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Application of the TPACK Framework by Integrating a Geological Virtual Lab Among Pre-service Teachers at the College of Basic Education in Kuwait

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Abstract

This study applied the "TPACK" Framework to integrate a virtual lab of rocks and minerals replacing the hands-on laboratory among science and mathematics pre-service teachers at the College of Basic Education (CBE) in Kuwait in achieving effective and interactive distance learning. The instructional materials and strategies were well-organized and adjusted to meet diverse abilities and talents. The study involved 79 subjects of pre-service teachers studying geoscience, none had utilized a virtual laboratory before, and were guided by a self-training approach by communicating using MS Teams as a learning management system. The assessment rubric for grading attitudes and projects was promotive; 88% graded excellence, and 12% were very good. The output feedback of the pre-service teacher experience in the virtual lab demonstrates a medium to a high significance level of mean values. The results recommended adopting virtual labs in geoscience education with well instructional materials and interactive learning strategies.

Keywords: TPACK, Virtual Labs, Distance Learning, Geology, Learning Management System.

Introduction

The COVID-19 pandemic has caused havoc on education systems worldwide, and the student population has been affected by the closure of schools, institutions, and other learning environments. Social distancing has considerably disrupted traditional educational techniques, transforming learning to distance learning. On March 12, 2020, the

World Health Organization (WHO) declared the coronavirus disease 2019 (COVID-19) as a pandemic (WHO, 2020). On March 18, 2020, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) reported that 107 nations had adopted COVID-19 related nationwide school closures, affecting 862 million children and young people, or about half of the world's student population. This issue has quickly escalated from 29 countries closing their schools to halt the spread of Covid-19 (UNESCO, 2020). Governments worldwide have implemented new academic rules, with one of the most important being the phase-out of face-to-face teaching in favor of online distance education, which requires a certain level of pedagogical content knowledge (PCK), primarily concerned with designing and organizing for better learning experiences and creating distinct learning environments using digital technologies (Rapanta et al., 2020). Online distance learning is a viable option for continuing education during this epidemic, as it adheres to the physical distancing rule. Murphy (2020) claims that securitization theory is a helpful tool for educators not just for witnessing the issue of emergency e-Learning but also for campaigning for school DE-securitization when the COVID-19 crisis has passed.

Before the epidemic, schools and universities rarely used online distance education due to a lack of online distance learning tools and infrastructure and their needs. However, to avoid COVID-19 spreading, all schools and educational institutes moved to online distance learning as the physical distancing requirements. In many countries, the governments work very hard with the telecom providers to enhance internet connectivity, and the educational institutions perform an excellent assignment of invoking appropriate distance learning management systems. However, not all instructors, learners, and parents are prepared for online distance learning methodologies in the current epidemic, which creates difficulties in the learning process. Unprepared instructors in using e-learning tools and strategies struggle to develop effective online distance learning activities, and this issue affects students' motivation to study online, particularly in a situation like the COVID-19 crisis and the lockdown.

The College of Basic Education (CBE) is the most prominent pre-service teacher's qualification educational institute in Kuwait and Gulf Cooperation Council (GCC) countries (Alenezi & Alenezi, in press). It proceeds to online distance learning during the COVID-19 epidemic. This study demonstrates the methods and the results of adopting the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006, 2008; Koehler & Mishra, 2009; Koehler et al., 2014) by integrating a virtual geological lab to fill the gap of a hands-on lab in identifying the physical properties of specific minerals as an essential lesson in the geologic curriculum. The web-based laboratory approach includes hands-on activities and virtual experiences in a laboratory-like setting. A virtual lab gives the student a virtual experience that seeks to engage them realistically while maintaining the quality of a comparable hands-on laboratory experiment.

This research aimed to investigate the effectiveness of a proposed program based on (TPACK) framework competencies in developing pre-service teachers' technology-based learning concerning the geology curriculum. The study adopts rocks and minerals virtual laboratory developed by K12 stride company and Microsoft office (365) applications (MS Teams -PowerPoints) in distant learning during the pandemic of Coronavirus and tends to evaluate the effectiveness of such tools in geoscience education strategies. This study is the first of its kind in Kuwait and GCC countries.

The main research questions targeted by this study are:

1 - What role does the TPACK framework play in pre-service teachers integrating a virtual geological lab?.

2 - What is the role of TPACK in achieving effective and interactive distance learning and e-learning?.

