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Comparing Engineering Students Perceptions Of Online And Traditional Face To Face Environments During A Problem And Project Based Learning (PBL) Module

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ABSTRACT

Research examining the future of engineering education has highlighted forthcoming challenges for engineering institutions, such as increasing cohort sizes, limited budgets and a demand for the delivery of flexible, diverse and student-centred curricula. To this end, scholars have suggested the use of problem and project based learning (PBL) methodologies that can be implemented within hybrid learning environments. This paper examines and compares students' perceptions of a PBL module that was delivered by means of online and traditional face-to-face environments. The goal of this paper is to highlight the students' voice over other stakeholders to provide valuable insights into their preferences of current pedagogical practices. This in turn can provide information to improve teaching and learning in hybrid learning environments. This study was carried out with two student cohorts of first year engineering students. One of the cohorts completed the module in 2021 (N=94) in an online environment and the second in 2022 (N=89) in a traditional face-to-face environment. This paper focus on analysing the 2022 cohort and comparing the results against the findings presented at SEFI 2022 in Barcelona for the 2021 cohort. The findings revealed areas of significance for educators conducting PBL within online and hybrid environments. This includes the role of communication, module planning, dealing with conflict, and flexibility in learning.

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1 INTRODUCTION

1.1 Background

As engineering education begins to move to more flexible learning environments, such as online and blended, using student centered active learning strategies, such as problem and project based learning (Graham 2018; Hadgraft and Kolmos 2020), educators are expected to implement evidence informed pedagogies. However, in recent years the COVID-19 pandemic has highlighted many deficiencies in our current approaches to PBL in online and blended environments (Khandakar et al. 2022; Supernak, Ramirez, and Supernak 2021; Beneroso and Robinson 2022). Additionally, development of effective pedagogical strategies are also stifled due to a known publication bias in reporting positive findings over negative in PBL research (Kolmos and de Graaff 2014). If we are to develop effective pedagogical strategies for PBL within online and blended environments, we must report on and review research that outlines both the success and the failures of current engineering programs.

1.2 Context of the study

In this paper we uncover factors that affect student perceptions of PBL in the traditional face to face environment. This is done with the objective of comparing these factors against the ones presented in an earlier study (O'Connor et al. 2022), completed within the same module, in an online environment. By developing a clearer understanding of the factors that affect student perceptions of PBL in both the traditional face to face environment and online environment, we can proactively develop effective pedagogy strategies for hybrid environments.

1.3 Research Questions

This research paper aims to identify how engineering students perceive PBL in the traditional face to face environment, while also comparing the findings against the online environment. To accomplish this goal the following research questions will be addressed:

a) What factors enhance and/or inhibit the success of PBL in traditional face to face environments as perceived by students?
b) How do the factors compare against the one presented within the online environment?

2 TERMONOLOGY AND DEFINITIONS

2.1 Problem and Project based learning (PBL)

Both problem based learning and project based learning are considered two similar, but separate, teaching and learning strategies commonly used within engineering education. These two teaching and learning strategies are often used interchangeably; however, they are two distinct strategies that have unique features. However, in this paper will be using the hybrid approach know as problem and project based learning or the abbreviation PBL (Kolmos 2017; Edström and Kolmos 2014; Chen, Kolmos, and Du 2020). Problem and project based learning can be defined as *"a very comprehensive system of organizing the content in new ways and students' collaborative learning, enabling them to achieve diverse sets of knowledge, skills, and competencies"* (Kolmos and de Graaff 2014, 147).

2.2 Online learning

Online learning can be defined as *"education being delivered in an online environment through the use of the internet for teaching and learning. This includes online learning on the part of the students that is not dependent on their physical or virtual co-location. The teaching content is delivered online and the instructors develop teaching modules that enhance learning and* *interactivity in the synchronous or asynchronous environment"* (Singh and Thurman 2019, 302).

2.3 Blended learning

Blended learning can be defined as *"defined as a combination of digital and face-to-face content delivery method"* (Bouilheres et al. 2020, 3050). Blended learning is often also referred to as hybrid learning.

3 METHODOLOGY

3.1 Approach

This study was carried out over an academic semester in a first-year engineering module. The data was gathered in two consecutive phases. The data was gathered with the use of open-ended questions (Phase 1) and a semi-structured interview (Phase 2). The capstone project within the module was a Conceive, Design, Implement and Operate (CDIO) project, which was informed by combining both PBL and CDIO pedagogies (Edström and Kolmos 2014). During this project students designed and manufactured a miniature battery-powered vehicle to fulfil a given design brief.

