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Assessing Lecturers' Technological Pedagogical Content Knowledge in Teaching Online Courses at Selected Universities in Liberia

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Abstract Teachers' nature plays a critical role in creating a learning environment that allows students to successfully engage with the current educational framework. When integrating technology into education, it's crucial to understand its impact and utilize it effectively for teaching purposes. The purpose of this research was to evaluate the technological and pedagogical content knowledge of university lecturers involved in online teaching in Liberia. The research employed a mixed method, that is, a blending of qualitative and quantitative data. The study's population consisted of 350 lecturers from three chosen universities, and a simple random sampling process yielded a sample size of 170, in which 165 participants took part. Among the participants, 155 completed survey questionnaires, while 10 lecturers participated in open-ended interviews to provide additional insights. The findings indicated that the lecturers had a basic understanding of TPACK. Lecturers had different levels of technology awareness and skills for online instruction. Particularly, knowledge gaps emerged in technological content and pedagogical expertise. The study found a positive relationship between pedagogy knowledge and TPCK, and it highlighted the complex interaction between teaching expertise, technological components, and successful technology integration. The study proposed that education stakeholders organize specialized training programs to improve TPACK capacity for online instruction. This will deepen lecturers' understanding of the model. Adequate resources, such as internet connectivity, hardware, and software, are important for quality online teaching. The technical infrastructure should be maintained and updated with the necessary investments. Strengthening teachers through TPACK and providing strong technical support is critical to enhancing online learning experiences.

Keywords: *e-learning, digital pedagogy, technology integration, teaching effectiveness, TPACK*

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1. Introduction

The educational landscape has changed dramatically in the twenty-first century. The days of merely being able to teach in a classroom have long passed. As a result of the internet, the fundamental technique of learning has undergone a paradigm shift. Online schooling is becoming increasingly popular. Online learning is likely to develop quickly, thanks to technological advances and increased access to the rapid internet. In recent years, the framework known as Technological Pedagogical Content Knowledge (TPACK) has attracted significant attention for its effective integration of technology [1]. E-learning is no longer limited to a planned and implemented pattern featuring only one-way conversations between the teacher and the students. [2] highlights the importance of ensuring that all teachers possess the necessary confidence to effectively utilize technologies. The effectiveness of technologies in improving how students learn depends on how skillfully teachers use these tools to enhance education. [3] stressed that technological improvements in virtual settings allow learners to be active participants in knowledge acquisition through real-time collaboration and assessments. This has considerably boosted the efficiency of the teaching approach and brought it up to pace with classroom-based learning [3]. The importance of using technological tools to enhance students' learning outcomes is highlighted by [4]. There is a general belief that these elements are basic prerequisites for effectively disseminating instructional content.

This belief suggests that using different types of instructional resources can enhance students' learning outcomes. Online learning has emerged as one of the major discoveries of the 21st century. Digital knowledge is enabling the expansion of education throughout society, undoubtedly the most beneficial development of our era. It provides an opportunity that, if properly capitalized on, has the potential to take the entire world into a new period of prosperity and wealth [5]. Technological breakthroughs have made it feasible to achieve an unprecedented level of modification. Teachers can redesign curriculum practices in ways that advance each learner's interests, skills, and abilities by playing the roles of models, assets, and strategic partners.

The web is a prime source of education, including distance learning, access to global experts, global collaboration, accessible archives, and e-libraries. Learning can occur in practically any location [6]. Similarly, [7] states that the advent of the Internet and other digital resources has enabled educators to develop innovative educational settings and activities that occur in online settings. Utilizing ICT tools can enhance learners' capacity to use higher-order thinking abilities more efficiently. However, the insufficient proficiency and effectiveness of Liberian teachers, along with their lack of willingness to employ ICT, result in students being inadequately prepared [8]. Instructors' attitudes play an important role in determining the implementation of technology in education.

The pandemic forced educational institutions worldwide, including the University of Liberia (UL), to postpone their classes. Therefore, the system faced pressure to incorporate e-learning into the entire curriculum, despite its inadequate infrastructure. This especially applies to the technological challenges that e-learning poses. Some students may experience substandard implementation of proper online learning due to lecturers' lack of technological readiness [9].

