2023

Teamwork Satisfaction And Student Attitudes Towards Online Learning During An Engineering Problem And Project Based Learning (PBL) Module

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Recommended Citation

O'Connor, S., Power, J. R., Blom, N., Tanner, D. A., & De Brún, V. (2023). Teamwork Satisfaction And Student Attitudes Towards Online Learning During An Engineering Problem And Project Based Learning (PBL) Module. European Society for Engineering Education (SEFI). DOI: 10.21427/99WQ-7N48

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Conference Key Areas*: Virtual and Remote education in a post Covid world*
Keywords*: Engineering Education, Online Learning, Distance Education, PBL, Student Satisfaction, Student Attitude.*

ABSTRACT

Research has shown that students that report high levels of learner satisfaction and positive attitudes are more likely to succeed within the online environment. This is reflected in the considerable body of research that focuses on these factors across a range of academic disciplines. By assessing students' attitudes and satisfaction, educators gain a valuable affective perspective that allows for a more complete examination of strategy effectiveness. This paper examines teamwork satisfaction and student attitude towards online learning, while also highlighting elements of successful online collaboration as identified by students using the instruments developed by Hasler-Waters & Napier, Ku et al, *and* Tseng et al. This case study was carried out over a seven-week period with first-year engineering students (N=94), in a module entitled *Design for Manufacture*, during the COVID-19 pandemic. The findings revealed high levels of student satisfaction and attitudes towards working in teams in the online environment while participating in problem and project-based learning (PBL). Additionally, the findings outline multiple factors that affect the success of online collaboration. The relevance of these findings is then discussed in the context of an increasing move towards blended and online engineering education provision.

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1 INTRODUCTION

1.1 Background

Engineering education is experiencing a global shift in how students and educators interact during the teaching and learning process (Graham 2018; Hadgraft and Kolmos 2020). As technology advances and the needs of key stakeholders evolve, new challenges emerge for engineering education. These challenges, in turn, can lead to the development and implementation of new and renewed approaches to teaching and learning, that are responsive to the stakeholders' needs and support quality teaching and learning in engineering classrooms.

In recent years, discussions around the future of engineering education have highlighted many challenges facing engineering education institutions (Hadgraft and Kolmos 2020; Graham 2018). One of these challenges includes the delivery of student-centred active learning to large student cohorts with limited institutional budgets (Graham 2018; Hadgraft and Kolmos 2020). To address this challenge, engineering education institutions are increasingly using student-centred active learning approaches, such as problem and project-based learning (PBL), in online and blended learning environments.

However, in recent times the COVID-19 pandemic has highlighted a deficiency in evidence-based pedagogy for online and blended PBL education (Asgari et al. 2021; Syauqi, Munadi, and Triyono 2020). This deficiency in evidence-based pedagogy has emphasised the need for a new body of research to support the implementation of pedagogical strategies in these adopted digital environments.

1.2 Context of the study

In this paper, we investigate engineering students' teamwork satisfaction, attitudes towards online learning and elements of successful online collaboration, as identified by students during the COVID-19 pandemic. Findings will then be compared to similar research within the field including a previously published qualitative study on the same cohort of engineers published by the authors of this paper (O'Connor et al. 2022).

1.3 Research Questions

This research paper aims to use quantitative data analysis tools to provide an overview of student's perspectives of PBL conducted in an online learning environment. To accomplish this goal the following questions are addressed:

a) What degree of teamwork satisfaction is outlined by students during a PBL task in the online environment?
b) What are students' attitudes toward working collaboratively in an online environment during a PBL task?
c) What elements do engineering students perceive to be embedded in successful online collaboration?

2 LITERATURE REVIEW

2.1 Problem and Project based learning (PBL)

This paper utilises a hybrid active learning approach combining both problem-based learning and project-based learning which is commonly referred to as the abbreviation PBL for short. The popularity of this abbreviation is somewhat misfortunate as it is commonly used for a range of different pedagogical strategies in education such as place based learning, problem

based learning and project based learning. Nevertheless, problem and project based learning (PBL) 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 education 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).

