An Evaluation of the Impact of Project-based Learning on Student Engagement in the Six Sigma Green Belt Quality Module at Galway-Mayo Institute of Technology

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Abstract

Subject specialist knowledge and professional, practical skills are critical in the engineering domain. At the same time, soft skills, such as communication, teamwork, critical thinking and problem-solving have become increasingly important at the workplace. Lecturers in the Department of Mechanical and Industrial Engineering at GMIT equip students with the right skills, competences and knowledge. Project-based learning (PBL) is a teaching strategy proven to enable students acquire both hard and soft skills. The PBL approach, moreover, has the potential to increase motivation and interest in learning, which, consequently, leads to increased student engagement, as well as enhanced learning and improved academic performance. The aim of this research was to evaluate the impact of PBL on student engagement in the Six Sigma Green Belt Quality module at GMIT. A mixed methods case study methodology was employed, and data collection methods included a questionnaire, observation and interviews. The findings suggest that PBL has a positive impact on student engagement. More case studies, modelled on the same process, including a variety of disciplines, degree levels and years of study are necessary to supplement these findings.

Keywords: *project-based learning, student engagement, active learning, higher education, Six Sigma, case study*

1. Introduction

At Galway-Mayo Institute of Technology (GMIT), lecturers in the Mechanical & Industrial Engineering Department aim to equip students with hard skills, i.e. a high standard of discipline knowledge and professional, practical skills, which are critical in the engineering domain, but also with soft skills, including communication, teamwork, critical thinking and problem-solving, which are considered increasingly important at the work place [1]. Despite continuous, collective efforts at department level to enhance student engagement, some students disengage with the challenging engineering content. One teaching strategy proven to enable students acquire knowledge and equally develop soft skills is project-based learning (PBL) [2]. PBL offers students the possibility to actively participate in a project related to real-life situations [3] and has the potential to increase motivation and interest in learning [4]. A real-world simulated project was added to the Six Sigma Green Belt Quality elective module for 3rd year mechanical engineering students. The project was specifically designed for this study and involved problem-solving and decision-making, and the use Minitab, a piece of software largely used in industry by Six Sigma practitioners. In light of these adaptations to the module, in this study the author investigated the following research question: what impact has a PBL strategy on student engagement in the Six Sigma Green Belt Quality module?

2. Student engagement

Although student engagement has been researched for a long time, there is not a clear agreement on conceptualising engagement. Some researchers argue that student engagement encompasses in-class as well as non-academic aspects of student experience [5], others argue that it is a process requiring out-of-classroom experiences [6], whilst other authors consider the place of learning is not important [7]. Despite the multitude positions and opinions, student engagement can be conceptualised as “the extent to which students actively engage by thinking, talking, and interacting with the content of a course, the other students in the course, and the instructor” [8]. Literature reveals many benefits of engaging students in learning. It fosters student learning, increases enthusiasm for learning, promotes more active learning, facilitates learners to take more responsibility for their own learning [9], enhances academic performance and promotes personal development [10], [11].

For this study, student engagement was defined along three dimensions: behavioural, emotional and cognitive [12], [13]. Indicators of behavioural engagement include effort and time spent engaging in learning activities [6],[14], as well as interaction with lecturer and peers [6], [15]. Among indicators of emotional engagement researchers mention interests, values and attitudes towards learning and a perceived sense of belonging within a learning community [6], [14]. Finally, indicators of cognitive engagement include: active construction of knowledge [10], persistence to overcome academic challenges [10], [14], motivation to learn [15], [16] and self-regulation [16].

3. Project-based learning (PBL)

In a PBL approach, students actively participate in a project, usually related to real-life situations, and cooperate with their group members to reach a specific goal or result. They learn through data collection, problem solving, discussions, presentation of results and reports [3]. Authors have identified a number of characteristics of PBL, which are summarised in Figure 1. As Figure 1 shows, PBL helps students create their own knowledge by using real-life scenarios, giving students independence in making their own decisions, and encouraging collaboration and discussion.