TPACK framework

The Technological Pedagogical Content Knowledge (TPACK) framework introduced by (Mishra & Koehler, 2006) stands for a comprehensive understanding of how content and teaching methods must form the basis for any effective educational technology integration to enhance student learning experiences. TPACK is a technology integration framework that identifies three types of knowledge instructors need to combine for successful integration of education and technology: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK). The specific technological tools (hardware, software, applications) are used to better understand the lesson's topic. Koehler et al. (2014) believe that if the teacher is allowed to design the lesson electronically, his technological knowledge will develop implicitly, contributing to a broader understanding of the impact of content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK). Content Knowledge (CK) assign to the subject matter knowledge and integration with other fields. Pedagogical Knowledge (PK) associates educational strategies and teaching practices, including teaching methods, objectives, learning outcomes, lesson planning, student characteristics, different ways of thinking, and teaching and learning theories to promote students' learning. Technology Knowledge (TK) invokes teacher knowledge about traditional and new technology applications combined into the curriculum. Figure (1) shows these three primary forms of knowledge (CK, PK, and TK): interacted, constrain, and integrated.

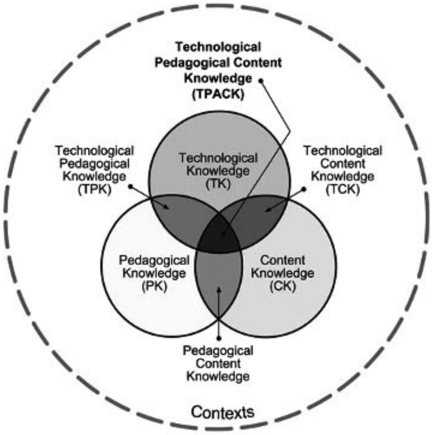

Figure 1

The technological pedagogical content knowledge framework (Koehler and Mishra 2009)

Pedagogical Content Knowledge (PCK) accredits the pedagogical approaches, specific learning objectives, and best practices for teaching educational content targeted to learners' various interests and skills (Shulman, 1986). Technology Content Knowledge (TCK) introduces the relationships and interactions between technological tools and specific educational practices, learning how to use the digital resources to enhance or modify content, and how to display it to students and have them interact with it. Technological Pedagogical Knowledge (TPK) refers to the connection and intersections between technology and learning objectives and how digital tools enhance learning outcomes and experiences. (Mishra & Koehler, 2006, 2008; Koehler & Mishra, 2009; Koehler et al., 2014).

Voogt et al. (2013) conducted a systematic review of 55 peer-reviewed academic publications (plus one book chapter) on TPACK, published between 2005 and 2011. The review main objective was to investigate the theories, models, and practical applications of TPACK. They make several recommendations for further research on the TPACK framework's evolution. Koehler et al. (2016) introduce the TPACK framework that describes knowledge for effective technology integration. On the other hand, Tondeur et al. (2016) arranged a symposium that includes four studies exploring research questions concerning identifying effective strategies to prepare teachers for technology use from different perspectives.

Virtual Laboratory

E-learning has enhanced teaching and reinforced learning science concepts through the rapid development of web-enhanced science courses as an alternative to the traditional approach. The virtual lab is used to create an e-environment where learners work in a virtual space while engaging in science learning activities. A web-based laboratory approach combines both hands-on activities and virtual experiences. A virtual lab provides students with a virtual experience that attempts to engage them literally while possessing the quality of a comparable hands-on lab experiment. Several authors define virtual labs and state their benefits. Chatterjea (2008) refers to the virtual lab as a lab facility on virtual space that can be accessed through the internet. Kuleshov (2008) defined a virtual lab as "A web site or software for interactive learning based on simulation of real phenomena. It allows students to explore a topic by comparing and contrasting different scenarios, to pause and restart the application for reflection and note-taking, and to get practical experimentation experience over the Internet". According to (Ramadhan & Irwanto. 2017), a virtual laboratory is a media that can enable direct experimental visualizations via an interactive virtual environment in practical and more efficient experimentation and cost savings on experimental tools. (Ramadhan & Irwanto, 2017) used qualitative research methods to analyze 23 papers about the benefits of virtual labs in science learning. Their results exhibited that the virtual laboratory could improve students' problem solving, critical thinking, conceptual understanding, creativity, lab and science process skills, motivation, and learning outcomes. Therefore, they recommend that educators adopt virtual laboratories to improve teaching quality and student learning outcomes. Chu (1999) developed an interactive virtual laboratory system for sub-degree engineering students. The positive feedback from the students regarding this innovative working environment encouraged developing the virtual laboratory through many cycles of design, testing and evaluation, and modification.

