AMISH, M. and JIHAN, S. 2023. Developing collaborative online project-based learning model to enhance learning in engineering. In *Proceedings of the 4th Global conference on education and teaching 2023 (GlobalET 2023), 21-23 April 2023, Athens, Greece*. Vilnius: Diamond scientific publishing [online], pages 59-75. Available from: https://doi.org/10.33422/4th.globalet.2023.04.105

Developing collaborative online project-based learning model to enhance learning in engineering.

AMISH, M. and JIHAN, S.

2023

OpenAIR @RGU

This document was downloaded from https://openair.rgu.ac.uk

CC BY

Developing collaborative online project-based learning model to enhance learning in engineering

Mohamed Amish and Sha Jihan
School of Engineering, Robert Gordon University, Garthdee Road, Aberdeen, AB10 7GJ, UK
Corresponding author: m.amish@rgu.ac.uk

Abstract

It has been widely reported that knowledge and skills gained in formal Higher Education Institute courses are different from those required at work. Students lack soft skills, according to feedback from employers. Many universities have become proactive in improving their curricula to address industry demands. Collaborative learning (CL) is the current trend towards active learning, bridging both academia and industrial expectations. This paper presents a collaborative online project-based learning (COPBL) approach using the ADDIE (analysis, design, development, implementation, evaluation) model in order to improve the quality of learning, teaching and practice collaboration. The COPBL framework is designed to help students conduct projects independently or collaboratively in a safe and engaging manner.

A set of data was obtained and analysed using a mixed-methods research design. Questionnaires were used to collect quantitative data from 155 students, and interviews were conducted with 25 of them to collect qualitative data. Analysis revealed that 90% of students engaged in group discussion to reach a decision, and students collaborated and shared information about the project with their peers. Students engaged in teamwork within their learning community and participated in group problem solving as they worked through the COPBL. They were active and motivated in group meetings and used workbooks to plan and record activities. As a result, they were able to better understand the ideas, objectives, or resources involved in the projects, as well as improve their ability to listen to and respect the ideas of others. Students believed that when they communicated and participated in group activities, they learned more. Students agreed that CL was more effective and better than individual work, that they understood the subject better, used technology better, and learned things of significant value. The findings indicated that COPBL gives students the opportunity to apply their knowledge of the discipline in the given activities, learn more advanced information from practical performance, and develop digital skills and a set of soft skills (including communication, collaboration, critical thinking, problem-solving, time management, and creative skills) that complement hard skills in the evolving job market.

Keywords: ADDIE model, digital skills, collaborative learning, project-based learning, soft skills

1. Rational of the collaborative learning experience

The trend toward active learning in education in the 21st century is collaborative learning (CL). As a result of discovery, discussions, and expert guidance, students engage in cooperative knowledge building, shifting from individual efforts and autonomy to teamwork and community (Alozie, et al., 2010). It has been widely reported that knowledge and skills gained in formal Higher Education Institute courses are different from those required at work. Feedback from employers pointed out that students lack soft skills (White, 2013). Several workplace assessments have shown that hard skills (technical skills) alone are not enough to keep individuals employed, but soft skills are becoming more important because soft skills complement hard skills. According to Arnold-Smeets (2015), it is important to have hard skills if you want to get into an organisation, but soft skills keep you there. In order to succeed, you need five soft skills: working together in a team, communicating verbally with both internal and external organisations, resolving problems, making decisions, planning, gathering, and processing information, as well as prioritising and organising tasks (Adams, 2014). Many universities have become proactive in improving their curricula to address industry demands (Lin & Tsai, 2016). To enhance a university's reputation as a place that produces "industry-ready" graduates, it's vital that graduates are marketable and competitive in the job market. The curriculum must be revised to incorporate soft skills. Embedding soft skills that have been identified requires a new approach from educators. In traditional instruction, university courses have a more content-based approach focussed on educator-centered learning. Due to this narrow focus, the courses were insufficient for preparing students for the job market. Scholars would most likely agree that this type of learning approach is limited in its effectiveness in terms of student comprehension, and that students should engage in some activities to make the approach more engaging (Biggs & Tang, 2011). Integrating CL Approaches into the teaching and learning process can help educators overcome the shortcomings of this type of instruction (Yu-Hui & Yu-Chang, 2013).

1.1. Collaborative learning concept

Among the most effective learning methods of the 21st century is collaborative project-based learning (Chanpet, et al., 2020). A CL approach is an instructional model that prioritises student collaboration within small groups (two to five students) in order to maximise individual and group learning. Together, students work on a structured activity, and each student is individually responsible for the assigned work as a part of reaching a common goal (Ormrod, 2008). As well as their own learning, the students are responsible for each other's. In this way, the success of one learner makes it easier for other learners to succeed. In addition to developing interpersonal skills, students may also learn how to resolve conflict and evaluate themselves. Students gain a deeper understanding of the content they study by participating in a variety of collaborative activities guided by clear objectives. There are many models of CL such as Learning Together, Student Team-Achievement, Circles of Learning, and Group Project-Based Investigations. CL has been proven in promoting knowledge and soft skills development. CL has the following characteristics, identified by Ning (2010):

- Learning authentically uses collaboration to align content with curriculum standards, so students have a clear objective.
- Students can learn participatory skills through collaboration.
- Various forms of technology can be used effectively to present multiple modes of instruction to learners.
- Collaborative project-based learning requires innovative assessment techniques, including learners evaluating themselves and their peers, so evaluations are not limited to educators alone.

Students who participate in CL experience an increase in retention, academic performance, improved soft skills (e.g., collaboration, communication, and problem-solving skills), and higher satisfaction with their education (Zhu, 2012). Working together has proven to be the most effective way for students to interact during the learning process. CL is most effective when students are able to express their ideas and opinions, engage in a dialogue and challenge one another to think critically, and work together on a given issue. The performance of undergraduate students is significantly improved when they interact with their peers (Chen, 2011). CL can improve soft skills among students when it is incorporated into their courses (Ballantine & Larres, 2007).