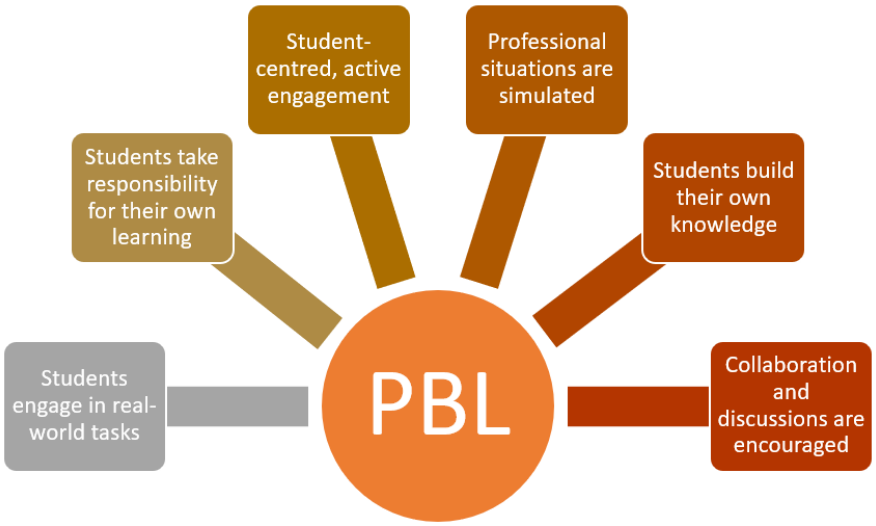

Figure 1. Characteristics of PBL, based on [3], [4]

Although PBL is a well-established learning method, which has been successfully applied in STEM subjects, there is not extensive evidence of its application in engineering. The authors have reviewed a number of studies on PBL applied to engineering and concluded that all initiatives were successful in terms of achieving the main goal, that of constructing professional knowledge, but also acquiring soft skills, such as teamwork, collaboration, communication, problem-solving, as well as enhanced engagement and motivation [18], [19], [3], [17].

4. Research methodology

Case study [20], [21], [22] was deemed the most suitable research methodology for this study. It facilitated the in-depth exploration and description of the student engagement within one specific GMIT engineering module and helped the researchers understand the specific impact that PBL had on student engagement in the case study by means of analysing multiple student perspectives.

The study employed mixed methods for data collection [23]. This choice helped capture the complexity of the phenomenon under study and the multiple views of the phenomenon, by using quantitative and qualitative approaches in combination, in a phased sequence. The specific data collection tools used in the three-phase study included observation (in phase 1, during a class dedicated to project work) followed by a questionnaire (in phase 2, a week after project class) and interview (in phase 3, a week later). The design of the three tools was an iterative process. After numerous cycles of refinement, an observation sheet was created, and an online form of the questionnaire were created using MS Forms. A small pilot study was conducted in which student feedback was solicited. The interviews were carried out after processing the initial data in order to collect more in-depth information so that the researchers could understand the participants' experience with PBL and gather as many points of view as possible in relation to the way they perceived engagement. The adoption of mixed methods and a triangulated approach assured the research was more valid and reliable. This research was

carried out in accordance with GMIT research ethics policy, GDPR and the requirements of the GMIT MA in Teaching & Learning Research Ethics Committee.

5. Research findings

There were 37 students registered on the case study module. Due to special circumstances (COVID-19), the access to the GMIT buildings was restricted and the module was delivered fully online at the time of data collection. Of the 37 students, 20 volunteered to participate in the observation, 22 completed the questionnaire and 5 were interviewed. The sampling method used for the selection of the participants to interview was purposive sampling, which is accepted in case study research [22].
The research findings are organised along the impact of PBL on three main student engagement themes: behavioural, emotional and cognitive engagement.

5.1 Findings related to the impact of PBL on behavioural engagement

An important indicator of behavioural engagement is participation in class. A high number of students participated actively during the project session, finding suggested by both quantitative and qualitative data. For example, 19 out of the 20 observed participants (95%) were discussing the project when the researcher was visiting their breakout room. Quantitative data from questionnaire (see Figure 2) also suggest a good participation of students in project class.