Geoscience is a life science that studies different subjects related to earth sciences; it depends mostly on laboratory exercises, experiments and field trips and in-Situ tests to understand and model some geologic phenomena. Laboratory activities in geoscience classes build up and strengthen skills and knowledge that assist the competence of lesson objectives. Students use the scientific method in lab investigations, answering questions by conducting experiments, using necessary materials, following logic procedures, using equipment and materials, collecting data and analyzing it, and coming to conclusions. Identifying minerals' physical properties (Skinner & Murch 2011) is an essential geologic subject that students must practically understand. Hence, it is crucial to set a virtual laboratory as a hands-on lab to identify these properties. K12 stride company (2020) empowers high-quality reinforcement learning developed a virtual laboratory of rocks and minerals (VLRM) simulation (Figure 2) using artificial intelligence designed using Flash Reinforcement Learning platform (FlashRL), which supplies an environment for Flash games on a novel platform for Flash automation (Anderson et al., 2018) Educators can perform standard mineral identification tests on selected mineral samples in this lab. The lab was designed with learning objectives to conduct examinations for color, hardness, streak, luster, fracture, cleavage, and other unique properties on some mineral samples to identify them like reaction with HCL and magnetism.

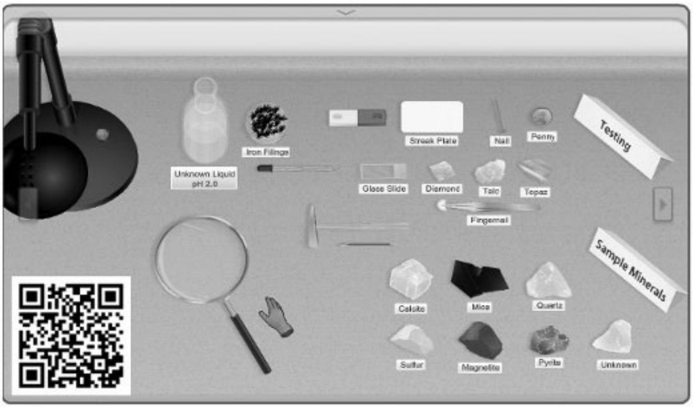

Figure 2

Virtual laboratory of rocks and minerals (VLRM) developed by a 12K stride company (2020), illustrating the testing tools and sample minerals. The QR is a demonstration walk-through of how to use the lab Activity.

Materials and methods

This study is based on (TPACK) framework (Mishra & Koehler, 2006, 2008; Koehler & Mishra, 2009; Koehler et al., 2014) to produce effective learning by integrating an online virtual laboratory of rocks and minerals among math and science pre-service teachers at the College of Basic Education (CBE). The researchers used a (VLRM) developed by K12 stride company (2020) in which data are available to students in ways similar to a hands-on lab scenario, and students can perform standard mineral identification tests on selected mineral samples. The exploration is nonlinear so that students can investigate minerals of their choosing in any order. Before using the virtual lab, the pre-service teachers introduced to a lecture targeting the subject that provided several photos, videos, and educational websites for various minerals, and the procedures applied to identify the fundamental physical properties of some minerals which can be tested using the tools provided in the virtual lab (i.e., color, streak, luster, hardness, cleavage, fracture, magnetism, and reaction with hydrochloric acid (HCL).

The instructional materials and strategies on mineral identification properties lesson were very well-organized and represented, and they were adapted to meet the various interests and skills of the pre-service teachers to promote their learning. A questionnaire was developed to assess Pre-Service teachers' perceptions of the learning strategies in using (VLRM), MS teams, and PowerPoint as learning tools.

Students must understand the procedure of identifying mineral's physical properties as it is one of the most critical lessons in geology. Accordingly, the pre-service teachers were informed that a questionnaire would be performed in the purpose of research to evaluate their point of view of the advantages and disadvantages of using "rocks and minerals virtual lab" that replace the hands-on laboratory as teaching moved off-campus during the Coronavirus pandemic and students learning online at home. Microsoft Teams (MS Teams) is a communication and collaboration platform developed by Microsoft as a part of the Microsoft 365 family and was applied in this study as an E-learning management system due to the Coronavirus pandemic. It offers workspace chat and videoconferencing, file storage, and application integration. Microsoft PowerPoint was used to organize the presentations with illustrative infographics, figures, and videos as a part of the teaching tools. MS Teams and PowerPoint were adopted for online education and enhancing students' learning skills.

The current research also conducted a quantitative study to explore CBE pre-service teachers' perceptions regarding using the virtual lab of rocks and minerals concerning the teaching methodology plan. The researchers used a self-report survey methodology with several statistical tools to examine mean differences (Pearson correlation, multiple regression, Cronbach's Alpha, split-half coefficient, means, and ST Deviation. The evaluation tends to measure five basic categories (Domains).

1 - Evaluating the virtual rocks and minerals lab developed by the K12 stride company (2020).

2 - Adopting virtual labs in distance learning during the pandemic of Coronavirus and meeting via MS Teams.

3 - Providing for Cooperative learning among the pre-service teachers in work completion.

4 - Developing pre-service teachers' skills in presenting creative PowerPoint presentations and demonstrating the virtual lab testing tools to identify mineral's properties.

5 - Stating the difficulties and challenges in using virtual lab and distance learning.

