshop session was scheduled to walk in detail through the requirements of the assignment with students.

In both modules, students posed several questions via emails to lecturers about the assignment; for example, "*can you please explain the difference between <includes> and <extends> on a UML use case diagram?*", "*where can we see some further examples of a Functional Decomposition Diagram?*", "*is it allowable to make minor changes to the case study if we make assumptions about some things that are not explicitly stated?*", "*regarding the last sentence of Section X.X of the case study, are we correct in interpreting that as meaning ... ?*". Answers were posted on the Blackboard VLE system for the equal benefit of the entire class.

The looseness of the specification was intentional, so as to create greater scope for variety and less opportunity to copy the work of others. Students were advised that there was no single best solution and that each group's assignment was expected to have its own unique character, with extra marks going for very well presented solutions that demonstrated innovative capabilities. Assignments were submitted via the Turnitin originality checking portal, so as to compare each group's solution against those of others.

Prior experience with students on this programme was that they tended to help each other on assignments, at times crossing the line between legitimate assistance and illegitimate collusion. Because of this, it was decided to introduce peer-assisted learning into the assignment with clear guidelines as to what was allowable. Every group was required to provide peer feedback on the draft solutions of two other groups (specified by the lecturer), and in turn each group received feedback on their preliminary efforts from two other groups (not the same ones). Thus, each group interacted with four other groups. Each group was told to appoint a leader to take responsibility for the submission to Turnitin and communicating

with peer groups. In assigning peer groups, the 16 groups taking just one module were paired with groups taking that same module.

Students were told that peer review feedback should be brief (less than 1 page to each group). They were advised not to directly comment or agree on the correctness/incorrectness of the drafts that they reviewed, but rather to give 'pointers' instead of answers. Indicative examples of allowable comments were provided, such as: "*Are you sure that you have chosen a primary key for Table X that is unique and not null?*", "*Consider again the cardinality of the relationship that you indicate between Table X and Table Y?*", "*Is Table Z really necessary in your model?", "It seems that you have a 'grey hole' on your second level DFD*", "*Your UML activity diagram appears to be missing important aspects relating to XXX*", etc.

A date, one week in advance of the final deadline, was set, at which point in time groups circulated draft solutions to each other for peer feedback. Communication with each other prior to that date was not permitted. The groups were allowed three days to review the two draft solutions that they received and provide feedback; they then had up to another four days to consider the feedback they received and to finalise their own solutions. Each finalised solution was required to contain, in addition to the aforementioned requirements, a copy of the feedback points received from peer groups and an explanation of any changes made in response to that feedback. Separately, each group member was required to submit their personal reflections on positive and/or negative experiences of peer-assisted learning on this assignment. In addition, each group member had to fill out a confidential 'Individual Contribution and Peer Evaluation Form', in which they outlined their own input to the group's submission, and commented on the equity of work done by each group member (if two or more members of a group indicated that some of their peers did not contribute fairly, follow-up action was taken to investigate the reasons why).

Students were also requested to complete an opinion survey about their experiences of PAPBL, which was closely based on items drawn from instruments used in previous studies (Luce, 2000; Hammond et al., 2010).

Results and Discussion

Students' experiences of using PAPBL to develop business analysis and database design skills were tremendously positive and enthusiastic. Interestingly though, a Kruskal-Wallis test revealed a statistically significant difference across age groups in the strength of agreement with the statement that 'Overall, peer-assisted problem-based learning was a useful experience for me', $\chi 2$ (df=4, n=212) = 9.707, $p<.05$. Although all age groups overwhelming agreed with this statement, those who strongly did so differed noticeably by age group (19-21: 35%, 22-25: 42%, 26-30: 51%, 31-40: 75%, 41+: 86%). This may be because the class included some mature adult learners, who seemed to engage more with the process than the younger cohort.

Development of Skills

88% of students agreed that PAPBL helped them to develop their study skills and prepare better. A similar percentage agreed that the exercise enabled them to improve their self-confidence. 88% of respondents indicated that the assignment helped them to clarify their understanding of fundamental concepts, and 83% found that it helped them improve their

grasp of more complex concepts. Notably, 93% of students responded that group work helped them to develop and practice interpersonal communication skills.

Experiences of PAPBL within Groups

As regards learning preferences, it was notable that just 19% of students felt that they learn better by themselves than in a group. 31% of students were undecided on this, but a clear 50% were in agreement that working in groups enabled them to learn more easily.

81% of students agreed – 48% of them strongly – that PAPBL made the assignment more enjoyable than if they had been working alone. 77% indicated that the quality of their work improved as a result of working in a group for this assignment, and 89% responded that working with a team motivated them to keep their own progress on track. An even higher percentage, 95%, were in agreement that PAPBL helped them to consider and value other students' perspectives.

