Is Team-Based Online Learning Activities Enhances Critical Thinking Skills of Engineering Students or Not? An Exploratory Study During the COVID-19 Pandemic*

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This study was conducted during the COVID-19 pandemic to explore whether team-based, online learning activities play a role in enhancing undergraduate engineering students' critical thinking skills. To conduct the study, we distributed a Google Form–based online survey among undergraduate engineering students through Tecnológico de Monterrey learning management system platform during the fall semester of 2020. In total, we received 50 complete responses through a convenient sampling approach. To analyze the quantitative data, we applied a hierarchical regression technique using the IBM SPSS 26.0 statistical software program. The findings of this study affirm that participation in team-based online learning activities meant to improve (1) the quality of learning and (2) reasoning ability have a significant positive correlation with critical thinking skills of undergraduate students in engineering programs. We also conclude that quality of learning has higher significant association with critical thinking skills as compared to reasoning ability

Keywords: COVID-19; critical thinking; educational innovation; engineering education; e-learning; team-based learning

1. Introduction

In the 21st century, emerging technology became a backbone of all sectors – especially education. The purpose of implementing these technologies into the educational sector, especially into higher education institutions, was to facilitate the offering of technology-driven degree programs. Most of the reputable degree-awarding universities offering online courses of study are of a high caliber. These degree programs not only cover emerging technologies, but they also offer market-driven course curricula based on online activities, with the aim of developing students' critical thinking skills [1]. In academia, critical thinking skills refer to students' learning abilities, and these skills can be acquired during individual and team-based academic activities [2]. Individual and team-based activities encourage students to share knowledge of specific topics through new teaching approaches [3].

The latest published literature is witness that after the arrival of the COVID-19 pandemic, educational institutions around the globe immediately reformed their existing policies and transitioned the traditional method of teaching to a digital one:

electronic learning (e-learning) [4]. In e-learning, teachers and students heavily rely on online activities for continuation of education. During this transition, teachers designed online course-based activities and added content from online social media platforms [5, 6] – such as Facebook, Twitter, Instagram, LinkedIn, and YouTube – to their educational arsenal.

In the case of Latin American countries, especially Mexico, all public and private universities completely transitioned their physical activities to online platforms [4]. This was because of the high number of coronavirus cases in these areas. For the sake of public health, higher education institutions in Mexico transferred their academic activities to virtual platforms [7] such as Zoom, Microsoft Teams, and so on. A prime example of this was in Tecnológico de Monterrey (TEC), one the leading private universities in Mexico, which introduced the hybrid educational model (HyFlex+ Tec) of education [8], aiming to continue providing education to students of all levels. The HyFlex+ Tec model allows faculty members to design state-of-the-art course content and engage students in virtual activities.

The objective of this research study is to analyze team-based online learning and determine whether it is associated with critical thinking skills in under-

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graduate engineering students. To achieve the set objectives of this study, we adopted questionnaires from previously published work and then designed and distributed a Google Form–based online survey among TEC undergraduate students through the university learning management system (LMS) Canvas. Later, we analyzed the collected data using the IBM SPSS 26.0 statistical tool and confirmed the association between independent and dependent variables by employing a hierarchical regression technique.

2. Relevant Literature and Hypotheses

The sharing of knowledge among individuals and groups can revolutionize science and technology by filling the gap between theoretical knowledge and practical skills [9, 13]. In higher education, collaboration is considered an important tool for knowledge creation and sharing [10, 14]. To extend collaboration via digital means, universities and research groups are implementing technology-driven methods. For collaborative learning, university teachers can design their course contents and employ online activities in their courses. The purpose of these online team-based activities is to enhance critical thinking through virtual means (i.e., the Internet).

2.1 Quality of Learning

During the pandemic, successfully transitioning the mode of education to digital platforms was vital so that all levels of students could continue their studies [11]. On the other hand, there has now been a rapid growth in online courses and degree programs, which raises concerns about the quality of course content and material, as well as evaluation methods [12]. The digital transformation in learning has increased teachers' concerns about the quality of instruction and the effects on student learning [13]. However, online learning environments positively impact students' performance [14]. A measure of the quality of student learning after their engagement in team-based, online academic activities shows the effect of knowledge sharing through a digital medium (i.e., using critical thinking skills) and its association with the quality of learning [15].

H1: Quality of learning has association with critical thinking skills.

2.2 Reasoning Ability

In an online setting, academic activities provide a collaborative environment between the teacher and his or her students [13]. Team-based activities are associated with a teaching strategy [16] that enhances the reasoning abilities of students. Reasoning ability is having the capacity to form critical arguments based on relevant knowledge and evidence [17]. Paul and Elder [18] argued that students attend classes without understanding how the skills they learn in their degree program will benefit them in future careers. Reasoning ability allows students to raise questions and find relevant solutions by gathering information from different sources and addressing the issues through effective communication and by solving real-world problems.

H2: Reasoning ability has association with critical thinking skills.