The original survey was written in Arabic and then translated into English. To ensure the validity of this survey, a panel of professors from the College of Basic Education (CBE) reviewed the questions and endorsed the content validity of the items. In addition, the researchers conducted a pilot study before applying the survey and modified it according to the reviewers' and the instructors' feedback. The survey was scored using the five-point scale of Likert (1932). After creating the final form of the questionnaire on Microsoft Forms, the researchers sent the final version of the questionnaire as a web link to the targeting sample of the pre-service teachers.

Participants

The study sample consisted of 79 pre-service science and Math's teachers' that took geological courses; general geology (GG) and economic geology (EG)) as part of their graduate major sheet. The percentage of pre-service science teachers (ST) is 54.4%, while the pre-service Math's teachers (MT) is 45.6%, and the proportion of those studying general geology (GG) is 51.9%, and those studying economic geology (EG) is 48.1%. None of them used a virtual laboratory (VL) before Table 1.

Table 1:

sample descriptive

		Frequency	**%**
Specialization	**ST**	43	54.4
	MT	36	45.6
Course	GG	41	51.9
	EG	38	48.1
Using VL before	No	79	100
Total		79	100

Procedure

Measure Pre-Service teachers' performance: The pre-service teachers' assessment for lesson grading depends on a series of questions related to the lab lesson, including demonstrating the using of the virtual lab minerals and tools to identify physical properties of the minerals, creating a creative presentation of a data table classifying minerals according to their properties, and listing the advantages and disadvantages of this virtual lab. The collaboration between the team in producing a creative talk and PowerPoint presentation, also, assisted for grading based on their final work and attitudes using an assessment rubric design for this purpose (Figure 3). The assessment results were very promotive, as 88% of pre-service teachers were graded by excellence, and 12% were very good.

Assessment Rubric
Rocks and Minerals Virtual Lab

General info	
Course name: (choose one)	Introductory Geology
	Economic Geology
Team Code:	
Team leader:	
Students' names:	
(1)	(2)
(3)	(4)
(5)	(6)

Student assessment*					
Student Name:					
Criteria	Excellent	V. Good	Good	Intermediate	Poor
Understanding the Subject					
Capability to convey information					
Presentation structure					
Level of student collaboration					
Ability to motivate participants interaction					
Potential to manage feedbacks and discussions					

Student's overall evaluation	Excellent	V. Good	Good	Intermediate	Poor

*Each student has its own form of evaluation

Project assessment*					
Criteria	Excellent	V. Good	Good	Intermediate	Poor
The degree to which the activity follows the instructions					
Quality of the scientific material					
Tools and methods used					
Achieving educational goals					
Diversity of interactive activities and exercises used					
The Success of the cooperative activity					
Duration of activity display					

Project evaluation	Excellent	V. Good	Good	Intermediate	Poor

Quantitative Grading

Evaluation	Excellent	V. Good	Good	Intermediate	Poor
Student evaluation	5	4	3	2	1
Project evaluation	10	8	6	4	1

Figure 3

Assessment rubric for pre-service teachers and projects

Calculate the relationship between items: Pearson correlation was used to calculate the relationship between the items. It was used to calculate the correlations of the items with subdomains Table 2. Correlation coefficients between items and axes of the questionnaire were positive and statistically significant at the level of 0.01 and ranged between 0.338 - 0.928, indicating the validity of the questionnaire axes.

Table 2:

Pearson correlation between items and domains degrees

Evaluating (VLRM)		Distant learning and the use of (VLRM)		Cooperative learning		Application of Power-Point presentation		Attitude towards (VLRM)	
N	Correlation	N	Correlation	N	Correlation	N	Correlation	N	Correlation
1	0.359	1	0.734	1	0.837	1	0.896	1	0.778
2	0.338	2	0.800	2	0.858	2	0.865	2	0.796
3	0.422	3	0.735	3	0.824	3	0.867		
4	0.218	4	0.632	4	0.905				
5	0.419	5	0.718	5	0.928				
6	0.679	6	0.634	6	0.901				
7	0.726	7	0.777						
8	0.646	8	0.385						
9	0.563								
10	0.497								

Note. Significant of Correlation at 0.01 level

Findings of this study indicate that the survey instrument is reliable in applications with CBE instructors. The internal consistency reliability (ICR), as well, is calculated using Cronbach's Alpha in Table 3.

Table 3:

Cronbach's Alpha scores

Domains	Items	Cronbach's Alpha
Evaluating (VLRM)	11	0.560
Distant learning and the usage of (VLRM)	8	0.831
Cooperative learning	6	0.938
Application of PowerPoint presentation	3	0.846
Attitude towards (VLRM)	3	0.544
Total questionnaire	31	0.916

The value of Cronbach's Alpha coefficient of stability for the overall questionnaire is (0.916) and ranges for the sub-domains between (0.544-0.938), and that values are indicative of the questionnaire stability and its axes despite the high value of the Cronbach's Alpha coefficient in the Cooperative learning axis.