1.2. Model and type of interaction

Interactions within a learning environment occur between learners and the content, between students and educators, and between students and each other. Moore (1989) provided the first systematic study of interaction in the learning environment. According to Moore, the subject of a study is the content. Therefore, enhancing student understanding and perspectives on learning through learning-content interaction is essential. To motivate students to engage with content, it is important to develop a variety of engaging activities (Ali et al., 2011). The educator should design content and assessment that can produce learning activities to increase interaction (Zimmerman, 2012), which contributes to successful learning outcomes and course completion (Shea & Bidjerano, 2014). Also, in learner-educator interactions, students seek expert guidance from educators who are well experienced in the content, and instructors act as facilitators who encourage and assist students. The interaction between educators and students can reinforce students' understanding of course materials, which, combined with timely and frequent feedback from students, contributes to the enhancement of learning (Kyei-blankson et al., 2019). The term "learner-learner interaction" refers to any interaction between two or more students, regardless of whether or not the educator is present, in order to achieve an educational goal or to develop social relationships (Rossi et al., 2013). Learners who interact with one another in online environments tend to broaden and deepen their learning experiences, as well as increase their satisfaction (Sher, 2009) and academic performance (Al-rahmi & Othman, 2015). This assists students with understanding learning content and constructing new knowledge by integrating existing knowledge (Frisen & Kuskis, 2013). In turn, this improves productivity, satisfaction, problem-solving, and critical thinking skills. Learner–learner interaction can be encouraged through collaborative learning structure activities, and educators should provide guidelines that facilitate these interactions (Fear & Erikson-Brown, 2014).

Over time, Garrison and Anderson (2003) added three new components to Moore's interaction model (of student-content, student-educator, student-student). These were: educator-content, content-content and educator-educator interaction. The purpose of educator-educator interaction is to enhance student learning understanding by interacting between educators to create better content and activities. A teacher uses technology to create and use content. This type of interaction is known as "educator-content interaction." Interaction between content and content is common in digital networks, where content itself is used to create and update other content. In a meta-analysis of 74 previous studies by Bernard et al. (2009), it was noted that at least one of three types of Moore's interaction has been studied. Learner-learner, learner-educator, and learner-content interactions are often discussed in the literature. According to the literature on online learning, either educator-learner or student-student interaction is critical for increasing motivation and engagement (Song et al., 2016). Some studies have exhibited a higher prevalence of learner–educator interaction (Jaggars & Xu, 2016). In contrast to this, the Bernard et al. (2009) study found that learner–learner interaction was dominant. Nonetheless, this study integrated the

collaboration theory, where learners are responsible for their learning with the instructor's aid. Thus, it is essential to emphasise learner-to-learner interaction as well as learner-to-instructor interaction.

1.3. Collaborative learning challenges

There is also evidence to suggest that CL is not always adequately implemented in classroom practice. Educators form heterogeneous and homogeneous groups of students based on ability and gender, but those groups don't necessarily lead to effective collaborations (Baker & Clark, 2010). Research shows that students face a variety of obstacles when engaging in CL, including unequal participation for each student in group tasks (Freeman & Greenacre, 2011) and ineffective communication and collaboration. It can be challenging for educators to design collaborative activities, including creating tasks for groups, composing groups, and scheduling time for classes, as well as strengthening and monitoring collaborative activities (Van Leeuwen, et al., 2013). Ha Le, et al. (2018) examined teachers' and students' perspectives on obstacles and antecedents to its effectiveness. The authors identified four main obstacles to CL effectiveness: a lack of collaboration skills, free riding, a low status of competence, and friendship between participants. Researchers have shown that lack of interpersonal and teamwork skills can hinder group interaction, as well as inhibit individual and CL (Shimazoe & Aldrich, 2010). Students who are not skilled at collaborating can't fully contribute to the project. Students indicated that, when working on group assignments, some colleagues put in more effort than others, and some hardly put effort in at all. According to the study, free-riding had a negative impact on students' learning behaviours, for instance, high-contributing members did not devote time to helping others learn. Competence status is found to suppress collective learning by constraining low-status students' participation and overlooking their efforts, whereas high-status members have an increased potential to contribute and are less likely to ignore low-status members' efforts (Bunderson and Reagans, 2011). Finally, friends tend to socialise more than be able to focus on group activities, which may interfere with the function of friendship groups (Janssen, et al., 2009). It has become clear that teaching group-learning requires very different methods, and has many advantages compared to educator-centred one-to-one tutorials. It enables students to develop the interpersonal, professional, and cognitive skills required to filter and synthesise relevant information more efficiently. Introducing a more collaborative student-centred design forum allows students to learn alongside peers rather than in a competitive or individualistic manner. When the student-centred learning model is integrated throughout the teaching process, it can be applied to project design. According to Brooks and Ammons (2010), students prefer continuous assessment over evaluation made mainly by a single assessor. In addition, they believe continuous assessment tasks, with timely feedback, promote critical thinking in the evaluation of design solutions. Instead of educator-centered learning, student-centered learning promotes deeper learning by motivating students, enabling them to reflect on previous experiences and knowledge, encouraging active participation, and facilitating their participation in class (Entwistle, 1992). However, the implementation of CL methods in teaching and learning has resulted in many graduates still not having the soft skills employers need. Cooperative groups tend to have difficulty establishing and maintaining success because other members do not participate actively in their work (Chiong & Jovanovic, 2012). Collaboration in a group does not occur naturally. It is not possible for educators to assume that each member of a group contributes equally to the group work and, therefore, give all members equal marks. Thus, educators should award marks based on individual contributions to motivate students to actively participate in group projects (Swan, Shen, & Hiltz, 2006). Educators in these studies will need online learning tools to record and monitor their

discussions and to assess the contributions they make to their group tasks. This paper aims to provide an online learning management system to facilitate CL.

1.4. Digital skills

Digital technologies, such as online collaboration platforms and mobile devices, are an everyday part of many workplaces (Cascio & Montealegre, 2016). As a result of this digital shift, the skills that are needed in the modern job market are changing. In today's global economy, digital technologies are driving innovation, growth, and job creation. A framework for digital competence, "Digital Competence 2.0", was published by the European Commission. There are five key competence areas in which digital competence is classified: Information and data literacy with a focus on communicating and collaborating, digital content creation with a focus on security, information and problem solving. As of version 2.0 (Vuorikari et al., 2016), the proficiency framework has been revised to identify eight proficiency levels rather than three. This revision provided a detailed description of each level's characteristics (knowledge, skills, and attitudes). There are three main dimensions that are distinguished, namely: (1) a technological dimension that emphasises both problem-solving ability as well as the ability to provide flexible solutions in response to changing technological environments; (2) a cognitive dimension that focuses on reading, selecting, interpreting, evaluating, and presenting information; (3) in the use of technology, there is a moral dimension based on accountability. CL is a widely used concept with potential value in education. CL can promote and facilitate interaction through technology and instructional activities. Educators can use technology to monitor the teaching process and assess student activities in order to make sure learning occurs. Educators should provide an online platform that facilitates collaborative learning that is easy to use, flexible, and accessible. The selection of an online learning platform that fosters collaboration and communication is essential (Abrami et al., 2012). Collaborative online project-based learning (COPBL) has been proposed to be combined with a learning management system and a project-based approach, in order to boost student interaction and soft skills. The paper will describe how the online learning environment and learning design were developed and how they can be used to increase student interaction. Soft and digital skills have become requirements in the labour market in the 21st century, and it is imperative to implement the COPBL to provide them with these skills.

