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Critical Factors for Enhancing Students' Collaborative Learning Experiences in a Project-based Connectivism Learning Environment

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Abstract. The advent of technology has led to a significant challenge in redesigning today's learning environment, as much technology is under-utilized in many classrooms, and educators still lack the confidence and proper theoretical frameworks to redesign their classes efficiently. The objective of this study was to design a project-based connectivism learning environment that transforms the traditional teacher-centered class environment into more student-centered learning approaches to enhance their collaborative learning experiences. Students were engaged in developing a group project and constructivism learning activities to complete their projects collaboratively. A mixed-method research design using four data collection instruments (survey, open-ended questions, interviews and online posts) was deployed on 300 participating students in a Malaysian university to investigate the critical factors for improving students' learning experiences within this learning environment. The Exploratory Factor Analysis performed yielded four factors, 1) Group Dynamics and Experiences, 2) Motivation, 3) Use of Technologies, and 4) Real-World Relevance. The findings demonstrated that students improved their collaborative skills, technology was better optimized, and Connectivism Learning effectively enhanced the student learning process. The resulting Multimedia-based Connectivism Learning Framework (MCLF) was successfully aligned with four shifts in the Malaysia Blueprint for Higher Education and may serve as a practical guideline for redesigning classrooms for 21st-century education.

Keywords: Connectivism; project-based learning; multimedia; Malaysia; online learning

1. Introduction

The 21st century has experienced the rise of globalization, the advent of the digital revolution, the new paradigm of the knowledge economy, and the emergence of the net generation. The ever-changing information and shifting realities bring a rapid growth of knowledge and the lifelong learning trend. The popularity of technologies has also stimulated innovation in learning that requires higher information literacy and digital fluency. In preparing university students for future challenges, the traditional learning approach has shifted towards the trends of learning through technologies and making connections with communities and resources. As digital technologies advance in their capacities and innovations, new possibilities in the teaching and learning context arise (Halili et al., 2021; Pelletier et al., 2022). However, it also brings challenges in optimizing the use of technology and ensuring the quality of teaching and learning to enrich students' learning experiences in university classroom contexts (Kukulska-Hulme et al., 2020; Moorhouse & Wong, 2022). Therefore, redesigning today's learning environment becomes a challenging process of exploring different ways of learning while conforming to the social requirements and students' needs. Contemporary educational approaches are moving towards blended learning. Blended learning utilizes a range of technological resources in facilitating traditional face-to-face (F2F) instruction; and flipped classroom (or inverted classroom), which engages students in learning activities (Al-Samarraie et al., 2021; Koh, 2019). These educational approaches focus on engaging students in collaborative activities, developing students' high-order thinking, and connecting all resources (Demosthenous et al., 2020; Murillo-Zamorano et al., 2019). Therefore, in the 21st-century learning context, implementing flipped classrooms, utilizing digital technologies, and fostering students' responsibility and ownership of their learning have become important components in constructing a conceptual framework (Al-Samarraie et al., 2020; Andres et al., 2017; Murillo-Zamorano et al., 2019).

Several research gaps motivated this research study. In Malaysia, the 2018 Malaysian Blueprint (Higher Education) tasked Malaysian higher education institutions with redesigning their learning spaces using 21st-century pedagogy and utilizing the latest teaching and learning technologies (Halili et al., 2021; Ministry of Higher Education Malaysia, 2015). It prescribed 10 shifts in the Blueprint, four of which were relevant to this study. These were: 1) Produce holistic, entrepreneurial and balanced graduates (Shift 1), Become a nation of lifelong learners (Shift 3), 3) Globalized online learning and transformation of educational delivery (Shift 9) and 4) Transformed higher education learning (Shift 10). However, studies have shown that the lecture model remains dominant in many Malaysian university classrooms (Halili et al., 2021; Müller & Mildenberger, 2021; Rahayu, 2019), creating a gap between the Malaysian government's call for using technology in classrooms with the actual scenarios in universities. Educators still focus on students' achievement and consider activities outside school that require collaboration as secondary to the university teaching and learning context (Brown et al., 2020; Halili et al., 2021; Ministry of Higher Education Malaysia, 2015).

There is also a research gap in the level of technology use among instructors. Studies have found that instructors' competencies and confidence in using technologies play an essential role in peer interaction and the community of support (Fuad et al., 2020; Gomez, 2020; Moorhouse & Wong, 2022; Rahayu, 2019). However, many instructors still lack confidence in creating engaging learning environments other than simply uploading their lecture notes online. This is due to ineffective pedagogical models that support and enable instructors to create such learning environments. Studies found that there remains a lack of frameworks that engage students with the experiences of 'learning how to learn', develop their digital literacy, as well as enhance their capabilities in managing resources (Fuad et al., 2020; Moorhouse & Wong, 2022; Siemens et al., 2020). Research has also shown that students remain reluctant to engage in collaborative activities in the classroom due to poorly designed learning environments. This problem is more prevalent in Malaysia, where the secondary education system still operates on an individual basis, making it challenging for students matriculating to university to be comfortable working and collaborating in groups without effort from their instructors to create opportunities for collaborative work. With the increased use of technologies among this young generation of students, it has become more critical for instructors to efficiently select and utilize technology and web resources to effectively improve the student learning process (Alkhawaja et al., 2021; Fuad et al., 2020; Moorhouse & Wong, 2022; Ministry of Higher Education Malaysia, 2015).

