Evidence-Based Practice to the Forefront: A Case Study of Engineering Team Project-Based Learning in an Online Learning Environment

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ABSTRACT

Approaches such as problem and project-based learning (PBL) are the cornerstone of modern engineering curricula. With a growing need to move these student-centred active learning curricula to online and blended learning environments due to issues including increasing cohort sizes and limited budgets, it is essential that instructional designers in engineering education understand the impacts that these differing mediums may have on student collaboration. This study is the beginning of a body of work with the aim to develop effective teaching and learning strategies for team project-based learning in online and blended learning environments. This case study was carried out in an Irish university in 2021 in a first-year engineering module during the COVID-19 pandemic. The study followed an explanatory mixed methods design in which a questionnaire and semi-structured interviews were utilised to collect data. The research data was gathered in two phases. Phase 1 included a questionnaire with both closed- and open-ended questions (N=94). Phase 2 was based on semi-structured interviews (N=7). This paper will focus on the qualitative datasets, including the open-ended questions and interviews. After completing a thematic analysis, we identified six themes and eighteen sub-themes that affect students' perceptions of team project-based learning (PBL) in an online environment. Each of these themes are discussed within this paper. The paper concludes with an outline of future research plans for the ongoing project.

1 INTRODUCTION

1.1 Overview

As a consequence of the COVID-19 pandemic and the growing need to deliver high-quality, student-centred engineering education to large and diverse student cohorts [1], interest in blended and online learning has increased significantly worldwide. Active and student-centred learning strategies such as problem and project-based learning (PBL) has been researched extensively in traditional on-campus environments; however, research on effective PBL implementation in online environments, especially in engineering is still emerging. With the rushed implementation of online and blended learning approaches during the COVID-19 pandemic, the need for a body of evidence-based pedagogical practices in PBL has been highlighted [2], [3]. In this paper, we argue that to begin developing evidence-based pedagogical guidance for engineering practitioners, researchers first need to explore students' perceptions of PBL in online environments. This process can identify both success and limitations perceived by the students in current strategies. These successes and limitations can then inform practitioner design decisions when implementing team PBL in online and blended learning environments.

1.2 Research Question

What factors affect 1st year students' perceptions of team PBL in an online environment?

2 METHODOLOGY

2.1 Overview:

This study was carried out at an Irish university over an academic semester in a first-year engineering module. The study follows an explanatory mixed methods design where quantitative and qualitative data were used to inform participant interviews. The quantitative data was gathered with the use of a student's attitude and satisfaction survey, Phase 1 (N=94). The qualitative data was gathered with the use of open-ended questions, Phase 1 continues, and a semi-structured interview, Phase 2 (N=7). In this paper, we report on the qualitative datasets and the results identified from the thematic analysis of this data.