2. Research goal

'Digital generation' students are becoming more computer literate, thus making traditional learning environments more technologically integrated. The use of technology can also be used for collaboration, communication, measurement of learning activities, sharing resources, and creating high-quality instructional materials (Che Ku et al., 2015). The next generation of engineers who possess employability skills and digital skills will be in high demand. To prepare our engineering students for the challenges of globalisation and to stay current with industry requirements, we need to prepare them to be digitally literate now more than ever. Students can use COPBL to develop digital and employability soft skills like collaboration, critical thinking, innovation, teamwork, communication, problem-solving, and creativity, which are highly valued in today's evolving job market. The need to convert traditional design projects into a virtual collaborative form is urgent and timely. This study proposes to establish best teaching and learning practices, design, and develop a COPBL framework, thus enhancing the university's reputation as a place that produces "industry-ready" graduates.

2.1. Research methodology/materials

This research begins with the rational and concept of the CL and then describes the benefits of learning this strategy. A review of literature from previous studies, including reports,

conference proceedings, and journals, identifies key CL challenges. The research objectives and conceptual framework served as the foundation for the research design. In this study, the variables were supervisors' readiness and students' soft and digital skills. This research study's population included students, academic supervisors, and school expertise (i.e., during the design phase). The first population consisted of final-year students who had completed the group project module in engineering. The second population consisted of supervisors of the group project module. The sample size selection was based on the criteria established by Krejcie and Morgan (1970). A sample size of 155 respondents would represent a population of 260, according to Krejcie and Morgan. Twenty-three supervisors agreed to take part in the study. The current study was viewed as an opportunity to solicit feedback from project students and supervisors on the effectiveness of COPBL However, the purpose of this research was to implement COBPL framework strategy to develop an engineering teaching procedure that will improve engineering instruction. The COPBL platform provides a virtual learning environment based on the ADDIE (analysis, design, development, implementation, evaluation) model that allows students to communicate and collaborate safely while working together on real world engineering projects. Using the learning management system, educators can create groups, monitor, and record discussions, as well as assess students' performances. A mixed-methods research design was used to collect and analyse the data. This study's instrument was a pre-designed questionnaire. To collect quantitative data from students, questionnaires were used, and interviews were conducted with a sample of them to collect qualitative data. The variety of questionnaire responses was used to select the interview sample. A number of school staff with expertise in curriculum and instruction learning design were given the questionnaire in its initial form so they could express their observations and suggestions regarding the tool's suitability for achieving the goal it was intended to achieve, the validity of the content, the sufficiency of the content, the integrity and accuracy of the phrases, and their clarity. To create the final version of the questionnaire, changes were made after considering the referees' feedback. As a result, construct validity was used to validate the instrument's validity. The questionnaires were distributed during the design and implementation of the COPBL, and students were given ample time to complete them. The questionnaire used a five-point Likert scale (Strongly Agree, Agree, Cannot decide, Disagree, Strongly Disagree). It was designed to measure various dimensions, and the mean scores of each variable were interpreted in accordance with the range of scales. The questionnaire was created to gather responses from students and supervisors regarding supervisor readiness and students' soft and digital skills during COPBL implementation and evaluation in order to support a proposal framework for the school strategy. The interview consists of a series of preliminary questions designed to identify the students' data, teaching methods, and questions focusing on the participants' knowledge of COPBL and the differences between COPBL and traditional project styles. Finally, questions were posed to identify the role of students and educators while using COPBL, the most important benefits of the COPBL strategy, and the most significant challenges to learning application within that strategy. These interview questions were presented to a group of curriculum and instruction experts. The wording was changed based on the opinions of the referees.

2.2. COPBL development

Educators can improve teaching and learning processes by using active learning (Lima et al., 2017) and project-based learning (Mills and Treagust, 2003). CL is a method of learning that leads to Vygotsky's theory of constructivism (Vygotsky, 1978) and is widely used today (Ashton Hay, 2006). Technology is recognised as a key enabler of student learning outcomes. However, flexible instructional design practices are essential to getting the greatest benefit from technology. The ADDIE model is typically used by instructional designers (Morrison,

2010). It facilitates the development of interactive learning and training activities by creating a flexible support tool for the educational designers. It stands for the five stages of the teaching process: analysis, design, development, implementation, and evaluation. As an alternative to traditional curriculum development, Branson, (1978) employed ADDIE to create instructional systems across the U.S. military branches. As well as being helpful and practical, the ADDIE model has been adapted and applied to teaching design (Tzu-Chuan, 2014). The rapid prototyping has been one improvement made to this model (Ahmad, 2013). During the process of creating materials, it provides constructive feedback and continuous assessment. The ADDIE model was designed and developed in the framework of COPBL as shown in Figure 1.