Recent literature highlighted that a well-designed learning space and appropriate pedagogy complement each other in stimulating students' creativity and inspiration (Brown et al., 2020; Bulow, 2022; Fuad et al., 2020). These spaces are also fertile soil for nurturing students' 21st-century skills and transforming them to be self-directed, communicative, and resourceful in the diverse 21st-century workforce (Pelletier et al., 2021). Hence, this study sought to investigate the impact of redesigning the learning environment, through a pedagogically sound learning theory and with the support of multimedia and web technologies, on the student learning process. In this study, the Connectivism Learning theory was integrated into redesigning the learning environment supported by the Internet and digital technologies.

2. Literature review

Recently, an increasing number of universities have started using social media to engage students in their learning activities and online communication (Moghavvemi et al., 2018). Studies have found that appropriate uses of digital technologies in the university learning environment can potentially stimulate interactivity with other people outside the classroom, engage students in collaborative learning, and enhance students' ability in creative content development (Cheung, 2021; Moorhouse, 2023; Müller & Mildenberger, 2021; Rahayu, 2019). With social media and Web 2.0 tools, educators can better transition to more student-centred and technology-supported learning environments. However, studies have found that today's university class environments are still mainly organized by traditional teacher-led approaches,

supported by textbooks and lecture notes, controlled by instructors who conduct the class by delivering the lectures (Cheung, 2021; Fuad et al., 2020). In other words, there are still challenges for many educators making this transition, as educators with more technology-supported or e-learning teaching experiences can better transition to the virtual environment than those with little to no experience. Research has shown that there is still a lack of confidence in many educators to use e-learning technology and Web 2.0 tools in their classrooms, especially when the efficacy of these learning environments depends on the learning support of the educator.

The Malaysia Education Blueprint 2015-2025 (Higher Education) showed that Malaysian graduates lack communication, problem-solving skills, critical thinking skills and creativity skills (Azmi et al., 2018; Bakar, 2023; Fuad et al., 2020; Ministry of Higher Education Malaysia, 2015). The inadequacy of employability skills among Malaysian university graduates has resulted in a national drive towards nurturing students to be more innovative and adaptable to changes in today's learning environments (Goh & Abdul-Wahab, 2020; Ministry of Higher Education, 2015). Studies suggest that engaging students in collaborative projects with sufficient exposure to industry practices and social resources will allow them to acquire real-world experiences (Alexander et al., 2019). This further emphasizes the need to redesign learning environments to prepare university graduates with employability competencies in collaborative workplaces (Bakar, 2023; Pelletier et al., 2021).

Project-based learning (PjBL) has been widely applied in today's educational contexts, especially in higher education institutions, to promote a dynamic and action-oriented learning strategy. It engages students in group learning and assuming responsibility for their decisions. It also enables them to become active participants and to experience the role of the community, as it focuses on students' ability to work collaboratively to solve real-life problems (Almazroui, 2023; Mursid et al., 2022; Surur et al., 2023). PjBL requires students to work with a community and use various digital technologies to solve complex problems while developing an interdisciplinary project. Studies have found that successful PjBL is determined by the level of peer interaction and project complexity. By periodically tracking students' learning processes, the instructor can provide necessary resources to support students in managing their time, reflecting on their ideas, and setting priorities for co-constructing project work (Mursid et al., 2022; Tsybulsky, 2023). By providing more complex project contexts, more opportunities arise for students to co-develop the content, discuss desirable outcomes, and evaluate solutions from different perspectives (Markula & Aksela, 2022; Tsybulsky, 2023). In recent years, PjBL has been known as an effective method of developing students' competencies. Through the learning opportunities given by the project, students are equipped with not only subject-matter knowledge but also advancing students' critical thinking, communication, problem-solving and group collaboration skills (Markula & Aksela, 2022). Therefore, in this research, project-based learning (PjBL) was used as an instructional strategy for enhancing the student learning process with community building, problem-solving, and content-co-creation experiences.

In support of redesigning the learning environment from the conventional classroom to project-based learning within a technology-supported environment, the Connectivism Learning theory (Siemens, 2005) was used in this research. Connectivism is growing dominant as a theoretical framework that addresses learning in complex, social, networked environments and knowledge with its multiple perspectives (Downes, 2022; Siemens, 2005; Siemens et al., 2020). Connectivism learning is the process of connecting with various information sources and social networking with continuously shifting elements and diverse opinions (Downes, 2019; Siemens et al., 2020). It promotes 'learning how to be a learner' and evaluates learning based on the ability to filter information valuable to a situation (Chandrappa, 2018; Dziubaniuk et al., 2023). Connectivism learning emphasizes information flow in networked environments and emphasizes informal learning where students are encouraged to use social media, Web 2.0 tools and multimedia to engage with others who have different learning styles and capabilities. Connectivism learning provides opportunities for students to gain exposure to media and social information, adopt new tools used by others, acquire the necessary skills or resources, and express personal understandings. It also develops students' interests in becoming content producers, engaging in collaborative learning, and supporting others in various situations. Therefore, informal learning helps students gain more social presence and recognition in the community (Downes, 2019; Downes, 2022; Dziubaniuk et al., 2023; Siemens et al., 2020).

As such, Siemens's (2005) Connectivism Learning was deemed a suitable learning theory in this research study to support the transition from the traditional lecture-based approach of teaching towards a more student-centred, project-based learning environment that engages students in building a learning community, supported by digital technologies, social media and web resources. Figure 1 presents the conceptual framework for this research.