2.3 Problem and Project based learning during the COVID-19 pandemic

During the COVID-19 pandemic, many higher-level institutions were forced to move to online and blended learning environments to ensure student learning outcomes were fulfilled (Khandakar et al. 2022). This transition was particularly hard for engineering institutions who were trying to adapt current PBL strategies. PBL by design is a team-orientated active and student-centred learning strategy. The online environment poses some challenges for team-orientated activity when compared to traditional face-to-face environments (Saghafian and O'Neill 2018). These issues include a lack of effective communication among team members (Clark and Gibb 2006), issues with building relationships (Lee et al. 2006) and an increase in social loafing (Olson-Buchanan et al. 2007).

Research conducted during the COVID-19 pandemic on online PBL also highlights many of the same recurring issues. Studies during the COVID-19 pandemic have shown that courses and student outcomes that had to rely on laboratory experiments and teamwork tended to be the ones significantly negatively affected by COVID-19 restrictions (Khandakar et al. 2022; Supernak, Ramirez, and Supernak 2021).

Stakeholders' attitude towards the use of active learning strategies in distance education is mixed with both positive and negative points (Mielikäinen 2022). However, a commonality shared by a number of academics is the need to further develop pedagogical strategies to support the teaching and learning process online (Asgari et al. 2021; Graham 2018; Syauqi, Munadi, and Triyono 2020). The literature on PBL used within the online environment is still lacking sufficient attention to develop trusted evidence-based practices. This paper adds to the current body of literature by helping to identify areas of attention for engineering practitioners attempting to implement PBL online.

3 METHODOLOGY

3.1 Approach

This study was carried out at an Irish university over an academic semester in a first-year engineering module. The module was conducted using a strictly online format due to the Irish governmental restrictions around COVID-19. All elements of the module were delivered online. The capstone project within the module was a team based Conceive, Design, Implement and Operate (CDIO) project, which PBL based and aligned with a CDIO philosophy (Edström and Kolmos 2014). During this project students designed and manufactured a

miniature battery-powered vehicle to fulfil a given brief. Quantitative data was gathered with the use of two combined questionnaires and a single open-ended question.

3.2 Participants

The module had 170 students enrolled, 34 female (20%) and 136 male (80%). Students ages vary; however, the majority of students were aged between 17 and 19 years. The questionnaire had a participation rate of 55% (N = 94), 19 female (20.2%), 74 male (78.7%) and 1 preferred not to say (1.1%).

3.3 Online 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 module was fully completed off campus remotely by students. The lectures were delivered by co-leading lecturers, while the laboratories were delivered by TA's using Microsoft Teams. The technicians provided technical support through recorded videos, which, assembled and tested during the manufacturing phase of the project. The project was designed 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. Due to the Covid-19 pandemic the teaching team prepared all components and sent them out to a nominated student from each team for final assembly. Week 12 was vehicle time trials, where all completed projects were tested and timed.

3.4 Instruments

The study utilised three instruments:

a) Teamwork student satisfaction scale developed by Tseng et al. (Tseng et al. 2009). The Cronbach's alpha reliability for the scale was reported as 0.95 (Ku et al., 2013).
b) Online collaborative attitude scale developed by Tseng et al. (Tseng et al. 2009) based on Hasler-Waters & Napier (Hasler-Waters and Napier 2002) five collaboration factor model. The Cronbach's alpha reliability for the scale was outlined as 0.95 (Ku, Tseng, and Akarasriworn 2013).
c) The open-ended question was developed by Ku et al. (Ku, Tseng, and Akarasriworn 2013).

Both questionnaires used a five-point Likert scale to measure respondents' agreement with various statements. The scale ranges from 1 (Strongly disagree) to 5 (Strongly agree). All instruments are available on the Open Science Framework (OSF) [https://osf.io/4d2cz/?view_only=bbdf738274c54013a0bfdce7d3042204].

3.5 Data Collection:

Participant responses were collected using the Microsoft Forms platform. The questionnaire and open-ended question were distributed to students of the module over email and at the end of a weekly lecture after completing the capstone team-based project.

3.6 Data Analysis

The questionnaire data was analysed using IBM SPSS Statistics software. The questionnaire results were represented for both male and female participants. The questions were also ranked in order of agreement. The open-ended question was analysed by counting the number of reoccurring elements, as outlined by students, of a successful online collaborative setting.