Technological teaching practice has become an essential aspect that teachers should use to improve their teaching roles during online course delivery. During the adoption of fully remote instruction, it became obligatory for learners and faculties to obtain the requisite knowledge and training. Faculty members, often referred to as those from the "pre-computer era," found this particularly applicable. Because it was the first time for universities in Liberia to offer courses online, teachers and students received daily training on various e-learning platforms, such as Moodle and Google Classroom, among others [9]. Teaching through technological applications is difficult to manage, but professors at universities in Liberia need to implement online teaching methods to meet the current reality and increase the quality of education. Moreover, it is globally known that technological pedagogical knowledge aids learners in overcoming their educational shortcomings and improves the quality of their learning.

According to a study by [10], learners who don't have access to people with the necessary skills or who can help them can benefit from online resources. Moreover, the innovative nature of online resources can aid in alternative education and bolster online professional education and advancement in universities during times of crisis. Furthermore, in times of crisis, such as Ebola and COVID-19, when it's not possible to conduct in-person classes, the use of TPACK and online teaching applications can provide effective and adequate learning opportunities. With some universities in Liberia now using a blended mode for teaching and learning, this paper, therefore, sought to assess the lecturer's TPCK and how they implement it in online teaching to enhance the learners' skills and achievements in Liberian universities.

1.1. Aims and Objectives

The study aimed to evaluate lecturers' TPACK and its use in online teaching at universities in Liberia. To achieve this goal, the study encompasses the following general objectives:

1. To evaluate the teaching expertise required for online courses.
2. To investigate the level of technological expertise required for teaching online courses.
3. To assess the skills required for maintaining a learning environment while teaching online courses

In pursuing generalized objectives, the successful completion of this study hinged on meeting these specific objectives:

1. To investigate how lecturers at universities in Liberia use TPACK
2. To assess the lecturers' approach toward TPACK during online lectures at universities in Liberia
3. To investigate TPACK's role in online teaching methods
4. To analyze the improvements offered by TPACK in online teaching

1.2. Research Questions

In quest of meeting the aims, the following questions were carefully designed to formulate an ecologically valid conclusion for this research:

1. What are the perceptions of Liberian lecturers about teaching online and student learning?
2. How does1TPACK improve lecturers' teaching quality at universities in Liberia?
3. What role does TPACK play in online teaching and evaluation methods?
4. What approach do the lecturers use while teaching online courses at universities in Liberia?
5. How does TPACK improve teaching in online course delivery?

2. Literature Review

Over the past years, educational integration of technology has been transformative, while the framework for TPACK has played a pivotal role. [11], [12] have demonstrated the importance of TPACK in innovating without losing content or pedagogy. [13] likened the role of technology to seasonings in a soup, highlighting its integral role in enhancing the learning process. [14] and [15] both emphasized the need for the teacher to master the technology so that she could produce an intriguing pedagogy and content. They believe that technology alone does not improve instruction.

[16] and [17] discussed the challenges and opportunities provided by technology for instruction and learning in education. In this process, Goradia insists on using more than one technology. [18] and [19] assert that we should apply TPACK to pedagogy, balancing out the experience, training, and self-efficacy of teachers, as argued by [20]. This overview of studies relates the multifaceted, essential nature of TPACK to the ongoing

evolution of pedagogy. The TPACK framework is critical to the pedagogical use of technology. TPACK has the combining effect of technological, pedagogical, and content knowledge [21]. In teaching practice, this model evolves with careful planning and reflection [22]. According to [23], teachers with strong pedagogical content knowledge are likely to improve students' outcomes. [24] and [18] assert that pedagogical content knowledge has a significant influence on teaching effectiveness. According to [25], teachers tend to overestimate their own competencies, resulting in differences in their self-evaluation. Similarly, skills for integration with technology differ among educators. According to [26], higher scores on TPACK relate to innovative teaching.

The pandemic enabled the use of online pedagogical tools [27]. According to [16], TPACK facilitates the use of technologies such as online whiteboards to improve learning effectiveness. In addition, TPACK can generate new knowledge, which is important for effectively using educational technology and pedagogy online. Factors such as experience, training, and comfort level with technology influence the differences in TPACK levels among educators [26,28,29]. Therefore, there is a relationship between TPACK and the effective use of educational technology and pedagogies.