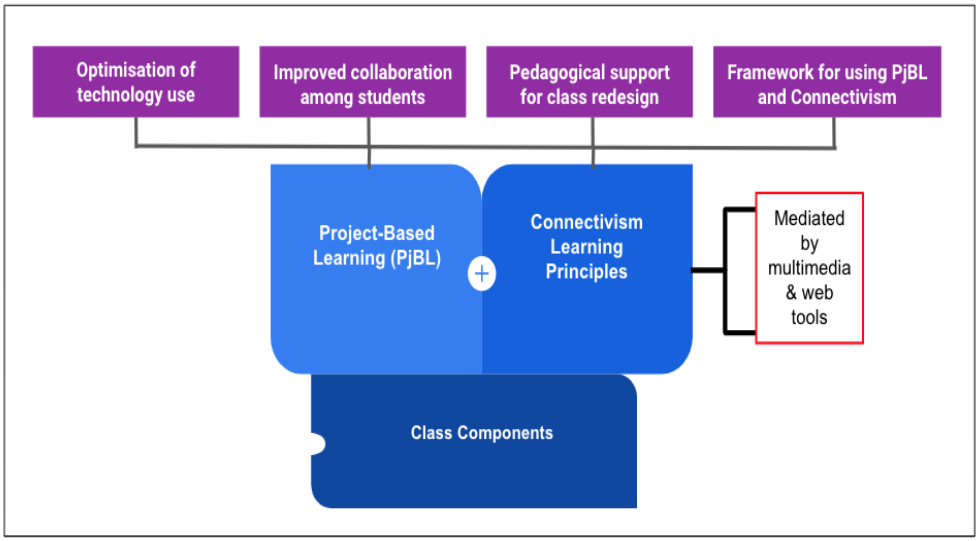

Figure 1: The conceptual framework for the research study

Thus, this research sought to investigate the following question: "What are the factors for improving students' learning experiences in a project-based Connectivism learning environment?". By identifying the key factors contributing to the efficacy of this learning environment, educators would be better able to transition from conventional lecture-based classes to more pedagogically sound project-based and collaborative learning environments with better student learning experiences.

3. Method: Designing the Connectivism Learning Environment

Siemens's (2005) Connectivism principles were incorporated into designing a connectivism learning environment that allows students to network connections with peers via social networking or online collaboration tools. The mapping of Siemens's (2005) Connectivism principles to the connectivism learning activities in the class is shown in Table 1.

Table 1: Mapping of Siemens's (2005) Connectivism to the classroom

Siemens' Connectivism Learning Principles	**Implementation in the class**
Principle 1: "Learning and knowledge rests in diversity of opinions"	Students were tasked to solve problems in a multimedia group project with their peers by using digital technologies to produce a shared solution.
Principle 2: "Learning is a process of connecting information sources"	Students were encouraged to consolidate the sources and publish with the references in a blog post as the Background Study Journal.
Principle 3: "Learning may reside in non-human appliances"	Students accessed learning content through e-library resources, their university's LMS, e-learning platforms, video streaming sites, online databases, and web-based search tools to search for media files, books, and websites.
Principle 4: "Capacity to know more is more critical than what is currently known"	Here, students were engaged in an "apprenticeship" with senior students, industry experts, online forum users, guest lectures, and campus-wide academic-related events.
Principle 5: "Maintaining connections is needed to facilitate continual learning"	Students published their productions on YouTube video channels, and competitions, showcasing their productions in their social profile.
Principle 6: "Ability to see connections between ideas and concepts is a core skill"	Here, students shared their project prototypes in Facebook Groups for communicating their ideas and seeking more ideas.
Principle 7: "Currency is the intent of all connectivism	Students were required to record the accessed documents, achieve tasks, and summarize the

learning"	current results for posting in the Work Progress Journal.
Principle 8: "Decision-making is a learning process. Choices affect outcomes"	Students' were responsible for all levels of decision-making during the project duration.

In this research, 300 IT undergraduate students at INTI International University, Malaysia, participated in this study. These students were taking the subject, 'Graphic Design and Animations.' They signed a consent form and agreed to participate in the study. With convenience sampling, the research samples were formed by the participating students who had 1) fulfilled the requirements of the subject entirely without dropping out; 2) agreed with a signature on the acknowledgement form to participate voluntarily in this research study; and 3) provided valid responses and feedback in both written and oral forms upon completion of the multimedia group project. Thus, the research samples comprised 300 first-year undergraduate IT students as participating students, who were, on average, aged 18 to 20 years old. These 300 students were divided into 83 project groups, each with three to four members within the first two weeks of the semester.

A multimedia group project was assigned to all groups, and the project required students to work collaboratively in solving the problem. Students were tasked to rebrand the existing advertisement content, which had an unattractive and outdated design, within 14 weeks. Figure 2 shows an example of a student's project outcomes, and Figure 3 illustrates their online collaborations.

Figure 2: Student team's final project outcome

Figure 3: Student online collaboration with web tools

Data collection procedure

A mixed-method research design was employed in this research study. In this mixed-method research design, the triangulation data analysis approach was used to combine various viewpoints, different opinions, and multiple forms of data collected from all research instruments. Four research instruments were utilized for collecting both quantitative and qualitative data from the perspectives of what students think, say and do. These research instruments were 5-point Likert scale questionnaires, open-ended questions, face-to-face interviews, and students' online posts and activities.

The 5-point Likert scale questionnaire was administered to all participating students to gauge their perceptions and attitudes about the Connectivism learning environment they were exposed to. This questionnaire consisted of 40 survey items with 5-point Likert scale, with 1 for strongly disagree (SDA), 2 for disagree (DA), 3 for undecided (U), 4 for agree (A), 5 for strongly agree (SA), and administered at the end of the trimester. Additionally, open-ended questions were administered together with the questionnaire form, allowing students to respond simultaneously with the questionnaire. These open-ended questions allowed them to provide more detailed comments on the learning environment. Face-to-face interviews were conducted on another day but in the same week after the participating students completed the questionnaire and open-ended questions. After obtaining consent from the participants, the interviews were recorded and subsequently transcribed. Finally, students' online posts and activities were culled from their online blogs, which included their chat transcripts, media uploads, updates of the events, written reports, discussion threads and replies, announcements, and exchange of resources, which were all made available and updated by the groups throughout the entire project development process.