2.3 Critical Thinking Skills

Critical thinking is considered a vital tool for students in the development of professional competency, and it is also helpful in the decision-making process [19]. Critical thinking skills relate to logical reasoning, which is used to solve problems [20]. These skills help students link theoretical knowledge with practical skills during studies, and course-based learning activities facilitate this process [21]. These learning activities rely on face-to-face or virtual communication. In an e-learning environment, online activities can directly help students utilize their soft skills by giving them the ability to practice using multimedia tools to solve advanced levels of real-world problems using critical thinking skills [6]. These learning strategies promote critical thinking skills for better academic achievement [22].

3. Material and Methods

3.1 Participants

Due to COVID-19 pandemic, emergency online education policy was adopted by institution with objective to continuation of educational activities. For continuation of studies and promotion of soft skills during offered course, we initially designed team-based online activities among third year undergraduate students of two programs involved (1) Architecture and (2) Civil engineering. The aim of online activities was to aid students being able to take better decision toward their area of interest. In this study, one professor designed two courses – "Real Estate Projects" and "Urban Design Methodologies" – during the fall of 2020. These courses offered a set of team-based online learning activities to undergraduate engineering students, with the objective of promoting critical thinking (see Table 5 in Appendix). During the semester, engineering students participated in social media activities using the hashtag and shared posts of relevant interest. For team-based, online activities, students used the following five social media platforms: YouTube,

Table 1. List of survey questionnaires

Variables	Items	Source
Quality of learning	*Do you think the team helped you to understand course material more than studying alone?*	Yaqoob et al. [23]
	Do you think that you are in team you have learned a lot?	
	Do you think that being part of team helps you to improve your grades?	
Reasoning ability	*Do you think being a team member has helped you to become better proble solver?*	Yaqoob et al. [23]
	Do you think team makes good decision?	
	Do you think team discussion has improved your ability to solve problem?	
Critical thinking skills	*What are you ideas and assumptions that support your strategy or plan?*	Chartrand et al. [24]
	Is there solid evidence to support those assumptions, and what might be some gaps in your reasoning?	
	What other idea should be explored, and what else do you need to know?	
	After evaluation all of the facts, what is the best possible conclusion?	
	What specific evidence is driving your conclusion?	
	Is there new evidence that would impact your decision?	

Note. Adopted questionnaires.

Facebook, LinkedIn, Twitter, and Instagram. At the end of semester, students were asked to voluntarily participate in an online survey.

In this study, a total of 58 responses was received from undergraduate engineering students. We targeted respondents from TEC, and to do this, we asked an anonymous professor to circulate the link of the online survey form among registered students through the university LMS platform, Canvas (www.experience.tec21). In total, we received 58 responses, where 8 responses were considered incomplete and the remaining 50 were considered for final analysis.

3.2 Procedure

At the end of the fall 2020 semester, undergraduate students in the engineering program at TEC were asked to voluntarily participate in an online survey. We designed the survey in Google Forms and then distributed the link among engineering students during November 2020. The Google Form–based online survey contained two sections. The first section covered confidentiality statements and demographic information of the respondents. The next section contained the list of questions related to team-based, online learning activities (which aimed to improve quality of learning and reasoning ability) and students' critical thinking skills.

3.3 Survey Questionnaires

Three items related to quality of learning and reasoning ability were adopted from the published work of Yaqoob et al. [23]. We adopted six of the critical thinking skills items from the published work of Chartrand et al. [24]. Each item contained a Likert scale of 5 responses, where "0" represented "*Strongly disagree*" and "4" represented "*Strongly agree*".

3.4 Statistical Analysis

First, we applied descriptive statistics to get detailed information about the participants, in terms of frequency and percentage. Second, a Pearson's correlation analysis was applied to confirm the correlations among variables. Finally, we applied hierarchical regression to confirm the association between both independent variables – (1) quality of learning and (2) reasoning ability – and the dependent variable (critical thinking skills).

4. Analyzed Results

4.1 Demographics Information

Demographic information of participants is presented in Table 2, and it includes categories such as age, gender, scholarship, and social media usage in hours per day. Thirty-five (70%) of the respondents

Table 2. Demographics of the respondents

Demographics	Frequency (n = 50)	Percentage (%)
Age		
18 to 20 years	3	6%
21 to 23 years	35	70%
24 years and above	12	24%
Gender		
Female	28	56%
Male	22	44%
Scholarship		
Yes	31	62%
No	19	38%
Social media usage (day per hour)		
Less than 3 hours	19	38%
3 to 6 hours	24	48%
Above 6 hours	7	14%

Table 3. Correlation between independent and dependent variables

Variables	Quality of learning	Reasoning ability	Critical thinking skills
Quality of learning	1		
Reasoning ability	0.079	1	
Critical thinking skills	0.332*	0.293*	1

Note. Level of significance *p < 0.05 (2-tailed).

were between the ages of 21 and 23, and 12 (24%) of the respondents were ages 24 or older. Only 3 (6%) of the respondents were between the ages of 18 and 20. Twenty-eight (56%) of the respondents were female, and the remaining 22 (44%) were male. Thirty-one (62%) of the enrolled students were studying on a scholarship, and the remaining 19 (38%) were self-financed. Sixty-four percent of respondents were used to spending between 3 and 6 hours on social media per day, whereas 38% of respondents were on social media less than 3 hours per day. The remaining 7 (14%) of respondents were on social media more than 6 hours per day.