3.7 Reliability and Validity

Several additional processes were followed to strengthen the reliability and validity of this study including, 1) preregistration on OSF to ensure sufficient transparency, 2) methodical methodology section covering all study procedures, 4) open access anonymized data file and questionnaire provided on OSF to facilitate independent re-analysis, 5) member checking of researcher interpretations of findings and lastly 6) the calculation of the Cronbach's alpha, which is a measure of internal consistency.

3.8 Ethical Considerations

An information sheet was provided to all participants outlining the aim and objectives of the research. Participants provided informed consent before accessing the survey. 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 granted by the host university.

4 RESULTS

4.1 Online Collaborative Attitude

In *Table 1*, each of the 20 items were analysed and ranked in order of agreement. The mean, standard deviation and overall mean rank are also shown. The overall mean result of 3.916 shows a high level of student positive agreement with their collaborative learning experiences in the online environment. The Cronbach's alpha reliability for the scale was 0.827. The online collaborative attitude scale included three underlying factors (F1) team dynamics, (F2) team acquaintance and (F3) instructor support. The Cronbach's alpha reliability for each of these factors were 0.850 for F1, 0.452 for F2 and 0.705 for F3.

Table 1: Students Online Collaborative Attitude Scores

Questions no.	Survey items	Male mean	Female mean	OA mean	Male SD	Female SD	OA SD	OA mean rank
20	My team members clearly know their roles during the collaboration.	4.460	4.632	4.5	0.623	0.496	0.600	1
11	Communicating with team members regularly helps me to understand the team project better.	4.351	4.474	4.372	0.607	0.513	0.586	2
10	My team members communicate in a courteous tone.	4.230	4.421	4.277	.653	0.507	0.629	3
4	My team is receiving feedback from each other.	4.230	4.368	4.255	0.562	0.597	0.567	4
16	My team trusts each other and works toward the same goal.	4.270	4.211	4.255	0.556	0.787	0.604	5
12	My team members encourage open communication with each other.	4.108	4.316	4.149	0.632	0.671	0.639	6
15	I trust each team member can complete his/her work on time.	4.135	4.158	4.138	0.709	0.898	0.742	7
18	My team sets clear goals and establishes working norm.	4.108	4.211	4.128	0.674	0.713	0.676	8

9	My team members communicate with each other frequently.	4.068	4.316	4.117	0.800	0.582	0.760	9
8	Getting to know one another in my team allows me to interact with teammates more efficiently.	4.095	4.158	4.106	0.706	0.688	0.695	10
14	My team members reply all responses in a timely manner.	3.932	4.263	4.000	0.689	0.806	0.718	11
19	My team has an efficient way to track the edition of documents.	3.892	4.158	3.936	0.945	0.834	0.925	12
17	My team develops clear collaborative practices to increase team learning efficiency.	3.757	3.895	3.787	0.755	0.809	0.760	13
13	My team members learn how other members wish to be treated and then act accordingly.	3.716	3.947	3.766	0.693	0.780	0.710	14
1	My team is receiving guidance for the group project from the instructor(s).	3.770	3.632	3.734	0.732	0.597	0.706	15
7	My team members share their professional expertise.	3.622	3.895	3.670	0.855	0.875	0.860	16
6	My team members share personal information to know each other better.	3.500	3.474	3.489	0.925	0.905	0.913	17
3	The support from the instructor(s) helps my team to reduce anxiety among team members.	3.487	3.474	3.479	0.763	0.612	0.729	18
5	My team members share cultural information to know each other better.	3.297	3.000	3.234	1.095	1.000	1.072	19
2	The instructor(s) acts as a referee when our members cannot seem to resolve differences.	2.960	2.790	2.926	0.784	0.713	0.765	20
Overall		3.899	3.990	3.916	0.136	0.146	0.128	

Please note: Responses range from 1 (Strongly disagree) to 5 (Strongly agree). OA: Overall, SD: Standard deviation.