An Exploratory Factor Analysis and Descriptive Analysis were performed on the quantitative dataset, while discourse analysis was employed on students' comments, online comments, and the frequency counts in the learning environment, communication channels, and social networks. The discourse analysis used the factors identified from the exploratory factor analysis as the main themes for coding and constructing various aspects.

4. Analysis and Findings

To determine the critical factors that reflected student perceptions and learning experience in this learning environment, the students' survey response on the 40-item questionnaire was used to analyze the statistical results through exploratory factor analysis (EFA), Cronbach's Alpha Test, and descriptive analyses. The IBM Statistical Package for the Social Sciences (SPSS) was used to analyze the quantitative data and perform the Exploratory Factor Analysis (EFA). In performing the discourse analysis with the sub-categories, the NVivo Software, a qualitative and mixed-method data analysis software tool, was used to study students' feedback and comments. The process included inserting, organizing, coding, and sorting the data using query tools to cross-examine the patterns or areas for further analysis and interpret the factors identified from the EFA.

Although there are no absolute thresholds for minimum sample size, Williams et al. (2010) suggested that a larger sample size is more accurate for defining the number of factors in an EFA. Hence, in this research study, the research sample size of 300 respondents was considered adequate to perform EFA and achieve good factor recovery as long as the average communality ranges between 0.5 to 0.6. This study employed Principal Component Analysis (PCA) with the orthogonal varimax rotation method to make the factors more interpretable. Based on the anti-image correlation matrix performed, all survey diagonal variables yielded values above 0.9, and all off-diagonal variables had minimal correlations. This result showed that the survey items correlated significantly, which made it conducive to performing an exploratory factor analysis (EFA). The EFA was performed using the Principal Component Analysis (PCA) factor extraction method. The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity were used to determine the adequacy of the data for factor analysis. Guidelines in the literature suggest that a KMO of more than 0.5 indicates the data is appropriate for applying factor analysis, and the data is considered good at above 0.7. In this research study, the data yielded a KMO sampling adequacy of 0.928, indicating that the data sample can be considered adequate for factor analysis. The correlations between items also proved sufficiently large for PCA, with the result of Bartlett's test of Sphericity showing $X2\ (300) = 3453.604$, $p < .001$. Table 2 presents the results of the KMO and Bartlett's tests performed.

Table 2. The KMO measure and Bartlett's test performed

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.928
Bartlett's Test of Sphericity	**Approx. Chi-Square**	3453.604
	df	300
	Sig.	.000

In reducing the number of survey items and organizing them into the factors for further interpretation, Kaiser's criteria were selected as the method in the process of factor extraction in this research study, with the average communality falling in the range between 0.5 to 0.6 (Field, 2013; Williams et al., 2010). In this analysis, 25 survey items yielded commonalities within that range and were retained. In addition, based on the results of factor extraction and rotation performed, a total of four extracted components (factors) with an eigenvalue greater than one were extracted, with an accumulative percentage of variance of 56.723% of the variability in the total number of variables. Specifically, the first factor explained 26.831% of the total variance, with the second, third, and fourth factors explaining 11.967%, 10.332%, and 7.594% of total variance respectively.

The orthogonal varimax rotation was used in this study to produce factor clusters or structures that can be better interpreted. The factor loading was set at 0.5 as the cut-off point for cleaning the factor structure. In the filtering process, four rounds of the EFA process were executed to suppress the loadings below .5. The first round of cleaning removed six items with a factor loading below 0.5, the second round removed five items, and the third round removed four items. Hence, the rotated component matrix remained with 25 variables, with 14 items loading onto factor 1, four items loading onto factor 2, four items loading onto factor 3, and three items loading onto factor 4. These four factors were then named based on the context and attributes or the variables identified within the factors through PCA.

In factor 1, the survey items consisted of the attributes surrounding peer interaction and personal experience in teamwork, as well as group settings and activities such as problem-solving, meetings and task allocation. It is consistent with the literature on group learning with project settings which emphasize team effort in complementing each other's skills, distributing responsibility, and increasing the vibrancy of interaction. Therefore, factor 1 was named Group Dynamic and Experiences. In factor 2, the survey items comprised the attributes surrounding the rise of students' motivation and inspiration, pleasant feelings, and the sense of satisfaction through developing the project. As presented in other studies, generating deeper understanding and increasing students' capabilities required motivating students to take charge of their learning process and be inspired to develop real-world skills by participating in the project development. Therefore, factor 2 was named Motivation.

In factor 3, the survey items consisted of the attributes regarding the use of web resources, the contacts between students and instructor, constant updates on the work progress, and skills enhancement during the learning process. The

literature supports that advanced digital technologies and social media have enhanced today's 21st-century learning for distributing knowledge across networks, expanding interactivity beyond classroom settings, and encouraging self-directed learning to complement classroom-based lecture models. Therefore, factor 3 was named Use of Technologies. In factor 4, the survey items consisted of the attributes surrounding managing project tasks, generalizing the learned skills for future enhancements and new achievements. It is consistent with the concept of connectivism learning where creating, manipulating, and utilizing information flow are vital activities in promoting active learning. It also encourages students to engage in informal learning and social interaction by joining or building the learning communities and repurposing the resources. Therefore, factor 4 was named Real-World Relevance.