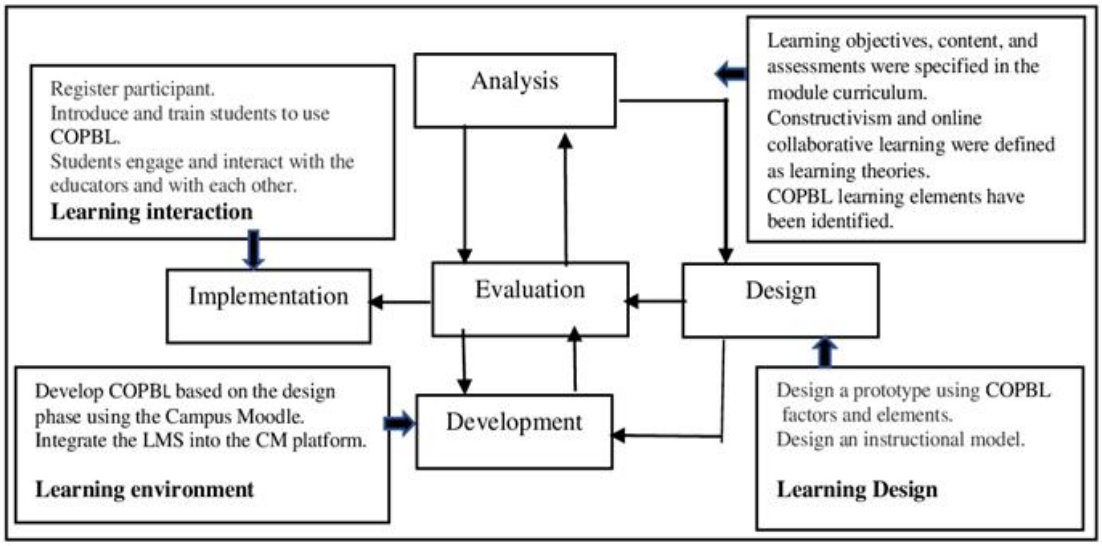

Figure 1 COPBL development model framework (modified after Morrison, 2010)

As part of the design process, ADDIE requires continuous revisions and reviews. Incorporating feedback continuously into instruction is made possible by this structure. The first phase of the ADDIE model is the analysis phase, during which the learning theory is defined. This study employed two theoretical approaches, constructivism, and online CL. The analysis phase is the phase of teaching design that involves analysing objectives, contents, requirements, resources, and tools. By analysing teaching materials, we can develop project-based activities based on the contents of the teaching design, align with industry practice, students' needs and ultimately, produce excellent results, integrated collaborative tasks and assignments. They learn to solve problems and work with others in a collaborative manner (collaborative assignments) by listening to their peers' insights. The structure of the teaching project module facilitates the interaction and organisation of the project's various stages based on the study of the content, the teaching methods, processes, and the schedule. In this phase, the factors and elements that determine effective online CL have also been determined. These factors include learning environment and technology, learning design, and learning interaction. As a result, learning outcomes, resources, and learning assessment need to be made in line with the module curriculum. The continuous feedback that students received during project development, both from their peers and from their educators (Olivo, 2012), was essential in developing thoughtful communicators. The feedback points should help students reflect upon what they might face in their real work while providing an opportunity for revision (Hall, 2014). Using these best practices, students can become more motivated and engaged in project work, interact with each other, and learn from their educators. In Table 1, the phases of project proposal and execution are shown. Students face several issues

during group project work (Alden, 2011), and educators are crucial in developing fair assessment mechanisms that accurately measure students' performance in group situations. Educators helped groups establish norms and establish expectations by clarifying the roles and expectations of project assignments (Oliveira, et al., 2011). The educators developed trusting relationships with their students, they provided individual opportunities to engage and motivate their students; (Beffa-Negrini, et al., 2002), and they created a sense of community in the online environment. CL project work offered educators diverse ways to increase student engagement. A central focus of the collaborative project learning was the role of educators. Students are divided into cooperative groups and the project specification is prepared. A time plan for implementation is also created. Sample projects should be provided to illustrate the scope of expectations, virtual drop-in sessions should be facilitated, and personal and group communication should be promoted. The project specification should be detailed, and a project guide handbook should be provided. A survey should also be given to students in which they can reflect on their experience and address any
concerns that may be raised. The development phase involves developing training modules and activities using modern information and training platforms in order to promote project results.

Table 1. COBPL strategy: project proposal phase and execution phase framework

Responsibilities	Activity
Projects Coordinator	Conducts project seminar for the students and supervisors. Introducing COBPL and providing early exposure to project-based learning.
Administrator	Enrolls students in the COBPL project module in CampusMoodle
Students	Project proposal: sources suitable project and submits a project proposal complete with Gantt Chart.
Project Moderation Panel	Examines the project proposal and either (1) approves it and assigns an academic supervisor to it, or (2) provides feedback and confirms the resubmission date. The project goal is formulated, and a time plan is drawn up for implementation, with the students divided into cooperative groups.
Students	Project design and development: students start work on the project when the proposal has been approved. Each group begins designing their project.
Students	Using campusMoodle forums for discussions: students in each group confer with each other to solve the obstacles and difficulties they face online. The educators' role at this stage is to guide them.
Students	Keeps in regular contact with the academic supervisor while keeping a diary of work. The students are responsible for managing their project.
Supervisors	COBPL progress and monitoring. Supervision: developing supervisory skills, improving supervisor communication skills, and changing students' negative attitudes. Collaboration: fostering interpersonal skills in both students and educators, as well as improving teamwork and collaboration among students. Communication: improving communication skills in students and supervisors. Creative thinking and problem solving.: since the first semester, educators have encouraged students' creativity and problem-solving abilities by regularly holding brainstorming sessions.
Students/supervisors	Submits projects and presents projects to an assessment panel. The panel grades their vivas and projects. Validates the grades.
Projects Coordinator	COBPL evaluating

In recent decades, it has become common place for educational institutions to use learning management systems, such as Moodle and Aula, to organise their teaching materials and instructional activities within a single environment (Carlos et al., 2013; Coates et al., 2005). Taking into consideration student and educator preferences, Campus Moodle learning data

was gathered. An assessment was conducted with subject-matter experts as a formative evaluation to ensure that analysis data and module curriculum are aligned. In fact, university Campus Moodle provides both educators and students with tools and resources that facilitate the process of managing both their teaching and learning. A campus Moodle feature, such as discussion forums, helps facilitate communication and collaboration among students and allows them to use external applications in addition to those that are built into the system. In this context, the COPBL instructional design (during the design phase) supported the CL subject approach. Based on Ellis and Hafner (2009), the educational design was modified to support the analysis phase's data. Feedback was gathered once more from subject-matter experts and online system designers (if needed) in formative evaluations and redesigns (if required) to ensure that data validity was in conformity with researchers' interpretations. Students were able to engage and interact with each other and with the educators as they worked with the project content by using the designed system. Following the completion of the design phase, a draft COPBL architecture was developed and integrated into the university Campus Moodle. COPBL implementation, its support, the teaching team's collaboration, hardware facilities, and the environment for teaching were addressed in this phase. After the prototype had been completed and implemented, staff and students were provided with a formative evaluation form so final revisions could be made to the COPBL management system supported by user feedback. After designing and developing a prototype, it was implemented and evaluated. As part of the evaluation stage, formative evaluation is conducted in order to make improvements to the COPBL management system, and summary evaluation documents learning satisfaction and outcomes. COPBL is improved through evaluation and insufficient content is revised through evaluation. Also, it involves the standardisation and value assessment of teaching modules. Teaching designers use the ADDIE teaching model as a systematic tool for ensuring the quality of results from teaching design projects. Through the ADDIE model, learning activities have been effectively constructed, while at the same time, it has provided a consistent flexible structure for the design of teaching in higher education (Fang et al., 2011).