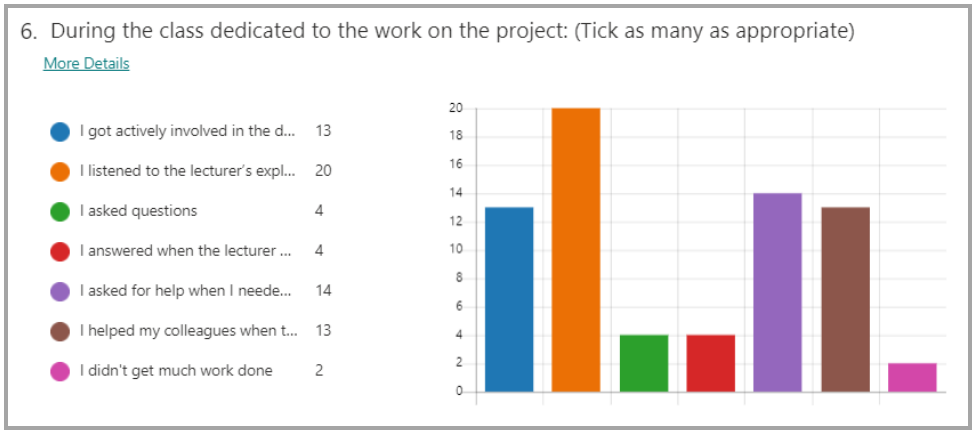

Figure 2. Responses to the question regarding student participation in class

Another indicator of behavioural engagement is communication. Most of the communication was verbal, but some participants preferred the chat box on MS Teams or email. The analysis of qualitative data identified a new factor that influenced students' behavioural engagement: the transition to online teaching and learning. For instance, all interviewees indicated they felt uncomfortable online when they were in big groups (the largest group has 15 students), but they found the breakout rooms helpful. Participant 1 called the online experience "scarier", participant 3 said "shy", participant 4 referred to it as "awkward" whilst participant 5 mentioned "intimidating".

5.2 Findings related to the impact of PBL on emotional engagement

The observation took place online, with a focus on verbal indicators in an attempt to capture indicators of emotional engagement. Although behavioural indicators showed that all students were actively involved in the project work, a very small number of incidences of energetic involvement in discussions or express of enjoyment were noticed. Furthermore, qualitative data reflected feelings of learning satisfaction, learning passion, belonging and being supported, which was experienced by students in relation to PBL. A few more ideas emerged from the analysis of the qualitative data. Participants related their feelings of learning satisfaction to the practical aspect of the project: Participant 4 mentioned: "I felt after completing the project that I had accomplished something by putting my previous learning into practice in a more real-life scenario". Three participants (14%) linked their interest in learning to PBL, as opposed to traditional learning, as described by Participant 22: "I'd personally rather project-based learning as opposed to reading slides and answering a standardised exam". Qualitative data from interviews clarified the lack of enjoyment; it related to a theme that has emerged earlier: online learning: "I feel it's maybe because it's the actual online stuff at the moment 'cause people don't enjoy sitting in front of a laptop" (Participant 3).

5.3 Findings related to the impact of PBL on cognitive engagement

Quantitative data from observation reflected that participants showed higher ability to do the analyses or to interpret the project results as they progressed with their project work, which concur with participants' perception of the way the project helped them build their knowledge. The dominant idea emerging from the analysis of the qualitative data was that PBL helped build up students' knowledge because of the practical work and the real-life application, as mentioned by Participant 4: "It might be different for other people, but for me, anyway, I learn best by actually doing stuff". Even more, the participants found that PBL contributes to better and deeper learning. Furthermore, the group work influenced positively their accumulation of knowledge because you can "learn off the other people" (Participant 1) and sharing ideas "helps you build your own skills" (Participant 2).