Factor 1 - Group Dynamic and Experiences

The descriptive statistics for factor 1, Group Dynamic and Experiences is presented in Table 2, where M is the means, STD for standard deviation, and p represents the percentage of positive responses on the survey (i.e., students reporting "*Agree*" or "*Strongly Agree*" on the survey).

Table 2. Survey responses for the factor of Group Dynamics and Experiences

Survey Items	Mean (M)	p
1. "I got to know my group members well."	4.17	80.8
2. "My group helped me do my best in the project."	4.07	77.6
3. "My group leader was very effective."	4.04	75.2
4. "My group was supportive of member's problems and helped resolve them."	3.98	73.6
5. "My group communicated well with each other."	3.97	72.3
6. "My group taught me some things I would not have learnt on my own."	3.96	70.3
7. "My group was able to solve our problems and conflicts in a positive manner."	3.95	76.7
8. "I learn more from the collaboration than on my own."	3.92	74.0
9. "I enjoy working in a team."	3.90	71.3
10. "Our meetings were well attended."	3.86	66.7
11. "My group's interactions were smooth."	3.85	69.0
12. "There was a lot of unity in my group."	3.79	68.0
13. "We were able to organize our work effectively."	3.67	61.7

Student Comments (verbatim):

1. *"I'm very like this type of learning…I can't do all the job by myself…cooperation can make more perfect project then one person."*
2. *"I learn from each other as each one of us has their own area of expertise…"*
3. *"We improved our leadership skills and our behaviour in working with groups…"*
4. *"We have a lot of interaction...have our dinner together and discuss about our group."*
5. *"Tolerate with each other, better relationship…I never regret joining this group…"*
6. *"…enjoy working with this team…we have a strong connection between each other, every meeting, we all will be there…"*
7. *"This project has strengthen the bond between our group members, there were minor conflicts but nothing we couldn't handle."*

As displayed in Table 2 (survey items were numbered based on the mean scores in descending order), 80.8% of students reported that they got to know their group members well (Item 1, M = 4.17), 77.6% reported that their group helped them to do their best in the project (Item 2, M=4.07), and 75.2% reported that their group leader was very effective (Item 3, M=4.04). Additionally, 73,6% of students reported that they found support in their group members (Item 4, M=3.98), with 72.3% and 70.3% of them reporting that they were able to communicate well and learnt things from the group they would not have been able to learn on their own (Item 5, M=3.97, and Item 6, M=3.96, respectively). Peer interaction was also important, as 76.7% and 74% of students reported that they were better able to solve problems with the group's help (Item 7, M=3.95) and learned more from their collaborations (Item 8, M=3.92), respectively, which resulted in 71.3% of students reporting that they enjoyed working in a team (Item 9, M = 3.90). In terms of team dynamics, 66.7% of students reported that their meetings were well attended (Item 10, M = 3.86), 69% reported that there was unity in the group (Item 11, M = 3.85), and 61.7% reported that they were able to organize their work effectively. These results showed that feeling familiar with their peers, building work relationships, and assuming a functional role were important in forming the project group. Based on the total word frequency count of all students' opinions and feedback, the keywords "members", "people'', and ''team'' were the most frequently mentioned in their comments. It also showed that students realized the benefits and values of collaboration. They have a stronger sense of personal satisfaction that brought positive feelings and impressions, consistent with the keywords "*problems*", "*solving*", "*asking*'' being the most frequently mentioned words across all student comments.

Factor 2 - Motivation

The descriptive statistics for factor 2, Motivation, are presented in Table 3.

Table 3. Survey responses for the factor of Motivation.

Survey Items	Mean (M)	STD	p
1. "The project made me want to do my best."	4.15	0.690	85.6
2. "I am very satisfied with my contribution to the project."	3.88	0.763	70.0
3. "I enjoyed working on a project like this."	3.86	0.865	71.0

4. "I was very motivated to do this project."	3.85	0.808	75.7

Student Comments (verbatim):

1. *"Our goal is to complete the project in the best way."*
2. *"To create an amazing project as possible as we can."*
3. *"…almost nothing better than creating something from scratch and then getting to see the final outcome."*
4. *"…learn more stuff is interesting…we learned that there are so many ways to create just a simple stickman."*
5. *"... felt very happy as I was tasked to do what I am best at the most, designing and drawing."*

As displayed in Table 3 (survey items were numbered based on the mean scores in descending order), 85.6% of students reported that they were motivated to do their best work on the project (Item 1, M=4.15), with 75.7% reporting high motivation levels (Item 4, M = 3.85) and 71% reporting that they enjoyed working on a group project like this (Item 3, M = 3.86). Overall, 70% of students reported that they were very satisfied with their contributions to the project (Item 2, M = 3.88). These findings showed that the factor of Motivation included the component of opportunities provided by the multimedia group project that inspired students to devote their efforts and achieve their aims. The second component was the interest in the learning process, which attracted students' attention and increased their motivation levels. These results are also supported by their comments. Students commented that they "*felt very happy….*" and that learning about the project was "*...interesting*".

Factor 3 - Use of Technologies

The descriptive statistics for factor 3, Use of Technologies, are presented in Table 4.