3. Results and Findings

An evaluation was conducted to ensure that the prototype functioned as planned and that the expectations of users aligned with the curriculum (Sefton-Green et al., 2009). This feedback was needed to ensure that a real study can be conducted with the prototype. Analysis revealed that 90% of students engaged in group discussion to reach a decision, and 85% of students shared information about the topic with their peers. Students engaged in teamwork within their learning community as they worked through the collaborative online project-based content. They were active and motivated in group meetings and used workbooks to plan and record activities. As a result, they were able to better understand the ideas, objectives, or resources involved in the projects, as well as improve their ability to listen to and respect the ideas of others. Students believed that when they communicated and participated in group activities, they learned more. According to the findings, 85% of students contributed ideas and participated in group problem solving, 95% of students stated that they used technology, specifically the internet, to complete their group task, 90% of students agreed that collaborative learning was more effective and better than individual work, and that they understood the subject better and learned things of significant value. Additionally, encouraging social contact through discussion forums, emails, and meetings, give students more chances to interact with colleagues while working on project tasks. Students were only graded on their own work based on the best practices for collaborative work. Each team member completed a component of the task and submitted it to the group for review. Each group member commented on the pieces of work done by the other members, or the members

combined their efforts to complete the assignment. To develop the content for their final project assignments, students attended peer feedback workshops. The students were matched up with randomly chosen peers with whom they exchanged constructive feedback on a draft of a part of the final project. Students were asked to discuss the project content from a variety of perspectives, solve problems in different ways, and develop their own views on key module ideas through this collaborative task. Educators then provided comments on a draft of the students' final project, and the students reflected on their learning experiences. Throughout the project module, educators utilised formative and summative assessments. Formative, or in-process assessments were used to measure learners' engagement with project concepts and ensure that learning objectives were met. For instance, educators assigned students to small groups, and they found after the first objective that some of the concepts that were to be integrated into subsequent tasks were not yet understood by the students. A workshop was conducted by educators to clarify the knowledge gap following the review of all performance data and the identification of points of confusion. During the project wrap-up, the objectives focused on the specific concepts that students had difficulty with, and the objectives were integrated into subsequent project goals. Educators engaged in regular communication with students as a form of formative evaluation as well. In order to gain insight into how the project was progressing, they sent personal emails to all students, regardless of performance. By engaging students in this manner, educators could identify areas where they could better meet learners' needs. The educators created and distributed a mid-project evaluation questionnaire to measure student engagement within the group project. In the reflection exercise, students were asked to reflect on what helped them learn, as well as what topics, concepts, or module structures hindered them. Participants of the group project task seemed to feel more connected, and students commented on how well the group task was received. A final project assignment was used for summative evaluation. Educators gained insight into students' engagement with the project concepts as they reviewed their final projects. Feedback from students and supervisors also led to smaller instructional changes during the development process. In the methodology, the Likert scale is used to create a questionnaire that can produce comprehensive and clear results. This can be helpful to students when they are completing a self-assessment (Table 2). The questions were grouped according to their connection to the soft skills dimensions and how they relate to the Framework for Digital Competence, which are related to the specifics of the COPBL used. The management learning system allows educators to create groups, communicate, facilitate, monitor, and evaluate students' progress, as well as assess their performance. The findings showed that the COPBL strategy improved learning efficiency, student academic comprehension and achievement, as well as increased self-growth (for instance, confidence, self-esteem, and responsibility), increased participation in learning, and students' development of empathy for others. This outcome is due to the fact that this strategy combines the benefits of both traditional and e-learning (digital technology). As we are all aware, technology has evolved into the new language of the age, making it easier for learners to access the information they require. As a result, students enjoy using educational technologies in the university's modern learning environments and feel proud in communicating and interacting with others through a variety of media, including university e-mail, a simulators database, discussion forums, written interaction, and others. Additionally, the face-to-face instruction in the lectures encourages interaction between students and educators. Moreover, COPBL places a high priority on user feedback and social interaction. The students acknowledged that through the COBPL process, they were able to apply their academic knowledge to the project-related tasks, learn more advanced material through practical performance, and improve soft skills.

Table 2. Students' and project supervisors' interpretations of the supervisor's readiness

Items	Students perspectives		Supervisors perspectives	
	Mean	Interpretation	Mean	Interpretation
1. The project module is organised and managed well,	4.50	Strongly Agree	4.70	Strongly Agree
2. Effective supervision has been provided to me by my supervisor.	4.10	Agree	4.40	Strongly Agree
3. I find the module resources are helpful to my learning.	4.0	Agree	4.50	Strongly Agree
4. The module content is intellectually stimulating and delivered effectively.	4.50	Strongly Agree	4.60	Strongly Agree
5. As problems arise during the project, students consult the supervisor.	4.0	Agree	4.50	Strongly Agree
6. I have established with my supervisor the project's objectives to be achieved.	4.50	Strongly Agree	4.60	Strongly Agree
7. Students' problem-solving skills have improved through COBPL.	4.80	Strongly Agree	4.80	Strongly Agree
8. I manage the information that we collect during our project with my team.	4.10	Agree	4.10	Agree
9. The assessment requirements and criteria are clear and easy to understand.	4.50	Strongly Agree	4.60	Strongly Agree
10. I am being given useful feedback and advice on how to improve throughout the project.	4.50	Strongly Agree	4.80	Strongly Agree
11. My supervisor has the relevant technical expertise for my project.	4.0	Agree	4.50	Strongly Agree
12. I feel involved and engaged in my learning on this module.	4.50	Strongly Agree	4.80	Strongly Agree