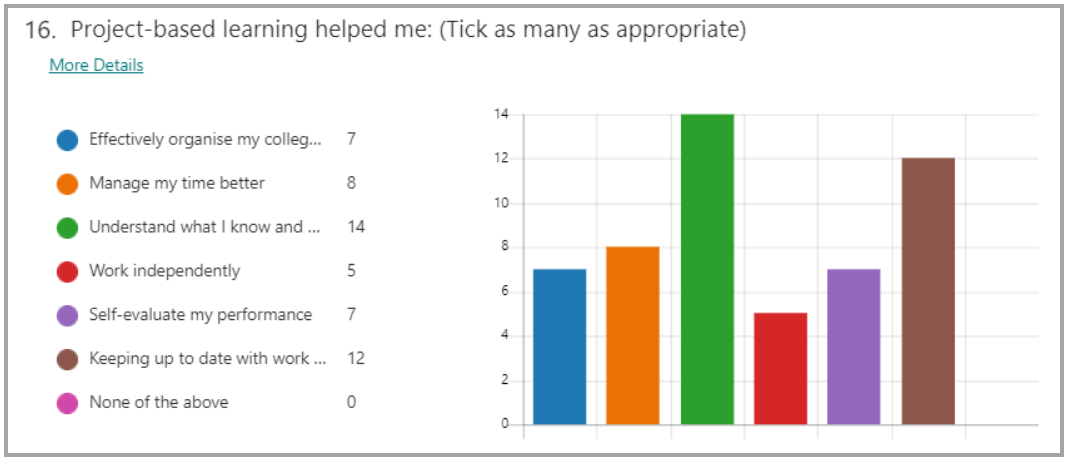

Figure 3. Responses regarding students' knowledge gained as a consequence of PBL

In terms of self-regulated learning, most of the participants (64%) thought PBL helped them to understand better what they knew and where they had gaps – see Figure 3. Another good proportion of the respondents (55%) perceived PBL as helping them keeping up to date with work instead of letting it pile up. The participants thought PBL helped them to manage their time better (35%), effectively organise college work (32%), and self-evaluate performance (32%).

2. Conclusions and recommendations for further study

This research aimed to evaluate the impact of PBL method on student engagement in the Six Sigma Green Belt Quality module with the aid of a case study. Based on quantitative and qualitative analyses of data related to student behavioural, emotional and cognitive engagement, it can be concluded that PBL has, on balance, a positive impact on student engagement with learning in the Six Sigma Green Belt Quality module. The results indicate that PBL can cause students to be more involved in their class activities and to collaborate with their peers. It can also increase students' motivation to learn and it has a positive impact on their learning satisfaction. Furthermore, the analysis of the study results revealed that PBL has the potential to enhance student learning. Several factors which lead to deeper learning and increased knowledge were identified, such as collaboration with peers, increased motivation and the real-life simulation, which makes learning more meaningful and relevant. PBL gives students more control over their learning, transforming them in independent learners.

This study has contributed to knowledge in a few ways. It analysed and discussed in detail the impact of PBL on all three aspects of student engagement – behavioural, emotional and cognitive – at third level education, in a Six Sigma module. Moreover, it contributed to the study of PBL impact in an engineering discipline.

One limitation of this research is the scale of the study. The sample size of 22 students, although representative for the cohort that was taking the Six Sigma Green Belt Quality module (37 students), is relatively limited. More case studies, modelled on the process outlined here, including a variety of disciplines, degree levels and years of study are necessary to supplement the findings. The study concluded that PBL has a positive impact on student engagement with learning in the Six Sigma Green Belt Quality module. Further studies could build on these findings and investigate the correlation between engagement and academic performance. The engagement with the module might be beneficial to the student learning experience, but it would be interesting to see if it has a positive impact on the student academic performance as well.