Table 4. Survey responses for the factor of Use of Technologies

Survey Items	Mean (M)	STD	p
1. "I enjoyed using the web to acquire information for my project."	4.03	0.758	77.9
2. "I found using the Web to communicate my progress very useful in my learning."	3.90	0.825	72.9
3. "The project allowed me to develop and improve my presentation skills."	3.87	0.823	72.3
4. "I was able to maintain contact with my lecturer."	3.85	0.882	69.0

Student Comments (verbatim):

1. *"I had researched a lot of information from the internet, including creative ways to present…"*
2. *"…get to make full use of the technology with different methods…the freedom to freely explore…"*
3. *"I am currently taking CS50 course from Harvard University as part of their Open Source Learning on iTunes University."*
4. *"…we can search through the open world, I very prefer and appreciate the learning environment…because that everybody has different design ideas."*
5. *"…have the chance to share our design ideas to everyone…and gain more creative design ideas by looking on others creation."*

As shown in Table 4 (survey items were numbered based on the mean scores in descending order), 77.9% of students reported that they enjoyed using the Web to search for information (Item 1, M = 4.03), with 72.9% reporting that they used the Web to display and present their progress (Iten 2, M = 3.90), and 69% reported that they were able to maintain contact with their lecturer (Item 4, M = 3.85). Overall, using technologies helped 72.3% of students to develop and improve their presentation skills (Item 3, M = 3.87). These findings showed that the use of Technologies included extending social support, which potentially transformed the students to be more active and resourceful in sourcing and managing their learning materials. The second component was creative thinking in the learning process which stimulated imagination and discoveries for generating new ideas and proposing better solutions. These were also supported by students' comments where they reported that the Web technology allowed them to "*…search through the open world, I very prefer and appreciate the learning environment*" and that having the "*...chance to share our design ideas to everyone…*".

Factor 4 - Real-World Relevance

The descriptive statistics for factor 4, Real-World Relevance, are presented in Table 5.

Table 5. Survey responses for the factor of Real-World Relevance

Survey Items	Mean (M)	STD	p
1. "The project increased my understanding on how to manage and develop an interactive application."	4.14	0.736	83.0
2. "I am now able to apply my skills in a more effective manner on future projects."	4.01	0.766	79.6
3. "We were able to complete all our tasks on time."	3.60	0.987	57
Student Comments (Verbatim): 1. *"…visit a real animator who create a movie animation name 'Upin and Ipin' guided me in the future I might want to be part of them."* 2. *"…our trip to Les Copaque, fulfilled my dream of being in an actual animation production company…none of their work would have been achieved if not for team work and dedication…"* 3. *"I learnt the importance of B-Roll with random objects…I look forward to apply the knowledge that i used in this project, later on."* 4. *"…I have gain much from the development team…in the future I want to create my own style of game."* 5. *"…we can share our creativity, manage our time that will be used in real life."*			

Results in Table 5 (survey items were numbered based on the mean scores in descending order) showed that 57% of students reported being able to complete their tasks on time (Item 3, M = 3.60), indicating that time management was a skill they had challenges with. However, overall results for Real-World Relevance were very positive, with 83% of students reporting that the project improved their understanding of developing and managing a project, and, more

importantly, 79.6% of students reported that they had acquired skills that they can now apply to their future projects (Item 2, M = 4.01). This is also supported by their comments that "*…we can share our creativity, manage our time that will be used in real life"* and that "*…I look forward to apply the knowledge that I used in this project, later on…".* These findings showed that the Real-World Relevance factor included the planning component, leading students towards lifelong learning and being more passionate about future development. The second component was the flexible minds that allowed students to be more adaptive to resources, restrictions, and requirements in completing the tasks and gaining new knowledge.

5. Discussion

In answering the research question, "What are the factors for improving students' learning experiences in a connectivism learning environment?", items from the survey were analyzed using the IBM Statistical Package for the Social Sciences (SPSS), where the Exploratory Factor Analysis (EFA) was performed. The result from the exploratory factor analysis of survey response identified four factors for improving students' learning experiences in a connectivism learning environment, Group Dynamic and Experiences (Factor 1), Motivation (Factor 2), Use of Technologies (Factor 3), and Real-World Relevance (Factor 4). In addition, discourse analysis was performed on the qualitative data collected (students' feedback and comments) using the NVivo Software, to provide and interpret the factor items identified from the EFA.

Factor 1 – Group Dynamic and Experiences

Factor 1, Group Dynamic and Experiences, consisted of items that focused on the attributes of peer interaction, team working experience, group settings and collaborative activities. Findings showed that team members were inspired to do their best in a project. Teamwork influenced the members to contribute from various aspects, made the group more united and the interactions smoother to produce a better outcome. Students perceived that the group's ability to solve problems and conflicts in a positive manner was associated with well-attended meetings and in line with findings in the literature on collaborative activities (Almazroui, 2023; Demosthenous et al., 2020; Murillo-Zamorano et al., 2019). Students' responses revealed that working in a project group gave them a sense of satisfaction, which developed a good impression and mutual understanding of collaborative activities.

Factor 2 – Motivation

Factor 2, Motivation, consisted of items that focused on the attributes of students' motivation and inspiration. Students' responses, feedback, and online posts showed that the project settings provided them with various opportunities to contribute their best efforts in areas they were familiar with and where they found the project fun and interesting. Motivation can be recognised as a factor that stimulates students to take charge of their learning process and improve their capabilities by co-creating content. As supported by the literature, being self-directed and self-independent was a critical step in transforming a passive learner into an active learner and a crucial educational innovation in the recent

education reform in Malaysia (Azmi et al., 2018; Bakar, 2023; Goh & Abdul-Wahab, 2020).

Factor 3 – Use of Technologies

Factor 3, Use of Technologies, consisted of items focused on using digital and web technologies to make constant contacts, progress updates, and enhance skills. Students' responses, feedback, and online posts showed that almost all students were active and capable of using web technologies to acquire the necessary support and information for their learning. Findings showed that the reason students enjoyed using web resources to acquire information was due to the usefulness of the Web in communicating and sharing their work progress with others and maintaining contact, whereas maintaining contact with the instructor was associated with improving students' presentation skills during the project development. The Use of Technologies factor played a role in shifting away from the traditional teacher-centred class environment into community building and collaborative project development with digital technologies. This research study found that the connectivism learning environment efficiently encouraged students to exchange ideas, construct social networks, and co-create content to enrich their learning experiences in both classroom and digital settings, aligned with the literature that integrating digital technologies and Web services in the learning context are effective in engaging students (Alexander et al., 2019, Brown et al., 2020; Moorhouse & Wong, 2022).