Several students commented that they would have preferred to nominate their own teammates rather than being randomly assigned. However, the rationale for random assignment was clearly explained in class: it was a deliberate effort to simulate the reality of a professional workplace, where individuals do not choose their colleagues but instead must learn to work productively and respectfully with others. It was put to students that perhaps they might find themselves working with a person who doesn't value their opinion, or they may feel that a member of their group is not sufficiently contributing, but they will almost certainly encounter such situations in their future careers and must learn how to deal with them. Moreover, when seeking academic references for graduates, employers typically ask about inter-personal and teamwork skills as matters of high priority. As one of the students noted in the personal reflection: "*It would have been better if we were asked to choose partners ourselves but, considering a real life situation, we often don't have a choice of working in the group of our choice so we have to make the best of things*." (Student 214).

The author's own experience is that if students are allowed to self-select partners, weaker performers and those in minority categories tend to be marginalised. That runs contrary to the principles of PAPBL, where every student has an equal opportunity and is equally valued.

Indeed, one student commented on the inclusive nature of the project: "*This is the only group project so far that reminded me of the workplace and I enjoyed how you got us to give feedback to each other. That was a really interesting element that I felt helped students prep for the real world. As someone who is dyslexic, I also felt that this assignment was learning disability friendly which I rarely come by.*" (Student 48).

Furthermore, if students have the same partners for group work across several modules, they may be tempted to carve up the work on an individual rather than a team basis, which defeats the purpose of PAPBL. It is also less likely that a student will report issues of non-contribution if placed in a group alongside his/her close associates, so that is a further reason to not permit self-selected groups.

Experiences of PAPBL between Groups

Overall, students were very positive about the quality of feedback that they obtained from other groups.

"*The feedback received was very much constructive, easy to read and understandable with clear suggestions on how we could better improve the overall assignment*." (Student 12)
"*When we gave our feedback to other peer groups, we got to know about a different way of doing things ... And when we received feedback from peers on our work, we got to know the mistakes we did throughout the different sections of the assignment*." (Student 193)
"*The feedback from other groups helped us identify gaps in our assumptions, solutions and places where we can improve. Feedback from a different group is always important as it provides a different perspective on our solutions*." (Student 127)

However, in a small number of cases, similar to experiences in previous studies (Glynn et al., 2006; Alkhalifa & Devlin, 2021), the feedback received was inadequate, unhelpful or not credible.
"*I did not think other students reviewing our paper helped as the ones that we viewed were not completed*." (Student 38)
"*I think this could be improved by submitting our final draft to our lecture and not send it to other students as not everyone acted accordingly for this part of the assignment*." (Student 131).

Level of Support from Faculty

As regards the amount of guidance provided by the teaching staff, close on half of the class (44%) were of the view that it forced them to learn things on their own, which of course was the intention. Responses on this question were quite guarded, with 29% opting for the neutral midpoint of the scale and a quarter of students disagreeing.

However, when asked if the staff should have provided more guidance, just 9% felt so, with 63% in disagreement and 29% sitting on the fence. Assuringly, 92% of respondents agreed that the teaching staff were satisfactorily responsive to questions that they or their colleagues raised. This was further borne out by comments in the individual reflections:
"*It was done very well. Our lecturers was very helpful throughout the duration of the assignment, giving clear direction. Even if it was just one student asking a particular question, a reply email to that question was sent out to all students, so everyone would get the same information*." (Student 44)
"*The process was new for me, but it was a worthwhile experience as I got to learn a lot. The guidelines defined by the professors were very straightforward and clear cut*." (Student 147)

Even though the lectures relevant to the assignment were recorded and made available on-line, as well as a dedicated Q&A session specifically focused on the assignment, a small number of students still felt they needed more clarity:
"*Maybe a tutorial lecture before the assignment based completely on the assignment*." (Student 98)
"*I would have liked more guidance on how to make the assignment or maybe a demo of building a assignment from scratch*." (Student 193)

A number of students also expressed the opinion that they would have liked if lecturers or monitors/tutors could have provided more specific feedback:
"*Apart from getting and giving peer feedbacks, a direct and logical feedback from the the professors would help us to improve better as it would provide us the exact idea of were we went wrong and were we should improve*." (Student 170).

"*An in-person discussion with monitors would have been enjoyable and productive*." (Student 79)

The practical difficulty in facilitating this request was the sheer volume of material to be assessed (over 1000 pages), so providing detailed formative or summative feedback would be immensely time-consuming and therefore not feasible. Instead, general points of summative feedback were given to the class on frequent mistakes made and areas for improvement. While the overall standard of submissions received was very high, marks were lost for a number of common reasons including: technical errors (e.g. 'black' or 'gray' holes on DFDs, incorrect use of UML modelling concepts, etc.), overly elaborate diagrams that were too complex, failure to adequately explain assumptions and design rationale, failure to adequately explain how the group responded to peer feedback received, and poor presentation.

Lessons Learned and Future Changes

In reflecting on the outcomes of this inter-module PAPBL exercise, it is useful to recapitulate its underlying motives:

- To enable students form a better understanding of how business process models (taught in the Systems Analysis module) and data models (taught in the Database Technologies module) dovetail together;
- To provide students with an opportunity to develop 'soft' transversal skills such as teamwork and inter-personal communication, analytical reasoning, innovative problem-solving, entrepreneurial agility, and critical thinking;
- To facilitate students in 'learning to learn' and 'learning to explain';
- To expose students to group work in diverse environments (i.e. national culture, disciplinary background, life experience, etc.), wherein they must learn to respect the alternative opinions and perspectives of others.