Evaluate Pre-Service teachers' perceptions in using (VLRM), MS teams and PowerPoint as learning tools: The inquiries in each of the five categories (domains) were ranked and rearranged according to the observation level of importance indicated by the Mean values. The significance levels of mean values were classified into three classes as follows:

- Low: 1 - 2.33.
- Medium: 2.34 - 3.66.
- High: 3.67- 5.

The first inquiry category was tackled by exploring the pre-service teachers' attitudes towards the applications of (VLRM) after a lesson, that covers this issue. Table 4 demonstrates the inquiries applied to measure the degree of using VLRM. It displays the arithmetic averages (Mean), standard deviations (SD), the significance levels of mean values, and ranking.

Results and Discussions

Table 4:

Evaluate the VLRM (Means and SD)

N	Inspections	Mean	SD	Level	Rank
9	The provided virtual testing tools were easy to use and helped identify the physical properties of minerals.	4.09	0.771	High	1
10	The provided virtual minerals for examination were sufficient for learning the fundamental concepts of the physical properties of minerals.	4.01	0.899	High	2
1	I examined the physical properties of minerals in a Hands-on laboratory.	3.91	1.015	High	3
7	The walk-through instructional demo enabled a realistic review.	3.87	0.939	High	4
6	The walk-through instructional demo was simple and useful.	3.84	0.912	High	5
8	The walk-through instructional demo reinforced the concept of self-learning.	3.82	0.971	High	6
5	Activating the virtual lab's flash player on google chrome was straightforward and manageable.	3.66	0.904	Medium	7
3	I prefer to substitute the Hands-on laboratory with a virtual laboratory.	3.02	1.064	Medium	8
4	I faced difficulties in studying the minerals physical properties in a virtual laboratory.	2.70	0.925	Medium	9
2	I faced difficulties in learning those properties in a hands-on laboratory.	2.59	0.884	Medium	10
	Total score	3.32	0.522	Medium	

The results in table 4 demonstrate that the student's assessment of using VLRM was Medium with an arithmetic average value of 3.32.

The values of the statements ranged between 4.09 - 2.59 representing high to medium levels. The High levels reported in the following inquiries:

1 - The provided virtual testing tools are easy to use and have helped identify the physical properties of minerals.

2 - The provided virtual minerals for examination are sufficient for learning the fundamental concepts of the physical properties of minerals.

3 - I examined the physical properties of minerals in a hands-on laboratory.

4 - The walk-through instructional demo in the virtual laboratory has enabled a realistic review.

5 - The walk-through educational demo was simple and useful.

6 - The walk-through instructional demo reinforced the concept of self-learning.

The statements in the medium level as the students' views were:

1 - Activating the virtual laboratory's flash player on google chrome was straightforward and manageable.

2 - I prefer to substitute the hands-on laboratory with a virtual laboratory.

3 - I faced difficulties in studying the mineral's physical properties in a virtual laboratory.

4 - I faced difficulties in learning those properties in a hands-on laboratory.

The second inquiry investigates the pre-service teachers' difficulties in learning the minerals' physical properties in a hands-on laboratory, which refers to the ease of using (VLRM). Accordingly, they asked to present their preference between a hands-on laboratory and the virtual laboratory or a combination of both. Figure 4 shows that the sample preference ratios for hands-on laboratories and the combination of both were equal to 39.1%. While the percentage of pre-service teachers who favor virtual labs and those not specified "don't know" were 10.9%. Subsequently, 89% of the sample prefer practicing the fundamental methodology in identifying the physical properties of minerals.

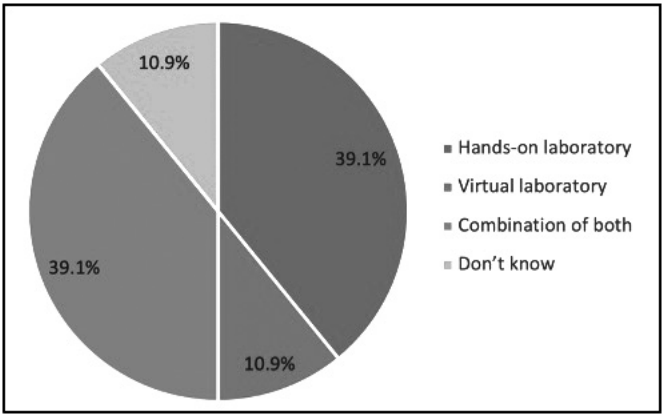

Figure 4

students' preference

The second group of questions addresses to what extent the MS Teams and the (VLRM) applications enhanced mineral's properties identification lesson and the benefits of using these applications in distant learning during the covid-19 pandemic Table 5.