3.2 Participants

The module had 173 students enrolled. Students' ages vary; however, the majority of students are aged between 17 and 19 years. The questionnaire had a participation rate of 51% (N =89), 23 female (26%) and 66 male (74%).

3.3 Module structure

The teaching team for Introduction to Design for Manufacture is made up of two joint module leaders with the support of additional teaching assistants (TA) and laboratory technicians. The module goal is to develop knowledge around basic manufacturing processes and fundamental design skills. The lectures were delivered by the co-leading lecturers, while the laboratories were delivered by TA's. The technicians provided technical support through recorded videos, which was required during the manufacturing phase of the project. The project was designed, built and tested by students in teams over a twelve-week semester. The project was broken down into three challenges. Week 1- 4 was an individual challenge where students developed individual design ideas. Weeks 6, 7 & 8 saw a teamwork challenge introduced, where students were paired into teams of 5 based on their results from the individual challenge and their preferred role on the team. Team leaders were also appointed based on results from the individual challenge. On completion of the teamwork challenge, teams submitted a design portfolio. Week 9-11 was a manufacturing challenge where teams used their design portfolio to develop a physical artifact. Week 12 was vehicle time trials, where all completed projects were tested and timed.

3.4 Instruments

Open-ended questions (Phase 1): The first three open-ended questions were developed by Ku, Tseng, and Akarasriworn (2013) with the remaining question being developed by the first author of the paper.

Semi-structured interviews (Phase 2): The semi-structured interviews were designed using the results of the student attitude survey, teamwork satisfaction survey and open-ended questions. Points of interest from the preliminary analysis of the surveys and open-ended questions were developed into semi-structured interview questions to further probe the participants' answers.

3.5 Data Collection

Participant responses were collated into one Microsoft Forms document. The questionnaire and open-ended questions were distributed to students of the module over email and at the end of a weekly lecture after completing the capstone team-based project. Microsoft Forms recorded all the participants' responses.

3.6 Data Analysis

A six-phase Inductive thematic analysis approach was undertaken to investigate both the open-ended questions and semi-structured interview datasets (Braun and Clarke 2022). The main goal of the thematic analysis was to identify what factors affect students' perceptions of team PBL in the 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.

3.7 Trustworthiness

A number of processes were used to ensure the reliability and validity of the study, including 1) member (Authors) checking of interpretation of the findings, 2) methodical methodology section covering all study procedures, 3) preregistration and 4) open-source dataset available on *Open Science Framework* (OSF). OSF Link: [Insert link here]

3.8 Ethical Considerations

The study explained in detail to participants the aim and objectives of the research. All participants provided consent. Students were clearly informed that participation was voluntary and that they could withdraw from the study at any stage without consequence. All data was collected, organised and stored according to the host university's data handling policy which is GDPR compliant. All student identifiers were removed to protect anonymity. Ethical approval was provided by the host university.

4 RESULTS AND DISSCUSSION

4.1 Overview

A thematic analysis was utilised on the data from three of the four open-ended questions and all the semi-structured interviews, to highlight factors (Themes) that affect students' perceptions of team PBL in the traditional face to face environment. The following four themes and seven sub-themes, shown in **Error! Reference source not found.**, were outlined to affect students' perceptions of team PBL in the traditional face to face environment.

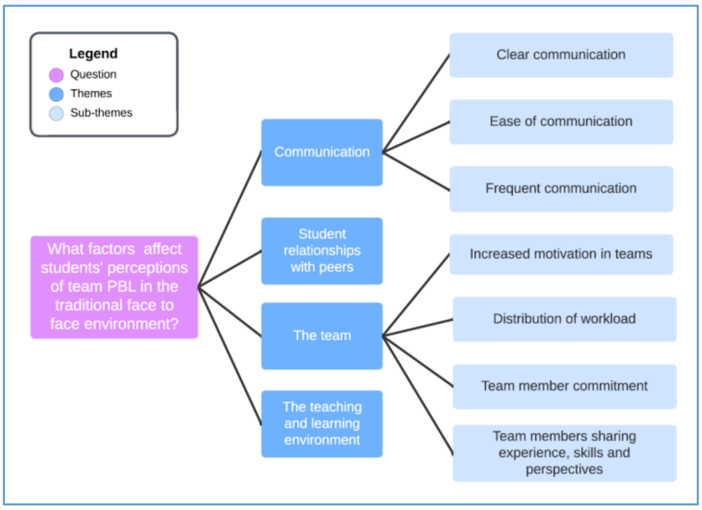

Fig. 1 Thematic Analysis Flow Diagram

4.2 Themes and Sub-Themes

Theme 1 - Communication: In this paper, communication was the second most discussed theme by participants. The theme communication also included three sub-themes A) clear communication, B) ease of communication and C) frequent communication.