2.2 Data Analysis

A six-phase inductive thematic analysis approach was undertaken to investigate both the open-ended questions and semi-structured interview datasets [4]. The main goal of the thematic analysis was to identify potential factors (Themes) affecting students' perceptions of team PBL in an online environment. All data from the open-ended questions and semi-structured interviews were uploaded to NVivo; however, the process was carried out with a mixture of both physical and digital documents to help identify all relevant codes, themes, and sub-themes.
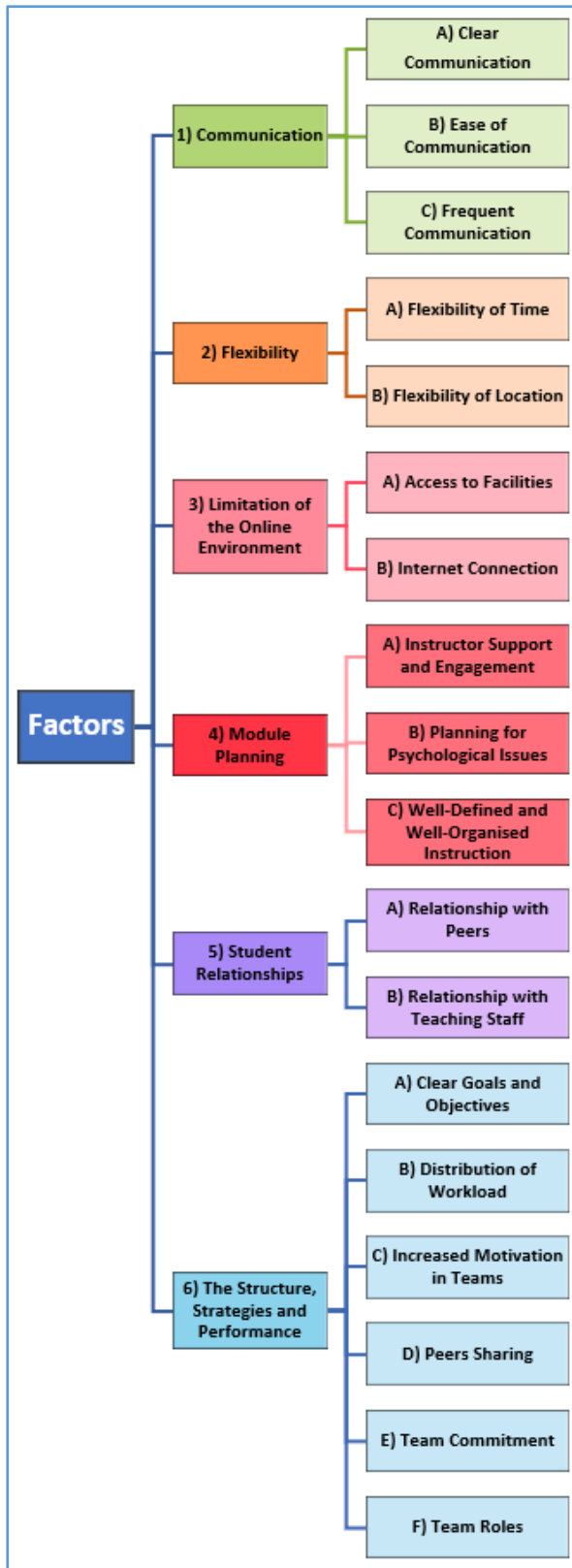
Fig. 1. Thematic Analysis Flow Diagram

3   RESULTS & DISCUSSION

3.1   Overview

Overall, the thematic analysis revealed that the participants demonstrated high satisfaction levels within their open-ended questions and interview responses within the module. However, we were able to identify several themes and sub-themes through the successes and limitations of the online format as perceived by students.

The following six themes and eighteen sub-themes, shown in Fig. 1, were identified to affect students' perceptions of team PBL in the online environment. The next section, 3.2, will discuss each theme and associated sub-themes in detail.

3.2 Themes and Sub-Themes

Theme 1: Communication (Student to Student and Student to Teacher): Communication was the second most common theme of discussion by students in both the open-ended questions and semi-structured interviews. It was clear from student responses that effective communication between student to student, student to teacher, teacher to student, teacher to teacher is essential for team PBL success within the online environment. Three sub-themes emerged from the data, including A) clear communication, B) ease of communication and C) frequency of communication. Although many comments were made referring to communication, students' main point of concern was the ease of communication. Students felt that their ability to communicate ideas with team members was limited in the online environment when compared to the traditional on-campus environment: (P.20) *"It is hard to fully explain and demonstrate ideas and concepts online, and I believe I would have a greater*

understanding by being explained there in person". Research suggests, many factors are shown to affect student performance in teams, while one of the most effective for improving it is the ease of communication between team members [5].

Theme 2: Flexibility of Online Environment: The increased flexibility of the online environment was seen as an improvement by many students. Two sub-themes under flexibility of the online environment emerged from the data, including A) flexibility of time and B) flexibility of location. One student stated how the increased flexibility was one of the benefits of working online: (P.19) *"I liked it in the sense I didn't have to actually set time aside to travel and meet the team". Increased flexibility is often highlighted to be a positive impact of online education"*. Students, in general, perceive that online learning allows for more effective use of time than traditional on-campus courses [6], [7].