4.2 Correlation Analysis

We applied Pearson's correlation (Pearson's r) analysis to determine the coefficient correlation between the independent variables (i.e., quality of learning, and reasoning ability) and the dependent variable (i.e., critical thinking skills). From statistically analyzed results (see Table 3), quality of learning positively correlates with critical thinking skills of undergraduate students. We also found that a significant positive correlation exists between reasoning ability and students' critical thinking skills.

4.3 Hierarchical Regression Analysis

We tested our designed hypotheses by applying a hierarchical regression technique through IBM SPSS version 26 (see Table 4). In Model 1, ΔR^2 shows that the quality of learning has 11% variance and significantly higher association on critical thinking as compared to reasoning ability (in Model 2) where reasoning ability has 7.2% variance on critical thinking skills. So, Model 1, $\beta = 0.332$, $p < 0.05$, which confirms and supports our first

Table 4. Hierarchical regression analysis

Variables	Critical Thinking Skills	
	Model 1	Model 2
Quality of Learning	0.332 (0.018)	0.311 (0.023)
Reasoning Ability		0.268 (0.048)
F	5.594*	4.109*
R^2	0.110	182
ΔR^2	0.110	0.72

Note. Level of significance *p < 0.05.

hypothesis – that is *H1: Quality of learning has association with critical thinking skills.* The significant value of p < 0.05 in Model 2 also reveals that *H2: Reasoning ability has association with critical thinking skills* ($\beta = 0.268$, p < 0.05) is supported.

5. Discussion

This study explored the role of team-based, online learning activities in the enhancement of students' critical thinking skills. In recent times, technology has become an important tool for successfully transitioning academic activities from traditional to online ones. In fact, during the time of the pandemic, technology has been a key factor in mitigating what some have called a "*disruption in the educational system*" [25]. Now that academic institutes around the globe have adopted of the latest online learning tools (such as Canvas, Blackboard, Moodle, and so on), higher education teachers can develop state-of-the-art course content and invite their students to register and actively participate in online activities by employing social media platforms such as Facebook, LinkedIn, Instagram, and Twitter [26]. These online team-based activities allow higher education students to actively participate in online academic activities and share knowledge and skills among their peers [27]. The correlation results of this study demonstrate that (1) quality of learning and (2) reasoning ability have a significant positive correlation with critical thinking skills in undergraduate engineering students. The hierarchical regression technique applied in Model 1 (Table 4) shows that an association exists between quality of learning and the critical thinking skills of undergraduate engineering students. The second step of hierarchical regression in Table 4, Model 2, also shows that quality of learning has an association with critical thinking. So, technology-driven activities based on reasoning and learning are an integral part of enhancing critical thinking [28] in academia.

The findings are consistent with other studies that show that the use of social networks in teaching favors the development of skills such as critical thinking, autonomy, initiative, collaborative work, and individual responsibility in students [29]. These findings also agree with the results that show a significantly greater improvement in critical

thinking skills in a team-based learning environment, in regard to lecture-based courses [30]. In this study, even though the implementation of the technology was necessarily precipitated by the pandemic, the results remain unchanged. The potential of technology in education has been revealed, and once the health situation has been overcome, the future of education must continue to develop new pedagogical models based on technology.

5.1 Limitations and Future Directions

This study has limitations in terms of sample size and geographical location. First, the reason for the limited sample is due to the nature of the designed research. For this study, we only distributed surveys among registered undergraduate engineering students enrolled in two courses. These courses depended on team-based, online activities for critical thinking. The second limitation was that only students from the one campus of private university in Mexico participated. The limitations of this study provide direction to scholars who wish to extend this research. New course contents involving individual and team-based online academic activities for the searching and sharing of innovative ideas and knowledge will also allow for critical reasoning that will further improve critical thinking skills.

6. Conclusion

Based on the preliminary results of this research study, we conclude that team-based learning through social media course activities provides a digital environment to undergraduate engineering students that enhances their soft skills in the form of critical thinking. We also conclude that quality of learning has higher significant association with critical thinking skills as compared to reasoning ability. So, when the purpose of team-based, online course activities on social media is to collect new information from reliable resources and share it with peers, (1) quality of learning and (2) reasoning ability are considered driving forces for the enhancement of learning abilities through this active participation.

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Appendix

Table 5. Summary of good practice for team-based online activities (Source: Talía González-Cacho)

Summary of good practice		
Planning, implementation, and evaluation of team-based online activities		
Stages	**List of team-based online activities**	**Purpose**
Planning	Determine a time on tasks	Allows students to organize and make strategies
	Diversity of social-media platforms	Allows students to choose which platform is better fit for their needs.
	Determine milestones	Allows students to share ideas and feel more confident about their results.
Implementation	Cooperation among students	Allows students to share their ideas and feel more confident about their results.
	Active learning during the course	Allows students to keep engage with their own learning.
Evaluating	Prompt feedback	Allows students to verify and improve their results with enough time.

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