Sub-Theme A: Clear communication: Clear and coherent communication was important to participants. A number of participants outlined the need for clear communication among team members: *(P. 39) "I enjoyed working with the group as I felt it really helped with the project. Meeting regularly on campus was very good for our collaboration. It meant we could all explain ourselves clearly and coherently, and no one struggled with connectivity problems or other tech issues. We could do up little sketches and paper models as we designed and show them to each other and collaborate on them in real time".* Many authors have also outlined the necessity for effective oral communication when working in technical disciplines (Darling and Dannels 2003).

Sub-Theme B: Ease of communication: The ease with which peers could communicate was also highlighted by several participants. One participant stated that the ease at which they communicate is vital to their progress within the project: *(P. 63) "i found it easier to analyse and solve any problems that arose when we could speak (…) bouncing ideas off each other until a solution was found, rather than waiting on texts or arranging video calls"*. Similarly, Nordstrom and Korpelainen (2011) outlined, that the ease of communicate between their students directly impacted their learning will engaging in teamwork.

Sub-Theme C: Frequent communication: Participants also stated that team communication needed to occur on a regular basis. One participant outlined how a lack of communication from one team members was damaging to the team's progress: *(P. 14) "I dislike the collaborative work, as my team members rarely communicate and often miss deadlines or meetings without notice".* Other authors, such as Iacob and Faily (2019), also state that participants highlight the positive role regular meetings played in the team's progress.

Theme 2 - Student relationships with peers: Numerous participants noted that they enjoy engaging in PBL within the traditional face to face environment as it provides them with the opportunity to develop new friendships: (P. 20) *"I enjoy working as a group as it is a good opportunity to meet new people and learn from each other"* and (P. 84) *"the ability to meet new people and interact with them on a regular basis was extremely helpful"*. Providing opportunities for undergraduate engineers to socialise with peer and develop interpersonal skills is important because the more developed the social skills the more chances to satisfactorily deal with the demands of different environments and interlocutors (Lopes et al. 2015)

Theme 3 - The team: The participants made reference to a number of factors that affect students' perceptions of PBL in the traditional face to face environment from within the team itself. For this reason, this theme included five sub-themes entitled A) Increased motivation in teams, B) distribution of workload C) team member commitment, and D) team members sharing experience, skills and perspectives.

Sub-Theme A: Increased motivation in teams: A few participants outlined that they experienced increased levels of motivation when working with others: (P. 29) *"I liked working as a group as it increased my motivation and I learnt from others' knowledge"* and (P. 47) *"working as a group helped to motivate each other to reach goals and due dates"*. Although increased levels of motivation is a common finding report by participants engaging in teamwork (Fini et al. 2018; Jun 2010), it's also common to see decreased levels of motivation due to team conflict and or social loafing (Borrego et al. 2013).

Sub-Theme B: Distribution of workload: A commonly shared benefit by participants was the distribution of work among team members: (P. 26) *"We could share the workload".* One student noted that the time constraints on the work meant that completing the project to a high standard wasn't possible if done alone: (P. 30) *"Unless I was given far more time in the manufacturing stage, I would not have been able to complete it alone, and I feel it wouldn't have been as high quality".* PBL strategies aim to simulate real world engineering environments by providing problem that require students to distribute work among team members to meet tight deadlines. This encourages students to develop a variety of team associated soft skills such as communication, reflection, self-regulation and commitment (Palmer and Hall 2011).

Sub-Theme C: Team member commitment: On a number of occasions participants discuss their team in a positive light: (P.76) *"I enjoyed working as a group. Mainly because I was lucky to be placed in a very competent team with a very strong team leader"*. However, some participants also noted having non-committed team members that affect their performance: (P. 58) *"There was also a huge difference in how much each member cared. I cared very much about the project and wanted to make it as good as possible, some just wanted something that moved to get the 6 marks. I found trying to get these people to do just about anything to a decent level very frustrating".* Borrego et al (2013) outlines in a systematic review, that issue such as social loafing and team conflict are often combated by building trust among team members to ensure equal team effort.