Theme 3: Limitation of the Online Environment: The students outlined two main limitations to teaching and learning in the online environment. These two limitations include A) access to on-campus facilities and B) poor internet connection. During the COVID-19 pandemic students were unable to access many of the on-campus facilities such as the university library, meeting rooms and workshops due to governmental restrictions. A few Students felt that limited access to the workshop impacted them negatively: (P. 27) *"we weren't able to go into the workshop […] mess around and create prototypes of the car […] we couldn't modify it in case something was wrong"*. A lack of access to facilities in online engineering education is also shared in other publications [8]–[10]. Students also highlighted concerns around poor internet access: (P.23) "There are still drawbacks with online as not everyone can take a call or a live meeting due to internet issues". This concern is also shared by many other students working in online and blended learning environments [7], [11].

Theme 4: Module Planning: Three sub-themes were identified under the theme module planning. These sub-themes included A) instructor support and engagement, B) planning for psychological issues such as increased anxiety and decrease in motivation and lastly, C) well-defined and well-organised instruction. Most frequently, under this theme, students expressed the need for well-defined and well-organised instruction. When one student was asked to provide advice to the module leader planning a team-based project online he recommended: (P. 89) *"Always start on the right foot, start early and communicate roles effectively and clearly, and set deadlines and timelines for things to be finished at"*. This also aligns with the finding of Ku et al.'s [12] publication on online collaborative learning. Ku et al.'s findings indicate that students expect instructors to provide a supportive collaborative learning environment and deliver well-defined and well-organised instruction for students.

Theme 5: Student Relationships: Two sub-themes emerged underneath the theme entitled student relationships. These sub-themes were A) relationship with peers and B) relationship with teaching staff. Students regarded making and maintaining good relationships with peers and staff member to be of high priority. Students had both positive and negative feelings towards building relationships in the online environment. Students felt that the team-based project gave them an opportunity to develop friendships that weren't usually possible in less collaborative modules: (P.1) *"it helped*

me to make friends and to communicate with my classmates in a way that hasn't been possible through online learning". However, some students felt that the online environment in general made forming relationships with peers and teaching staff harder. This can be seen in the responses given by participant 21 and 27: (P.21) *"On campus also allows you to build a personal relationship and not just a professional one"* (P.27) *"I would have gotten to get know my group members better and been able to be more interactive with my teachers".* Stenman [13] highlights that students perceive online courses as a negative experience when they feel a large transactional distance between instructors and their peers. She adds that online students view others as a number on a list rather than individuals, and this issue can influence whether a student will stay in or drop out of a course.

Theme 6: Team Structure, Strategies and Performance: Team structure, strategies and performance was the most common theme of discussion by students in both the open-ended questions and semi-structured interviews. Six sub-themes emerged from this theme included A) clear objectives and goals, B) distribution of workload, C) increased motivation in teams, D) peers sharing perspectives', experience, information and skills, E) team commitment and finally F) team roles. The most discussed sub-theme by student was peers sharing perspectives, experience, information and skills. The following comments highlight some of the sharing experienced by students: (P.48) *"everyone brings something else to the table and we had ideas that others came up with that I wouldn't have gotten myself"* (P. 1) *"I would have struggled with the maths and mechanics of the project had it not been for my teammates".* This coincides with the findings presented by Volkov and Volkov [14] who found that students reported they attained deeper understanding through the sharing of students' skill sets while participating in teamwork.

4 CONCLUSION

4.1 Summary

Students' perceptions of courses influence the likelihood of success or failure when working online. It's reported that satisfied students are more likely to be successful in the online environment [15], [16]. This paper outlined multiple factors that instructional designers in engineering education need to consider that can affect students' perceptions of team PBL in online environments. Each of the factors (themes) outlined in the thematic analysis can be linked back to issues experienced by other practitioners in the field, and as such, solidifies the importance of planning for teaching and learning with theses factor in mind.

5 LIMITATIONS:

It should be noted that data for this paper was gathered during the COVID-19 pandemic and that students were experiencing many changes to everyday life in Ireland due to heavy governmental restrictions. This change in lifestyle may have affected students' responses during both the open-ended questions and interviews.

6 FUTURE RESEARCH

This conference paper is part of a larger body of research on team PBL within the online and blended learning environment. The project is conducted following an explanatory mixed methods approach were both qualitative and quantitative data is used to inform the results and discussion. The data for the project is gathered in two rounds, in the same module, one within the online environment (2021) and the second within the traditional on-campus environment (2022).

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