A Likert scale was presented to students in order to allow them to choose their preference in the questions constructed according to the information provided as shown in Tables 3 and 4. Among the top soft skills, improving critical and creative thinking received the highest mean score, followed by verbal communication improvement, time management improvement, interpersonal communication improvement, learning to give and receive constructive criticism, skill development in listening, ability to think creatively and effectively communicate in a visual format, improvement in decision-making and analytical skills, and development of responsibility and accountability, developing multi-tasking skills; understanding problem-solving process; developing ethical values (e.g., integrity, honesty, responsibility, self-discipline), and increasing adaptability to new technologies and terminologies. As students work towards common learning goals in a COPBL environment, knowledge is shared or transmitted between them, such as an understanding of a subject as a whole or a solution to a problem. During their process of knowledge acquisition, students are not passive receptacles, but active participants, searching for information and exchanging ideas with their peers. Due to their mutual dependence on each other for knowledge construction, the learning process produces a bond between and among learners. Consequently, CL provides students with an effective way to develop higher-level thinking skills as well as retrieve deeper levels of understanding through shared exploration, goals, and a shared process of meaning-making. COPBL outcomes are typically measured by

student achievement. This is demonstrated by four measures, including student grades and graduate results, student satisfaction, and knowledge and skill gains measured by student design projects. The students' work in COPBL clearly creates a positive CL environment because it is measurable, adds value, and is positive. A formal and online Likert scale questionnaire was developed to collect input from users to further improve the designed system. One of the drawbacks was the absence of real-life case studies for students. Implementing industry projects-based and interactive industry practice videos has enabled us to overcome this challenge. It allows students to experience a real-world task which is incredibly realistic while still maintaining all the advantages of a COPBL. A number of workshops have been conducted to address the concern over case study practice (Wang and Guo, 2015). Educators and students respond positively to the questions with comments related to the inclusion of resources related to industry practice. A COPBL template has been designed to include these features. According to student feedback, COPBL offers flexible access and multiple feedback from peers and educators, which creates positive interactive learning experiences, builds trusting relationships, builds critical thinking, and helps students perform better as well as develop necessary skills for higher education. Additionally, the engineering simulators application is not accessible through the Campus Moodle learning platform. Thus, the platform has been designed to enable users who have never used MyApps before to access the instructions page by integrating it into the platform. Students' engagement in the process of engineering is enhanced by a standard interface that displays icons that convey key information and engage them in the process of engineering. It includes theories, resources, risk assessment, simulations, assignments, animated demonstrations, and self-assessment. They found COPBL to be an interactive, collaborative environment that prevents students from becoming passive listeners. In its place, it encourages students to engage in group activities and participate in CL experiences so they can develop skills that make them active participants in the learning process. Individually and collectively, students perform group project tasks, collect, and analyse data, and respond to questions to assess their understanding and knowledge.

Table 3. COPBL soft skills – Self Assessment

Soft Skills	Statement Group	Mean	Interpretation
1. Information processing	COPBL helped me share information with colleagues. Group discussion is required before a decision is made.	4.0	Agree
2. Problem solving	COPBL helped me solve specific problems. Participate in a collaborative problem-solving process. Enhance the ability to think creatively. Learn to apply discipline knowledge.	4.80	Strongly Agree
3. Communication	COPBL provided me with communication tools with colleagues and educators. Communication and interaction with others, individually and in groups, as well as developing interpersonal skills. Supervisors has the appropriate technical knowledge with regard to project and supervised effectively.	4.70	Strongly Agree
4. Collaboration	Participate in group meetings and build teamwork skills. Group activities benefit the group and oneself. When you learn in a group, you learn more.	4.60	Strongly Agree
5. Content creation	The COPBL facilitated and helped me with creating digital products. Enhance time management skills. Learn to give and receive constructive feedback.	4.50	Strongly Agree

The students found the work in the COPBL stimulating, they were exposed to different digital technologies and able to apply personal knowledge to complete tasks. The students said they would benefit from COPBL ability to provide different communication tools and exchange experience to help them to better solve problems in a digital environment. COPBL is an effective, flexible, and user-friendly learning environment that supports the course material. A summary of the survey and the relation between specific tasks in the virtual project-based and the enhancement of digital skills is detailed in Table 4.

Table 4. COPBL digital skills

Project-based activity	Digital skill	Mean	Interpretation
1. Search the internet for specific information using online manuals, video tutorials, and technology.	Information processing	4.0	Agree
2. Use of simulator tools and application of personal knowledge.	Problem solving	4.80	Strongly Agreed
3. Collaboration using different communication tools.	Communication	4.5	Strongly Agreed
4. Creating operational measurement, control, and monitoring products.	Content creation	4.50	Strongly Agreed
5. Remote access to online environments is enabled.	Security	4.0	Agree
6. Information is synthesised into a report.	Content creation	4.50	Strongly Agreed

4. Conclusions

In order to meet industry requirements and be competitive in the face of the problems brought on by globalisation, engineers must possess both soft and digital abilities workplaces (Cascio & Montealegre, 2016). The COBPL virtual learning management solution was designed and developed by the authors using the ADDIE instructional design approach in this case study. The goal of this design approach was to create an engaging, flexible learning environment where students could interact creatively with the project's subject matter, other students, and educators (Fang et al., 2011). Additionally, the COBPL approach enables educators to organise groups, encourage communication among them, monitor their development, and evaluate students' performance (Zimmerman, 2012). A mixed-methods study methodology was used to collect and analyse the data. Quantitative analysis supported qualitative analysis, as qualitative analysis revealed a number of positive aspects of the COPBL strategy, including fostering positive interactions between students, improving student understanding of the project tasks, and increasing a student's ability to plan activities and develop electronic activities, which aid in the production of digital teaching aids in evaluation, as well as aiding in the development of electronic classrooms in engineering. This result implies that students learned more real values and contributed to the teaching strategy by using COBPL to better comprehend the subject. The collaborative learning strategy demonstrates the need for both student and educator creativity in the information transmission process. In addition to raising academic accomplishment, it also cultivates and enhances students' market skills. The strategic finding from the present study is that COPBL gives students the opportunity to apply their knowledge of the subject matter to the provided activities, which upgrades their experience and improves their knowledge (Frisen & Kuskis, 2013). It was found that by using COBPL, students performed significantly better (Al-rahmi & Othman, 2015) and developed digital skills and a set of soft skills (including communication, collaboration, critical thinking,

problem-solving, time management, and creative skills) that complement hard skills in the evolving job market (Arnold-Smeets, 2015) and increase students' chances of finding employment. The results also imply that it will be beneficial for the engineering school at Robert Gordon University to adopt a more student-centered approach to teaching and learning, including project-based learning, emphasising group work, and technological advancement embedded in projects.