Sub-Theme D: Team members sharing experience, skills and perspectives: Not only did participants noted that team members shared information that helped the collective project but also information that develop their own skill: (P. 4) *"my teammates helped me understand more about this project",* (P. 21) *"I learned a lot more by working with teammates as we shared our knowledge on different topics" and* (P. 35) *"I liked with collaboratively in this module as we were able to combine everyone's good ideas and make it into one great idea"***.** Peer learning is one of the many benefits experienced by students during teamwork activities (Volkov and Volkov 2015).

Theme 4 - The teaching and learning environment: As participants were recently impacted by the COVID-19 pandemic restrictions, many students highlighted their appreciation for working within the traditional face to face environment: (P. 27) *"I always enjoy working as a group on campus, it is a lot more interactive and it's also such a nice way to create friendships"*. Although many students were pleased to have the opportunity to engage with team members face to face they also outlined issues related to locating group meeting spaces on campus: (P. 19) *"Meeting rooms, I would say. It's a very odd thing, I think, but it's difficult to get a space that is very easy to work in because going to the library, you have to fight for an appointment. And if you don't have an appointment, you go to the working areas which are really, really filled. And that takes too much time to try to organise. Having somewhere that you can just go into with your group to get things done, I think would be really, really helpful with group projects". While this particular issue is related more to the university as a whole, it is still relevant factor that affects students' perceptions within the module.*