Table 5:

Assessment of using MS Teams and (VLRM) in distant learning (DL)(means and SD)

N	Inspections	Mean	SD	Level	Rank
6	Training exercises to determine the physical properties of minerals adopting a virtual laboratory has resolved the inability to preforming the practice in hands-on labs due to the COVID-19 pandemic.	4.14	0.873	High	1
8	The virtual laboratory provides tools to measure the hardness of minerals that were not available in the hands-on laboratory, such as diamond.	4.04	0.869	High	2

Cont. Table 5:

Assessment of using MS Teams and (VLRM) in distant learning (DL)(means and SD)

N	Inspections	Mean	SD	Level	Rank
4	The MS Teams has promoted sustainable development by converting paper assignments into electronic versions.	4.01	0.792	High	3
7	The use of the virtual laboratory has encouraged sustainable development by converting paper assignments into electronic versions.	3.92	0.781	High	4
2	The MS Teams facilitated effective feedback with the instructor.	3.87	1.005	High	5
3	The MS Teams facilitated positive feedback among team members.	3.80	0.911	High	6
1	Using the MS Teams in distant learning was an uncomplicated and straightforward process.	3.73	1.118	High	7
5	The application of virtual laboratories in distant learning is effortless.	3.53	1.011	Medium	8
	Total score	3.88	0.627	High	

The results in table 5 demonstrate that the students' evaluation of distance education and the uses of VLRM and MS Teams was high with an average arithmetic value of 3.88, and the importance ranged in level between 4.14 - 3.53 that is high to medium. Inquiry 6 came with the highest level, while inquiry 5 came with the lowest. The ranking in the table 5 exhibits the observations level of priorities.

The third domain assessed the cooperative learning (CL) in work completion using VLRM and MS Teams during the covid-19 pandemic Table 6.

Table 6:

Cooperative learning (CL) Strategy (means and SD)

N	Inspections	Mean	SD	Level	Rank
3	CL contributed to the discussion and practical experiments in the identification of the unknown mineral.	4.41	0.689	High	1
4	CL encourages an active learning environment.	4.32	0.777	High	2
2	CL enhanced decision-making skills regarding the identification of the physical properties of different minerals.	4.30	0.722	High	3
5	CL develops communication skills.	4.29	0.787	High	4
1	CL enhanced educational attainment.	4.27	0.828	High	5
6	CL contributed to overcoming challenges and speed of achievement.	4.27	0.930	High	6
	Total score	4.31	0.692	High	

This domain trigged the assessment of the benefit of implementing group work to invest the time and to overcome the frustrations, tensions, and challenges brought by the covid-19 pandemic, and the switch to remote learning and ensure the quality of e-learning output. Both general and economic geology courses were grouped into small groups, and each group was comprised of 5-6 students. A group work strategy was assumed to be an effective method to motivating students, encouraging active learning, developing communication, essential critical thinking and decision-making skills, and investing time. Interpretation of table 6 data demonstrates that the students' evaluation of collaborative learning strategies used to complete the assignment of identifying mineral's properties using VLRM via MS Teams was remarkably high with a very positive view and an average arithmetic value of 4.31.

The fourth question category examined the teamwork productivity as evidenced by the final PowerPoint designed structure and oral presentation Table 7.

Table 7:

Evaluate the usage of PowerPoint tools (Means and SD)

N	Inspections	Mean	SD	Level	Rank
1	PowerPoint tools play an essential function in improving presentation skills	4.05	0.783	High	2
2	Infographics are a visual representation of data or information that aids in developing presentation skills.	3.95	0.876	High	3
3	Educational videos possess an active aid in enhancing presentation skills.	4.16	0.791	High	1
	Total score	4.05	0.715	High	

These questions were constructed to examine the advantages of using PowerPoint tools and supporting material like infographics, figures, and videos to build a creative presentation that represented self-learning and collaborative group effort to identify mineral's physical properties using the available minerals and tools provided with the VLRM. Oral presentation targeted to enhance student confidence in speaking tasks. The mean values and the standard deviation calculated in the fourth category inspections Table 7 are high, with an average arithmetic value of 4.05 and 0.715 respectively. The analysis shows that the approaches used to develop pre-service teachers' presentation skills in creating an informative presentation and increasing student confidence in speaking tasks were adequate.

The fifth questions category measures the challenges in distance learning in general Table 8 and uses the VLRM in specific Table 9.