Additionally, the decision to introduce PAPBL was mindful of:

- The need to provide students with timely formative feedback on their draft submissions within a very large class;
- The need to have reasonable controls in place to assure academic integrity (i.e. fair contribution and level of participation, no copying of others work, no outsourcing to on-line 'homework help' sites).

Overall, going by responses received to the survey and in the reflective pieces, students were overwhelmingly satisfied with their experience and the exercise seemed to go a long way towards achieving the aforementioned purposes. That said, a well known limitation of any PAL initiative is that peers are not professional teachers (Callese et al., 2019). A number of students indicated that they would have liked more guidance as regards what was expected from them as peer assessors. In retrospect, it would have been better if the lecturer took a small sample of the draft assignments and critiqued them in class for all to see, giving examples of useful feedback (as well as less useful feedback).

A surprising observation amongst a class of technically-adept students was that very many of them were not as literate as expected in the use of technologies for tasks such as collaborative document editing and collaborative diagramming. Students need to be shown how to pivot their group activities from face-to-face to on-line environments, as was necessitated at very short notice by the COVID-19 pandemic and again, in this case study, by a very disruptive cyberattack.

A few students suggested that groups should not be randomly formed, but purposefully chosen by the lecturer:
"*Divide people up according to their backgrounds. I was lucky to be in a team where we all came from different disciplines*." (Student 189).
"*Groups can be built with more members of varied experiences/fields/experience on either of the two subjects*." (Student 6).
"*Perhaps make teams of people from different backgrounds (IT, management, etc.) to give everyone a chance of meeting all kinds of people*." (Student 140)

This is a very valid suggestion but – based on the author's prior attempts to do this – not as straightforward to implement as it may seem. With several variables to juggle, and usually with incomplete information to hand, trying to 'match' students is quite complicated and the results of such efforts are not guaranteed to be any fairer or diverse than a random process.

Another suggestion that came from students was to introduce peer review earlier in the assignment:
"*It would be great to see this used at an earlier stage rather than a later stage of the assignment*." (Student 9).
"*Instead of one assignment deliverable, if it was a continuous process, it would be more useful*." (Student 165)
"*If we could divide break the assignment into smaller milestones (e.g. 2 or 3 diagrams a week) and if peers were asked to provide feedback on a weekly basis, then students could collaborate well and may provide better suggestions as it would give them more time to understand because they would only have to digest things in smaller bites as opposed to getting a large document all at once*." (Student 164)

This suggestion, again, is worth considering, but a delicate balance has to be struck between using PAPBL as a mechanism to help students improve their submissions, as opposed to a way that lazy individuals can just mimick the work of others. By leaving the window for preliminary peer feedback close to the final deadline, the scope for 'free-loading' was reduced but not eliminated. It was evident from survey comments that a small number of groups did not perform their part of the bargain, either by failing to submit sufficiently complete draft work or by providing no or unhelpful feedback. These evaders could be reeled in by asking all groups to submit their draft versions into the system (in advance of submitting the final version). This would enable spot-checks to be performed to ensure that all groups made a genuine effort. It would also enable a comparison to be done, if necessary, between draft and final versions, as well as similarities with the four other assignments that any given group saw.

Making the peer evaluation process anonymous may also have improved its efficacy, as previously noted by Sindre et al. (2003), but to do so would require the use of a suitable submission system, adding further administrative work onto the lecturer (although, perhaps, existing solutions such as open source paper review systems could have been adapted to this purpose).

Finally, the various controls that were in place to assure academic integrity seem, by and large, to have worked. However, detecting plagiarism of software diagrams is tremendously difficult and cannot be easily done by tools such as Turnitin. Much depends on the lecturer's sharpness and ability to recognise tell-tale signs that suggest collusion. The use of paid 'homework help' sites is another problem (e.g. requests for solutions were anonymously

posted on both Chegg and TransTutors.com, containing the precise wording as in the assignment specification). This was a disappointing discovery but the assignment only made up a portion of the overall marks for the two modules, so any student who cheated on the assignment was likely to do less well on the end-of-semester written test which examined knowledge of the same material. Using a well-known case study probably exacerbated this problem so a future lesson would be to use bespoke cases, either written by oneself or else suitably modified versions of published cases.

Conclusion and Next Steps

This paper reported on the experiences, from both students' and lecturers' points of view, of using a peer-assisted problem-based learning (PAPBL) approach to teach two complementary postgraduate modules in Database Technologies and Systems Analysis. The feedback received from students, as well as the lecturers' reflective observations, was largely positive but a number of possible areas for future refinement and improvement were identified. The next stage of this research will be more detailed statistical analysis of the quantitative survey data to explore factors and correlations, as well as open and axial coding of the extensive qualitative comments contained within the students' reflective pieces.

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