4.3 Comparing the Themes Against the Online Environment

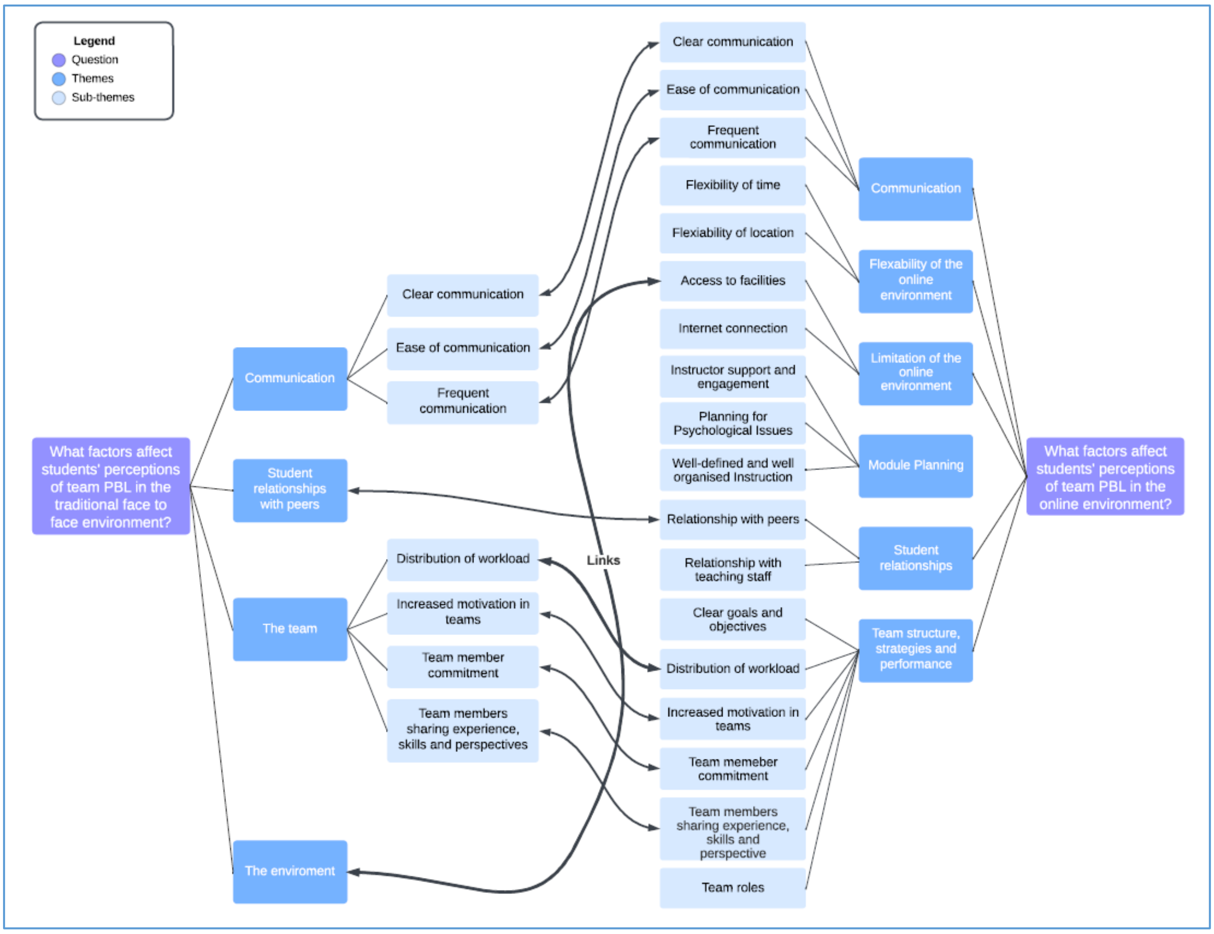

Fig. 2 Thematic Analysis Comparison Flow Diagram

When comparing the factors that affect students' perception of team PBL in the online environment (O'Connor et al. 2022) and traditional face to face environment, as shown in Fig. 3, we can see many commonalities shared between both environments. The strongest commonality shared between both environments fall under the themes entitled communication and the team.

The theme communication and linked sub-themes clear communication, ease of communication and frequent communication, are both clearly highlighted by participants as factors affecting students' perceptions of team PBL in both the online and traditional face to face environments. One of the core learning objectives, for PBL in engineering education, is developing students' transferable skills, such as communication, problem solving, and self-directed learning (Chen, Kolmos, and Du 2020; Edström and Kolmos 2014). Observe participants in both environments highlighting effective communication as a key factor affecting team performance is encouraging. As this provides them with the opportunity to develop and refine a variety of communication skill for working collaboratively. Nevertheless, educators facilitating such interactions between students must be aware of the pitfalls and success experienced by students, so that they in turn, develop effective pedagogical approaches for teaching and learning to assist students developing such skills.

The theme entitled the team and linked sub-themes distribution of workload, increased motivation in teams, team member commitment, and team members sharing experience, skills and perspectives, were also factors shared between participants in both the online and traditional face to face environments. In a similar way to communication, developing teamwork skills is also a key learning objective, for PBL in engineering education. In fact, PBL by design is a team-orientated active and student-centred learning strategy (Kolmos and de Graaff 2014). For this reason, it's clear to see why factors relating to the team play such an important role in each environment.

However, it's worth noting that several factors become less or, in some cases, non-significant to the participants depending on the environment in which they are engaging in. From participant responses, shown in Fig. 3, the range of factors affecting students' perceptions of team PBL in the online environment is greater than within the traditional face to face environment. Although some references were made to these additional factors, such as module planning and flexibility of the environment, the number of occasions didn't warrant the inclusion of an additional theme or sub-theme. Interestingly, one of these missing factors was overwhelmingly positive when identified in the online environment. This factor related to the increased levels of flexibility in time and location experienced by students in the online environment. Students, in general, perceive, that online learning allows for more effective use of time than traditional on campus courses (Bir and Ahn 2017; Young Roby and Hampikian 2002).

4.4 Significance of the findings:

The findings present in this study identifies how engineering students perceive PBL in the traditional face to face environment, while also comparing the findings against the online environment (O'Connor et al. 2022). As we move further towards engineering education that provides more flexible learning environments, such as blended, using student centered active learning strategies, such as problem and project based learning (Graham 2018; Hadgraft and Kolmos 2020), we can use such findings to inform teaching and learning. The findings can provide engineering educators with the foresight to pre-emptively implement strategies to solve issues before they occur. While also selectively choosing and combining elements that work better in either traditional face to face learning and online learning to create an ideal teaching and learning experience (Alkhatib 2018)

5 CONCLUSION

In summary, several factors enhance and or inhibit the success of PBL for participants in the traditional face to face environment. Each of these factors are also outlined and discussed by a number of academics in the engineering education literature base for PBL. This only solidifies the significance of each factor when planning for PBL.

Additionally, when comparing the factors identified in the online and traditional face to face environment, we can see that a number of factors are shared between both. However, there is a number of factors that are unique to the online environment. All of these factors, unique or shared, require careful consideration by engineering educators when planning and executing PBL. The findings clearly outline differences between the environments from participant responses and thus they should require individual tailored pedagogical approach to teaching and learning depending on the chosen environment, as one size won't fit all.

In the case of a blended environment these factors can also be used to inform engineering educator on elements better suited to either online or face-to-face teaching and learning. This will help engineering educators combine the most effective elements of each environment to create an ideal teaching and learning experience.

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