Factor 4 – Real-World Relevance

Factor 4, Real-World Relevance, consisted of items that focused on attributes such as managing project tasks and generalizing the learned skills for future success. Students' responses, feedback, and online posts showed that the multimedia group project increased students' knowledge and experiences in managing resources and solving complicated problems. Students also demonstrated their capabilities and skills in acquiring and connecting the learning resources, working around the limitations and restrictions, and factoring in the environmental issues and others' opinions for developing a more successful project in the future. The factor of Real-World Relevance has been identified as an essential element in leading students towards life-long learning as Siemens's (2005) believed that contemporary learning is a continual process that links with various activities and learners move into a variety of fields at different times of life (Siemens et al., 2020). This factor also helps students to make sense of their learning in advancing their level of expertise and critical thinking, consequently increasing their value in today's job market (Kukulska-Hulme et al., 2020; Mursid et al., 2022; Surur et al., 2023).

From the findings, a Multimedia-based Connectivism Learning Framework (MCLF) was developed. Table 5 shows the learning framework, which can guide educators to develop students' skills and 21st-century competencies.

Table 5. The MCLF framework for connectivism learning experiences

Factors for Improving Students' Learning Experiences	Siemens's (2005) Connectivism Principles (CP)	Connectivism Learning Experiences (CE)
Factor 1 - Group Dynamic and Experiences **Factor 2** - Motivation	**CP1** - "Learning and knowledge rest in diversity of opinions."	(**CE1**) Motivated by social support and new ideas that bring new values for improvement.
Factor 2 - Motivation **Factor 3** - Use of Technologies	**CP2** - "Learning is a process of connecting specialized nodes or information sources."	(**CE2**) Increased resourcefulness in addressing own needs and remixing information.
Factor 1 - Group Dynamic and Experiences **Factor 3** - Use of Technologies	**CP3** - "Learning may reside in non-human appliances."	(**CE3**) Adapted to the online environments with frequent discussions and deeper participation.
Factor 2 - Motivation **Factor 3** - Use of Technologies	**CP4** - "Capacity to know more is more critical than what is currently known."	(**CE4**) Developed new problem-solving approaches through multiple tools and resources.
Factor 1 - Group Dynamic and Experiences **Factor 4** - Real-World Relevance	**CP5** - "Nurturing and maintaining connections is needed to facilitate continual learning."	(**CE5**) Participated by implementing new ideas in the communities for further exploration.
Factor 1 - Group Dynamic and Experiences **Factor 2** - Motivation	**CP6** - "Ability to see connections between fields, ideas, and concepts is a core skill."	(**CE6**) Applied prior experiences and aligned with preferences in handling tasks and planning for enhancements.
Factor 3 - Use of Technologies **Factor 4** - Real-World Relevance	**CP7** - "Currency (accurate and up-to-date knowledge) is the intent of all connectivism learning."	(**CE7**) Adapted to changes for reflecting real-time updates and coordinating pace.
Factor 4 - Real-World Relevance	**CP8** - "Decision-making is a learning process. Choices and alterations affect the decision and outcomes."	(**CE8**) Developed purposeful solutions in a context for producing better outcomes.

As can be seen from the framework, the factor of Group Dynamic and Experiences (factor 1) was successful in improving students' learning experiences of being motivated by social support and new ideas (CE1), having deeper participation in online environments (CE3), implementing new ideas in communities (CE5), and applying their own prior experiences to current tasks (CE6). Hence, the factor of Group Dynamic and Experiences is consistent with Siemens's (2005) Connectivism principles (CP1), (CP3), (CP5), and (CP6). The factor of Motivation (factor 2) can improve students' learning experiences by being motivated by social support and new ideas (CE1), remixing and producing new information (CE2), developing a new approach to problem-solving (CE4), and applying their own prior experiences to current tasks (CE6). Hence the factor of Motivation is consistent with Siemens's Connectivism principles (CP1), (CP2), (CP4), and (CP6).

Furthermore, the factor of Use of Technologies (factor 3) was demonstrated to improve students' learning experiences of remixing and producing new information (CE2), having deeper participation in online environments (CE3), developing a new approach in problem-solving (CE4), and adapting to changes and coordinating pace (CE7). Hence the factor of Use of Technologies is consistent with Siemens's (2005) Connectivism principles (CP2), (CP3), (CP4), and (CP7). Finally, the factor of Real-World Relevance was successful in improving students' learning experiences of implementing new ideas in communities (CE5), adapting to changes and coordinating pace (CE7), and being capable of developing purposeful solutions (CE8). Hence the factor of Real-World Relevance is consistent with Siemens's Connectivism principles (CP5), (CP7), and (CP8).