Acknowledgements: The authors are grateful for the support of Robert Gordon University, UK.
Funding: No funding source is reported for this study.
Declaration of interest: No conflict of interest is declared by the authors.
Author Contributions: All authors have sufficiently contributed to the study and agreed with the results and conclusions. MA conceptualization, methodology, formal analysis, investigation, writing—original draft preparation; SJ writing, review, and editing.

References

1. Abrami, P.C., Bernard, R.M., Bures, E.M., Borokhovski, E. and Tamim, R.M., (2012). Interaction in distance education and online learning: Using evidence and theory to improve practice. Journal of The Next Generation of Distance Education, pp 49-69. Google Scholar
2. Adams, S. (2014). The 10 skills employers most want in 2015 graduates. Forbes. Google Scholar
3. Ahmad, Y. (2013). Instructional Design and Motivation in Computer-Based Learning Environment. IOSR Journal of Computer Engineering (IOSRJCE), 8(3), 9–12. Google Scholar
4. Alden, J. (2011). Assessment of individual student performance in online team projects. Journal of Asynchronous Learning Networks, 15(3), 5-20. Google Scholar
5. Ali, A., Ramay, M.I. and Shahzad, M. (2011). Key factors for determining student satisfaction in distance learning courses: A study of Allama Iqbal Open University (AIOU) Islamabad, Pakistan. Turkish Online Journal of Distance Education, 12 (2), pp.114–127. Google Scholar
6. Al-rahmi, W. and Othman, M. (2013). The impact of social media use on academic performance among university students: A pilot study. Journal of Information Systems, 4, pp.1–10. Google Scholar
7. Arnold-Smeets, L. (2015). 5 hard and soft skills that will get you hired. PayScale. Google Scholar
8. Ashton-Hay, S. (2006). Constructivism and powerful learning environments: create your own! 9th International English Language Teaching Convention. Google Scholar
9. Baker, T., & Clark, J. (2010). Cooperative learning – a double-edged sword: A cooperative learning model for use with diverse student groups. Intercultural Education, 21, 257–268. Google Scholar
10. Ballantine, J. & Larres, P.M. (2007). Cooperative Learning: Pedagogy to Improve Students Generic Skills? Journal of Education and Training, 49, 126-137. Google Scholar

11. Beffa-Negrini, P. A., Cohen, N. L., & Miller, B. (2002). Strategies to motivate students in online learning environments. Journal of Nutrition Education and Behavior, 34(6), 334-340. Google Scholar
12. Bernard, R.M., Abrami, P.C., Borokhovski, E., Wade, C.A., Tamim, R.M., Surkes, M.A. and Bethel, E.C. (2009). A meta-analysis of three types of interaction treatments in distance education. Review of Educational Research, 79(3), pp.1243–1289. Google Scholar
13. Biggs, J. & Tang. C. (2011). Teaching for quality learning at University, SRHE & Open University Press, ISBN 0-335-20171-7. Google Scholar
14. Branson, R.K. (1978). The interservice procedures for instructional systems development. Educ. Technol. 3, 11–14. Google Scholar
15. Brooks, C. M. & Ammons, J. L. (2010). Free Riding in Group Projects and the Effects of Timing, Frequency, and Specificity of Criteria in Peer Assessments. Journal of Education for Business. 78 (5), 268-272. Google Scholar
16. Bunderson, S., & Reagans, E. (2011). Power, status, and learning in organizations. Organization Science, 22, 1182–1194. Google Scholar
17. Carlos, A.-H., Miguel L., B.-L., Eduardo, G.-S., Juan I., A.-P., Guillermo, E.-G., and Adolfo, R.-C. (2013). Enhancing Learning Environments by Integrating External Applications. Bulletin of the IEEE Technical Committee on Learning Technology, 15(1), 21–24. Google Scholar
18. Cascio WF, and Montealegre R. (2016). How technology is changing work and organizations. Annual Review of Organizational Psychology and Organizational Behavior; 3:349–375. Google Scholar
19. Chanpet, P., Chomsuwan, K., & Murphy, E. (2020). Online project-based learning and formative assessment. Technology, Knowledge and Learning, 25(3), 685-705. Google Scholar
20. Che Ku Nuraini, C. K. M., Faaizah, S., & Naim, C. P. (2014). Personalized Learning Environment (PLE) Experience in the 21st Century. 4th World Congress on Information and Communication Technology. Google Scholar
21. Chen, Y. (2011). Learning styles and adopting Facebook technology. Technology Management in the Energy Smart World (PICMET) (pp. 1–9). Google Scholar
22. Chiong, R., & Jovanovic, J. (2012). Collaborative Learning in Online Study Groups: An Evolutionary Game Theory Perspective. Journal of Information Technology Education: ..., 11, 81–101. Google Scholar
23. Coates, H., James, R. and Baldwin, G. (2005). A critical examination of the effects of learning management systems on university teaching and learning. Tertiary Education and Management, 11(1):19-36, 2005., 11(1), 19–36. Google Scholar
24. Ellis, T. J., and Hafner, W. (2009). Building a framework to support project-based collaborative learning experiences in an asynchronous learning network. Interdisciplinary Journal of E-Learning and Learning Objects, 4(1), 167–190. Google Scholar
25. Entwistle, N., Thompson, S., and Tait, H. (1992). Guidelines for Promoting Effective Learning in Higher Education, Centre for Research on Learning and Instruction, Edinburgh: University of Edinburgh. Google Scholar
26. Fang, M.J.; Zheng, X.X.; Hu, W.Q.; Shen, Y. (2011). On the ADDIE-based effective instructional design for higher education classrooms. Adv. Mater. Res. 271–273, 1542–1547. Google Scholar
27. Fear, W.J. and Erikson-Brown, A. (2014). Good quality discussion is necessary but not sufficient in asynchronous tuition: A brief narrative review of the literature. Journal of Asynchronous Learning Network, 18(2), pp.1–8. Google Scholar