4.2 Student Teamwork Satisfaction

On completion of the student teamwork satisfaction scale, each of the 10 items was analysed and ranked in order of agreement. The mean, standard deviation and rank are shown in *Table 2*. The overall mean score of the student teamwork satisfaction scale was 4.011, which shows a high level of student positive agreement with their level of teamwork satisfaction in the online environment. The Cronbach's alpha reliability for the scale was 0.868.

Table 2: Students Teamwork Satisfaction Scores

Questions no.	Survey items	Male Mean	Female Mean	OA Mean	Male SD	Female Mean	OA SD	OA mean rank
4	I have benefited from interacting with my teammates.	4.162	4.632	4.255	0.597	0.496	0.604	1
9	My team members are sharing knowledge during the teamwork processes.	4.149	4.316	4.181	0.612	0.749	0.639	2
5	I have benefited from my teammates' feedback.	4.095	4.368	4.149	0.743	0.761	0.747	3
3	Interacting with the other members can increase my motivation to learn.	4.095	4.316	4.138	0.743	0.749	0.742	4
6	I enjoy the experience of collaborative learning with my teammates.	4.041	4.316	4.096	0.650	0.946	0.719	5
10	I gain online collaboration skills from the teamwork processes.	4.068	4.105	4.076	0.782	0.809	0.779	6
2	I like solving problems with my teammates in group projects.	4.041	4.053	4.043	0.784	0.705	0.761	7
8	Working with my team helps me produce better project quality than working individually.	3.919	4.105	3.957	0.962	0.875	0.938	8
1	I like working in a collaborative group with my teammates.	3.946	3.947	3.947	0.935	0.621	0.872	9
7	Online teamwork promotes creativity.	3.203	3.526	3.266	1.007	1.073	1.018	10
Overall		3.972	4.168	4.011	0.145	0.162	0.128	

Please note. Responses range from 1 (Strongly disagree) to 5 (Strongly agree). OA: Overall, SD: Standard deviation.

4.3 Elements of Successful Online Collaboration

The open-ended question was designed to identify what students viewed as important elements embedded in a successful online collaborative setting. The question was presented to participants as the following: *In your opinion, what elements should be embedded in a successful online collaborative setting?* After completion of data analysis, the authors were able to be identified 12 recurring elements of successful online collaboration from participant comments. Some of the categories used were supported by the elements identified by Ku et al. (Ku, Tseng, and Akarasriworn 2013).

Table 3: Elements of successful online collaboration

No.	Elements embedded in a successful online collaborative setting	Count (Ranked)
1	Frequent communication	26
2	Team commitment	24
3	Clear communication	19
4	Clear objectives and goals	13
5	Synchronous meetings	9
6	Camaraderie	9
7	Use of interactive software	8
8	Instructor support and encouragement	7
9	Timely resources	6
10	Member Rolls	6
11	Well-defined and well-organized instruction	5
12	Opportunities to access and view examples	3

Please note. Count: Frequency of element in participant responses.

Each of these elements has share commonalities with the findings presented by the authors in a recent publication, on the same cohort, reporting on factors that affect students' perceptions of problem and project-based learning (PBL) in an Online Learning Environment (O'Connor et al. 2022). Within this publication the authors outlined six themes and eighteen sub-themes affecting students' perceptions of PBL in the online environment. Some of the closest linked themes include:

Theme 1) Communication: The theme communication linking with the element's entitled frequent communication, clear communication, synchronous meetings, and instructor support and encouragement.

Theme 2) Module planning: The theme module planning linking with the elements entitled use of interactive software, instructor support and encouragement, timely resources, well-defined and well-organized instruction, and opportunities to access and view examples.