References

[1] Casner-Lotto, J., Barrington, L. “Are they really ready to work? Employers' perspectives on the basic knowledge and applied skills of new entrants to the 21st century US workforce”, Washington: Partnership for 21st century skills, 2006.
[2] Konopka, C.L., Bohrer Adaime, M., Mosele, P. H. “Active Teaching and Learning Methodologies: Some Considerations”, Creative Education, 6, 1536-1545, 2015.
[3] Hung, C.-M., Hwang, G.-J., Huang, I. “A Project-based Digital Storytelling Approach for Improving Students’ Learning Motivation, Problem-Solving Competence and Learning Achievement”, Educational Technology & Society, 15(4), 368-379, 2012.
[4] Bilgin, I., Karakuyu, Y., Ay, Y. “The Effects of Project Based Learning on Undergraduate Students’ Achievement and Self-Efficacy Beliefs Towards Science Teaching”, Eurasia Journal of Mathematics, Science & Technology Education, 11(3), 469-477, 2015.
[5] Barkley, E. “Student Engagement Techniques: A Handbook for College Faculty”, San Francisco: Jossey-Bass, 2010.
[6] Kahu, E. “Framing student engagement in higher education”, Studies in Higher Education, 38(5), 758–773, 2014.
[7] Pickford, R. “Student Engagement: Body, Mind and Heart – A Proposal for an Embedded Multi-Dimensional Student Engagement Framework”, Journal of Perspectives in Applied Academic Practice, 4(2), 2016.
[8] Dixson, M. “Measuring Student Engagement in the Online Course: The Online Student Engagement Scale (OSE)”, Online Learning, 19(4), 2015.
[9] Cook-Sather, A., Bovill, C., Felten, P. “Engaging Students as Partners in Learning and Teaching: A Guide for Faculty”, San Francisco: Jossey-Bass, 2014.
[10] Kuh, G.D., Kinzie, J., Buckley, J.A., Bridges, B.K., Hayek, J.C. “What Matters to Student Success: A Review of the Literature”, US, 2006.
[11] Zingier, D. “(Re)conceptualising student engagement: Doing education not doing time”, Teaching and Teacher Education, 24(7), 1765-1776, 2008.
[12] Ginty, C., Boland, J. “Supporting the first year experience in higher education in Ireland: impact on student engagement, teaching practice and institutional policy”, Student Engagement and Experience Journal, 5(1), 2016.
[13] Mandernach, B.J. “Assessment of Student Engagement in Higher Education: A Synthesis of Literature and Assessment Tools”, International Journal of Learning, Teaching and Educational Research, 12(2), 1-14, 2015.
[14] Trowler, V. “Student engagement literature review”, York: The Higher Education Academy, 2010.
[15] Zepke, N. “Student engagement research in higher education: questioning an academic orthodoxy”, Teaching in Higher Education, 19(6), 697-708, 2014.
[16] Lester, D. “A review of the student engagement literature”, Focus on Colleges, Universities, and Schools, 7(1), 1–8, 2013.
[17] Lee, J., Blackwell, S., Drake, J., Moran, K. “Taking a Leap of Faith: Redefining Teaching and Learning in Higher Education Through Project-Based Learning”, Interdisciplinary Journal of Problem-Based Learning, 8(2), 2014.
[18] Balve, P., Albert, M. “Project-based learning in production engineering at the Heilbronn Learning Factory”, Procedia CIRP, 32, 104-108, 2015.
[19] Sharma, A., Dutt, H., Sai, N., Naik, S. “Impact of Project Based Learning Methodology in Engineering”, Procedia Computer Science, 172, 9222-926 2020.
[20] Yin, R.K. “Case Study Research: Design and Methods (4th ed.)”, Thousand Oaks: SAGE Publications Inc., 2009.
[21] Cohen, L., Manion, L., Morrison, K. “Research Methods in Education (8th ed.)”, NY: Routledge, 2018.
[22] Yazan, B. “Three Approaches to Case Study Methods in Education: Yin, Merriam, and Stake”, The Qualitative Report, 20(2), 134-152, 2015.
[23] Creswell, J., Plano Clark, V. “Designing and Conducting Mixed Methods Research (3nd ed.)”, Thousand Oaks: Sage, 2017.