28. Freeman, L., & Greenacre, L. (2011). An examination of socially destructive behaviors in group work. Journal of Marketing Education, 33, 5–17. Google Scholar
29. Frisen, N. and Kuskis, A. (2013). Modes of interaction. in Handbook of Distance Education, edited by M. G. Moore, 3rd edn., New York, Routledge, pp.351–371. Google Scholar
30. Garrison, D.R. and Cleveland-Innes, M. (2005). Facilitating cognitive presence in online learning: Interaction is not enough. American Journal of Distance Education, 19(3), pp.133–148. Google Scholar
31. Ha Le, Jeroen Janssen, and Theo Wubbels (2018). Collaborative learning practices: teacher and student perceived obstacles to effective student collaboration. Google Scholar
32. James, R.F., & James, M.L. (2004). Teaching career and technical skills in a "mini" business world. Business Education Forum, 59(2), 39-4. Google Scholar
33. Janssen, J., Erkens, G., Kirschner, A., & Kanselaar, G. (2009). Influence of group member familiarity on online collaborative learning. Computers in Human Behavior, 25, 161–170. Google Scholar
34. Johnson, D., & Johnson, R., & Holubec, E. (1993). Cooperation in the classroom 6th ed. Edina, MN: Interaction Book Company. Google Scholar
35. Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research aactivities. Educational and Psychological Measurement, 30(3), 607–610. Google Scholar
36. Kyei-blankson, L., Ntuli, E. and Donnelly, H. (2019). Establishing the importance of interaction and presence to student learning in online environments. Journal of Interactive Learning Research Volume 30, Number 4. Google Scholar
37. Learning Using ADDIE Model. Procedia-Soc. Behav. Sci.195, 1803–1812. Google Scholar
38. Lima, M., Andersson, H., and Saalman, E. (2017). Active learning in engineering education: a (re)introduction. Eur. J. Eng. Educ. 42 (1), 1–4. Google Scholar
39. Lin, J., & Tsai, C. (2016). The impact of an online project-based learning environment with group awareness support on students with different self-regulation levels: An extended-period experiment. Computers & Education, 99, 28-38. Google Scholar
40. Mills, J., Treagust, D. (2003). Engineering education - is problem-based or project- based learning the answer? Australasian Journal of Engineering Education. Google Scholar
41. Moore, M.G. (1989). Three types of interaction. The American Journal of Distance Education, 3(2), pp.1–6. Google Scholar
42. Morrison, G. R. (2010). Designing Effective Instruction (6th Edition.). John Wiley & Sons.
Google Scholar
43. Ning, B. (2010). Applying project-based learning to product design teaching. International Conference on System Science, Engineering Design and Manufacturing Informatization. Google Scholar
44. Olivo, R. F. (2012). Collaborative online writing assignments to foster active learning. Journal of Undergraduate Neuroscience Education, 11(1), A82-A89. Google Scholar
45. Oliveira, I., Tinoca, L., & Pereira, A. (2011). Online group work patterns: How to promote a successful collaboration. Computers & Education, 57(1), 1348-1357. Google Scholar
46. Ormrod, L.E. (2008). Human learning (5th eds.). Upper Saddle River, NJ: Pearson/Merrill Prentice Hall. Google Scholar
47. Rossi, D., van Rensburg, H., Beer, C., Clark, D., Danaher, P. and Harreveld, B. (2013). Learning interactions: A cross-institutional multi-disciplinary analysis of learner-learner and learner-teacher and learner-content interactions in online learning contexts. Final

Report 2012. Dehub Report Series 2013. Armidale NSW, Australia, University of New England, Dehub. Google Scholar
48. Shea, P. and Bidjerano, T. (2014). Does online learning impede degree completion? A national study of community college students. Computers and Education, 75, pp.103–111. DOI: 10.1016/j.compedu.2014.02.009. Google Scholar
49. Sher, A. (2009). Assessing the relationship of student–instructor and student–student interaction to student learning and satisfaction in Web-based online learning environment. Journal of Interactive Online Learning, 8(2), pp.102–120. Google Scholar
50. Shimazoe, J., & Aldrich, H. (2010). Group work can be gratifying: Understanding & overcoming resistance to cooperative learning. College Teaching, 58, 52–57. Google Scholar
51. Song, H., Kim, J. and Luo, W. (2016). Teacher–student relationship in online classes: A role of teacher self-disclosure. Computers in Human Behavior, 54, pp.436–443. Google Scholar
52. Swan, K., Shen, J., & Hiltz, S. (2006). Assessment and collaboration in online learning. Journal of Asynchronous Learning ..., 45–62. Google Scholar
53. Tzu-Chuan, H.; Jane, L.H.; Turton, M.A.; Su-Fen, C. (2014). Using the ADDIE model to develop online continuing education courses on caring for nurses in Taiwan. J. Contin. Educ. Nurs. 45, 124–131. Google Scholar
54. Van Leeuwen, A., Janssen, J., Erkens, G., & Brekelmans, M. (2013). Teacher interventions in a synchronous, co-located CSCL setting: Analyzing focus, means, and temporality. Computers in Human Behavior, 29, 1377–1386. Google Scholar
55. Vygotsky, L. S. (1978). Mind in Society. Cambridge (Massachusetts): Harvard University Press. Google Scholar
56. Vuorikari, R., Punie, Y., Carretero Gomez S., Van den Brande, G. (2016). DigComp 2.0: The Digital Competence Framework for Citizens. Update Phase 1: The Conceptual Reference Model (No. JRC101254). Joint Research Centre. Google Scholar
57. Wang, D., and Guo, M. (2015). A study on the effects of model-based inquiry pedagogy on students' inquiry skills in a virtual physics lab. Computers in Human Behavior vol. 49, pp. 658–669. Google Scholar
58. Alozie, M., Moje, B., & Krajcik, S. (2010). An analysis of the supports and constraints for scientific discussion in high school project-based science. Science Education, 94(3), 395-427. Google Scholar
59. White, C. (2013). The real reason new college grads can't get hired. Time. Google Scholar
60. Yu-Hui, C., & Yu-Chang, H. (2013). Peer feedback to facilitate project-based learning in an online environment. International Review of Research in Open and Distance Learning, 14(5), 259-276. Google Scholar
61. Zhu, C. (2012). Student Satisfaction, Performance, and Knowledge Construction in Online. Educational Technology & Society, 15(1), 127–136. Google Scholar
62. Zimmerman, T.D. (2012). Exploring learner to content interaction as a success factor in online courses. International Review of Research in Open and Distance Learning, 13(4), pp.1–8. Google Scholar