Table 8:

The Challenges in using Virtual Laboratory

Inspections	Frequency	%	Rank
Wi-Fi connections problems	49	62.0	1
Understanding the learning objective of VLRM	16	20.3	3
VLRM does not support the use of smartphones.	39	49.4	2

Digital transformation of education due to the Covid-19 pandemic was an unplanned issue. As seen in Table 8, the most significant challenge was the internet interruption due to poor Wi-Fi connectivity. The second challenge was that the VLRM does not support smartphone users as most of the students don't have computers and mostly depend on smartphone applications to do most of their assignments. The least challenging issue representing 20% of the sample was understanding the minerals' lesson and performing tests to identify minerals' physical properties. Table 9 displays the final questions concerning the pre-service teachers challenging experience with VLRM because it is their first time using a virtual laboratory and remote learning. The outcomes demonstrate a medium level of agreement in using virtual laboratories in both distance and traditional learning as the mean values range from 3.49 - 3.33. The output feedback of the pre-service teachers' experience in the virtual lab questionnaire is summarized in Figure 5, illustrating a medium to a high significance level.

Table 9:

Evaluate the agreement of using virtual laboratory (VL) in both distance and traditional learning (Means and SD)

N	Inspections	Mean	SD	Level	Rank
1	I agree to use a virtual laboratory in distant learning.	3.49	1.119	Medium	1
2	I agree to use virtual laboratories in Traditional learning.	3.33	1.163	Medium	2
	Total score	3.41	0.898	Medium	

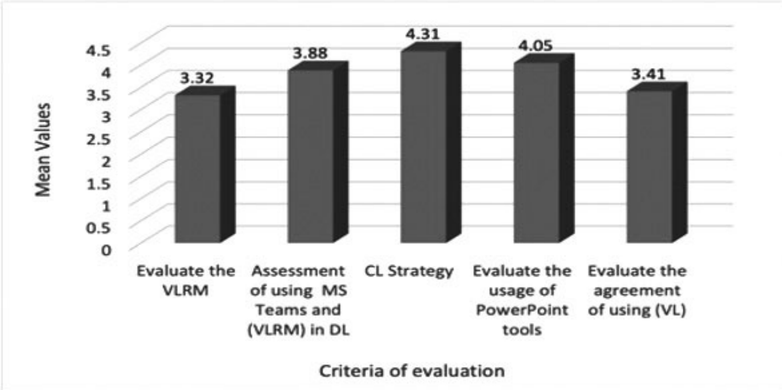

Figure 5

Summary of the output feedback of the pre-service teacher experience in the virtual lab questionnaire.

Analyzing the significant differences related to the domains means according to the field of specialization (science major and mathematics minor (S & M) or vice versa (M & S) and the course (module) being attended (general geology (GG) or economic geology (EG) using independent samples t-test shows no significant differences and in the same level (at level =0.05) Table 10 and Table 11. This result is achieved as both courses are instructed by the same instructor applying the same methodology for both, and none of them has ever practiced a virtual laboratory before.

Table 10:

The difference in domains means according to field of specialization

Domains	field of specia-lization	N	Mean	SD	T-test	Sig
Virtual labora-tory application	S & M	43	3.28	0.520	0.606	0.546
	M & S	36	3.36	0.529		
Distant learn-ing and the usage of virtual laboratories	S & M	43	3.83	0.648	0.772	0.443
	M & S	36	3.94	0.604		

Cont. Table 10:

The difference in domains means according to field of specialization

Domains	field of specialization	N	Mean	SD	T-test	Sig
Cooperative learning	S & M	43	4.27	0.661	0.567	0.572
	M & S	36	4.36	0.734		
The usage of PowerPoint presentation tools	S & M	43	4.04	0.746	0.217	0.829
	M & S	36	4.07	0.686		
Attitude towards usage of virtual laboratories	S & M	43	3.34	1.051	-0.801	0.426
	M & S	36	3.50	0.676		

Table 11:

The difference in domains means according to the course (module) being attended

Domains	Course	N	Mean	SD	T-test	Sig
Evaluating the virtual laboratory application	(GG)	41	3.33	0.500	0.225	0.822
	(EG)	38	3.30	0.552		
Distant learning and the usage of virtual laboratories	(GG)	41	3.80	0.597	1.128	0.263
	(EG)	38	3.96	0.656		
Cooperative learning	(GG)	41	4.37	0.633	0.879	0.382
	(EG)	38	4.24	0.752		
Evaluation the usage of PowerPoint presentation tools	(GG)	41	4.02	0.751	0.391	0.697
	(EG)	38	4.09	0.683		
Attitude towards usage of virtual laboratories	(GG)	41	3.35	0.777	0.591	0.556
	(EG)	38	3.47	1.020		

Conclusion

This study is the first of its kind in Kuwait and GCC countries. The purpose of this study was to evaluate how effective a proposed program based on the TPACK framework capabilities is in developing pre-service teachers' technology-based learning for undergraduate courses during the Coronavirus pandemic. The study implemented K12 stride's rocks and minerals virtual laboratory as the primary tool for studying mineral's properties incorporating Microsoft Office 365 applications (MS Teams-PowerPoints) in distance learning to evaluate the usefulness of such tool in geoscience teaching. The study demonstrates that virtual laboratories are essential for promoting the education environment. The assessment rubric for grading the pre-service teachers' attitude and their project was very promotive, as 88 % of them were graded by excellence, and the 12% were very good. The output feedback of the pre-service teacher experience in the VLRM concerning the five basic categories (Domains) evaluated in the questionnaire demonstrates a medium to a high significance level of mean values.