Theme 3) Team structure, strength, and performance: The theme team structure, strength, and performance linking with the elements

5 DISCUSSION

Overall, the participants showed high levels of teamwork satisfaction while participating in PBL within the online environment. This was a significant finding for the study, as student satisfaction is a widely accepted measure of the quality and effectiveness of teaching and learning (Wu, Tennyson, and Hsia 2010). In addition, student satisfaction has also been closely linked with student motivation, dropout rates and future recommendation to prospective students (Butt and Rehman 2010; Mai 2010; Sneyers and De Witte 2017) The numerous benefits from high levels of student satisfaction are clear within the available literature and as such is seen as an indicator of program quality within engineering (Sneyers and De Witte 2017). This high level of satisfaction was similar to results presented by Ku et al., (Ku, Tseng, and Akarasriworn 2013) and Tseng et al., (Tseng et al. 2009) who both implemented the same teamwork satisfaction questionnaire. Both Ku et al., (Ku, Tseng, and Akarasriworn 2013) and Tseng et al., (Tseng et al. 2009) highlighted high levels of satisfaction within their studies. However, Ku et al., (Ku, Tseng, and Akarasriworn 2013) conducted their study within a blended environment, which typically presents higher levels of teamwork satisfaction than in fully online counterpart (Means et al. 2009; Moskal, Dziuban, and Hartman 2013). This was of interest to the authors as this study arguable reports higher levels of student satisfaction from within a full online environment. Although this could be affected by a variety of different variables within the context of the study, it's a noteworthy finding. Further research examining potential variances due to differing social and educational setting would strengthen future use of this scale.

In addition, participants responded positively overall to the online collaborative attitude questionnaire. This was also a notable finding for the study, as students' attitudes are closely linked with their perception of engineering, motivation to learn, self-confidence, level of competency, performance, and retention in an engineering program (Besterfield-Sacre et al., 1998).

Moreover, this paper outlines twelve elements of successful online collaboration as identified by participants. These elements can be closely linked with the themes and sub-themes presented in the paper by O'Connor et al., (O'Connor et al. 2022). O'Connor et al., (O'Connor et al. 2022) presented six themes and eighteen sub-themes linked to students' perceptions of

PBL in the online environment. Although all elements can be clearly linked to the overarching themes, there are three themes that standout from participant responses. These themes include 1) Communication, 2) Module planning, and 3) Team structure, strength and performance.

Communication has singled itself out within the distance education literature base as a major problem for students when working collaboratively in the online environment (Belanger, Bartels, and She 2021). Many students have reported issues surrounding the ability to communicate effectively with others in the online environment when compared to the traditional face to face environment. Elements associated with communication was a popular topic of discussion for participant. Participants outlined that communication needed to be clear and frequent when working online between both team members and teaching staff. Academics such as Belanger et al., (Belanger, Bartels, and She 2021) outline that students identify fast, convenient and frequent communication as an effective strategy to collaborative work online. However, this isn't a new finding within online learning research. Many other studies have outlined the criticality of effective communication to success within the online environment (Tang et al. 2020). Additionally, participants expected communication to be both synchronous and asynchronous for effective communication to take place within the online environment. Participants also stated that they expected communication to include live face to face elements, such as live lectures on software such as Microsoft Teams or Zoom. Outlining that emails, group chats and other forms of communication lacking face to face engagement are insufficient for effective communication to take place.

Careful module planning is core to teaching and learning process. Module planning provides solid foundation at which teaching and learning can take place. Academics such as Berge (Berge 2002) states that teaching and learning is a social activity that becomes more effective when thoughtful planning and implemented by a facilitator. Elements associated with module planning was also a popular topic of discussion for participant. Participants stated the need for well-defined and well organised instruction to reduce confusion on collaborative tasks, timely resources and frequent instructor support and engagement.

Team structure, strength and performance was the final theme that could be linked to multiple elements outlined from student responses. Participants outlined that they wanted team members to be committed, share clear goals and object and have clear rolls within the collaborative task. Participants also outlined the necessity of team camaraderie

6 CONCLUSION

In conclusion, the findings revealed high levels of student satisfaction and attitudes towards working in teams in the online environment while participating in problem and project-based learning (PBL). This was a welcomed finding for the authors due to it's many links with beneficial outcomes for students. Additionally, the findings outline multiple factors that affect the success of online collaboration. Three of the most prevalent factors being 1) Communication, 2) Module planning, and 3) Team structure, strength and performance. These factors provide a unique student perspective into what affects them, both positively and negatively during an online PBL module. This information can help info future pedagogical decisions both for the authors and readership.

7 ACKNOWLEDGMENTS

The authors would like to acknowledge the financial support of the Irish Research Council (IRC) in the production of this work (Grant number: GOIPG/2021/352).

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