Therefore, this study demonstrates that the four factors for improving students' learning experiences in a connectivism learning environment have been successfully identified from the data analysis. Group Dynamics and Experiences factor emphasized the aspects of unity in the group, work relationships and functional roles, collective capabilities, and peer interaction in the social network. This factor raised students' responsibility and confidence in contributing to new knowledge, managing learning resources, and complementing each other's skills in a learning community. The factor of Motivation emphasized opportunities in the learning process, the options and choices in making decisions, the inspiration and learning interests. It motivated students to devote more effort to improve their performance, be more accountable for decisions, and determine their goals and values. The Use of Technologies factor emphasized the aspects of digital fluency in using social media, Web technologies and multimedia in the learning activities, the external exposures to open students' minds, and the new possibilities for future gain. This factor stimulated students' sense of creativity and skills in assimilating prior experiences into new knowledge. The factor of Real-World Relevance emphasized the aspects of repurposing resources, knowledge and skills transfer, and developing context-specific content in presenting solutions. It extended students' capacities to learn and relearn, the quality of the interactivity in the connectivism learning environment, and their employability value in today's job

market. Overall, the study showed strong evidence that connectivism learning experiences were well-supported by the four identified factors.

6. Contributions, Limitations and Future Research

In this research study, transforming the traditional teacher-centred class environment into a connectivism learning environment was an effective way to develop university graduates' competencies and employability attributes. This learning environment can be supported by the fact that net generation dominates the student population in university classrooms, and the current educational trends are redefining the roles of university instructors and students. Hence, in transforming the learning environment, it is important to redesign students' learning experiences by recognizing their prior experiences, optimizing digital technologies and social media, engaging students in learning communities, and enhancing their level of information literacy. In particular, there were several implications and contributions from this study. In particular, the findings showed that the learning environment was successful in optimizing the use of technologies in the classroom to support contemporary students' learning needs. As Siemens's (2005) Constructivism Learning Principles were used to engage students in technology-enhanced learning and informal learning, students moved away from passive to active learners as they became more capable of using resources and digital technologies for their projects.

Students experienced improved collaborative learning skills. The results demonstrated that by engaging in teamwork and group activities online during their project development stages, students became better team players, problem-solvers, were more interactive with each other, and were more motivated to complete their projects. It also motivated them to learn more beyond physical classrooms. In particular, this research study found that project development efficiently improved students' capabilities and learning experiences. Many students demonstrated their abilities to reason out the motives behind their actions, manipulate the ideas collected from other resources, improve from the mistakes made, and comprehend the issues clearly in group communication. It also encouraged students to formulate their strategies for collaborative problem-solving and efficient teamwork. This blended learning approach is successfully aligned with four shifts outlined in the Malaysia Education Blueprint (Higher Education) which were: 1) holistic, entrepreneurial and balanced graduates, 2) the development of a nation of life-long learners, 3) globalized online learning, 4) transformed higher education learning, and effectively addresses the issue of limited innovative and engaging learning opportunities in Malaysia.

Connectivism learning was found to be an effective pedagogical strategy to underpin the learning environment. The study's findings showed that integrating Siemen's (2005) eight Connectivism learning activities is effective and can be used to engage students in project-based classes and collaborative learning in higher education. Implementing Siemens's (2005) connectivism learning principles successfully engaged students in critical thinking, decision-making, and increased their sense of ownership. Through forming networked relationships with their peers, students recognized and developed their

strengths, made connections with existing knowledge, and planned for future projects. The Multimedia-based Connectivism Learning Framework (MCLF) presented in this study can be a strongly supported guideline for such transformation. As many university students live digital lifestyles, the MCLF can guide educators and students to harness the benefits of digital technological advances, Internet connectivity, and Web resources in teaching and learning contexts. The MCLF supports the nation's call for redesigning learning environments to prepare Malaysian graduates with problem-solving and collaborative skills and encourage them to play a role in learning communities, which are the most transferable and highly sought-after skills in the Malaysian work environments today.

This research study had some limitations that can be considered in future research. In this research, the study's focus was limited to the class environment of a university multimedia subject titled 'Graphic Design and Animations'. As such, the research samples were limited to students who studied at INTI International University and enrolled in this subject during the period. For future research, this connectivism learning environment can be designed for cross-disciplinary programmes or industrial project collaborations involving students from different universities, disciplines and academic levels. In addition, this research study allowed students to make connections based on their capabilities, experiences, preferences, or needs. Hence, students initiated the interaction, defined the values, and moved towards their goals without significant interventions or guidance from the instructors. Future research could investigate the role of the instructors in making the connections and enhancing the quantity and quality of the built connections in such a learning environment, as well as their feedback and experiences in designing the connectivism learning activities. Doing so may provide more insights and research-informed knowledge on the significant impacts of instructors' support in connectivism learning environments.

7. Conclusion

In conclusion, this research study sought to transform and redesign the traditional teacher-centred class environment into a project-based connectivism learning environment to help develop university graduates' competencies and employability attributes in Malaysia. Therefore, in transforming the learning environment, it was important to redesign students' learning experiences by recognizing their prior experiences, optimizing digital technologies and social media, engaging students in learning communities, and enhancing their level of information literacy. By combining project-based learning with Siemens's (2005) Connectivism Learning Principles in redesigning the classroom, critical factors for effective students' collaborative learning experiences were identified based on the findings from the Exploratory Factor Analysis (EFA) performed. These factors were Group Dynamic and Experiences, Motivation, Use of Technologies, and Real-World Relevance. As a result of this analysis, the Multimedia-based Connectivism Learning Framework (MCLF) was presented, where each of the eight connectivism learning experiences was co-supported and improved by one

or more of the four factors identified and were able to address the research issues investigated in this study successfully.

As can be seen in the quantitative and qualitative results, students experienced deeper collaboration through project-based learning approaches, gained more enhanced skills and capabilities through problem-solving and critical thinking, and developed better strategies in utilizing digital technologies and web resources to support their learning. This provided strong and encouraging support for redesigning conventional classrooms to become more technologically and pedagogically supported. Project-based and Connectivism learning has been shown to enable more meaningful and richer learning contexts for students, with the MCLF as an effective guideline for technology-based classrooms in 21st-century education.

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