The pre-service teachers stated only one disadvantage of VLMR, which is the poor internet connection. On the other hand, they list many advantages of the application of VLMR:

1 - The simulation helped test the mineral's hardness using diamond as it is not provided in a genuine Mohs hardness scale test kit.

2 - They were confident in using tools and minerals without worrying about breaking or damaging them.

3 - They feel safer in testing the reaction of minerals with hydrochloric acid (HCL) as it is a hazardous liquid that must be used with care and not come into contact with the skin or eyes.

4 - They Can plan their time and progress in studying according to their learning capabilities.

5 - They were having a fun time practicing the VLRM as video games.

In the previous studies on learners' attitudes and TPACK, instructors have provided scientific contributions in numerous scenarios prepared previously. This research, however, offers uniqueness in learners' attitudes and TPACK in the context of the Covid-19 epidemic, which requires the instructor to apply an online geoscience lab education without previous training in using virtual labs for both instructor and learners. In addition, as a research contribution, this research provided the key to the geological instructors to overcome any obstacles and potential in educational strategy while adopting online distance learning. Turning adversity into a blessing and designing an interactive strategy that meets the learner's diverse abilities and talents to motivate distance learning in the context of abrupt face-to-face education shed light on the importance of the instructor Knowledge in the subject area, pedagogy, and technology. This study supports the importance of developing various geological virtual lab exercises that improve the quality of e-learning strategies in the future.

Recommendations

The TPACK framework represents a comprehensive understanding of how content and teaching methods must form the foundations for successful educational technology integration to improve student learning outcomes. Accordingly, it is highly recommended to embrace virtual labs in science education and geoscience with well-constructed instructional materials and strategies. Because no chemicals or waste materials will be produced, the artificial intelligence in designing the virtual labs supports laboratory health and safety, sustainable development, and waste management besides the educational purposes and methods. Instructors and trainers must develop their skills in integrating technology based on a comprehensive understanding of the subject material's content and learning strategies. The limitation of computer laboratories and the shortage of access to the bayed application packages can be overcome by investing the open-access virtual labs in a web browser or cloud computing. Virtual labs have an intriguing potential that facilitates distance learning, allowing students to learn at their speed and time in a healthy and safe environment, and promotes interactive learning.

تطبيق إطار TPACK عن طريق تبني مختبر افتراضي جيولوجي مع معلمات ما قبل الخدمة في كلية التربية الأساسية في الكويت

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كلية التربية الأساسية - الهيئة العامة للتعليم التطبيقي والتدريب

دولة الكويت

ملخص

طبقت الدراسة نموذج تيباك (TPACK) عن طريق توظيف تقنية المختبر الافتراضي لفحص الصخور والمعادن كبديل للمختبر الحقيقي لتحقيق تعلم عن بعد فعال ونشط لمعلمات ما قبل الخدمة في تخصص العلوم والرياضيات في كلية التربية الأساسية في الكويت. تم تصميم محتوى تعليمي واستراتيجيات تحفيزية بشكل منظم ودقيق مع مراعاة الفروقات الفردية في القدرات والمواهب. طبقت الدراسة على عينة من معلمات ما قبل الخدمة يدرسن مقررات جيولوجية لم تستخدم أي منهن المختبرات الافتراضية من قبل، وتم تدريبهم على منهجية التدريب الذاتي والتواصل من خلال (MS Teams) كنظام لإدارة التعلم عن بعد. أظهرت نتائج القياس والتقويم الخاصة بتقييم المشاريع درجات مشجعة للغاية، حيث تم تصنيف 88% منهن بتقدير امتياز، و12% منهن بتقدير جيد جدًا. أوضحت التغذية الراجعة والملاحظات من تجربة استخدام المختبر الافتراضي لمعلمات ما قبل الخدمة نتائج متوسطة إلى عالية من الأهمية للقيم المتوسطة. أوصت النتائج باستخدام المختبرات الجيولوجية الافتراضية وفق مواد تعليمية واستراتيجيات تعلم فعالة.

الكلمات المفتاحية: TPACK، المختبرات الافتراضية، التعلم عن بعد، الجيولوجيا، نظام إدارة التعلم.

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