2.1. Challenges of Lecturers in Teaching Online Courses

In a customary lecture room, the task of an educationalist is to provide lectures to the students who are sitting in a row and listening attentively in class. As time changes, the role of teachers has evolved, and students are likely to take an active part in discussions and lectures. Students benefit from faculty members' dedication to online teaching, despite a lack of study on the elements that push or slash these efforts [30].

Lecturers face numerous challenges as they quickly transition from conventional to virtual education. Teachers are still adjusting to virtual education, which requires continuous learning to effectively establish, teach, and integrate courses. The study by [31] identified several factors that influence the efficacy of online learning. These aspects encompass facilities, instruction, feelings of isolation, negative emotions, adaptability, and suitability. [32] offers a comprehensive explanation of the difficulties encountered in the realm of virtual education. These challenges include inadequate training for educators and institutional support, issues with internet access, maintaining student engagement, conducting online assessments, and navigating the unique features of online education. Major issues hampering online course delivery include accessibility problems, instructional strategies, effective virtual classrooms, and limited technological skills [33]. Instructors faced a range of problems, such as shifts in their responsibilities, the transition from traditional to virtual training, issues with scheduling, and struggles in developing successful teaching methods. The content-related challenges encompassed the integration of multimedia, the use of instructional techniques, the participation of instructors in content creation, and concerns regarding distribution [14].

In Liberia, there could potentially be a compromise in the quality of education and the seamless integration of technology into courses, leading to a decrease in learning outcomes. Lack of ICT support for lecturers and students, internet connectivity issues, ICT facility issues, and electricity issues contribute to this situation [34].

2.1.1. Asynchronous Mode

During the online lecture, connectivity gaps are critical; this is also known as synchronization. The negative impact of linkage gaps can be bothersome for both students and lecturers. During the pandemic, universities found it to be a significant factor in managing online lecture delivery. However, the notification of asynchronous gaps may have a negative impact when the lecture pauses due to internet problems and an imbalance in voice and video quality [35]. The role of the special asynchronous factors also accounts for the gaps in students' understanding and activity. [36] identified several hurdles associated with the hasty migration to virtual education, including difficulties in adjusting, scheduling issues, distractions from social media, and technical obstacles. [37] reported that students struggled with asynchronous communication, which included signal interference, inadequate internet speed, educational technology ignorance, and inflexible instructional materials. The student's inability to connect in time could potentially delay the delivery of the lecture video. As a result, the students were unable to ask questions or clarify any confusion. Connectivity and synchronization issues may result in the marking of the student as absent. A study conducted by [38] identified several challenges associated with online instruction. The challenges identified included poor internet connectivity, insufficient access to technology, decreased motivation, low self-assurance and understanding, nervousness, and a sense of detachment. To mitigate the challenges connected with implementing asynchronous learning methods during a pandemic, the institution, teachers, students, and other stakeholders must fulfill their respective responsibilities.

2.1.2. Born Before Computer Generation

Educational quality is lower in Liberia as compared to other nations around the world. This is due to the fact that Liberia falls below the poverty line, and many African countries already struggle to meet their basic needs, indicating that education is not a priority for the country. The pandemic in Liberia necessitated entirely remote instruction, forcing students and instructors to fulfill mandatory education requirements. This had a particularly significant impact on faculty members, often referred to as those from the "pre-computer era." Because this was the first time that Liberian educational institutions offered online courses, both the instructors and the students at the universities received daily training on how to use a variety of eLearning platforms, including Moodle and Google Classroom, amongst others [9].

In Liberia, digital concerns are a hindrance to delivering online education to students. The majority of teachers at Liberian higher education institutions are members of the "born before computers" age, which is not a generation that is particularly well-suited to the implementation of online education. This agrees with the opinion that many instructional staff in Liberia are inexperienced and require more training to improve the quality of instruction for online learners. According to [39], when individual patterns' activities change because of an unanticipated yet unstoppable force, both acceptance and utilization of technology become mandatory for them.

2.1.3. Compromising the Quality of Education

Several factors work against Liberia's ability to offer superior levels of higher education. These factors include unqualified faculty, overcrowded classrooms, libraries, and other facilities that lack adequate furnishings. The current facilities adequately accommodate the growing number of students. The limitations of public institutions stem from the underinvestment of the sector by meager public funds and real transfers to institutes by the Government of Liberia, as well as the absence of supplemental monetary support from other sources.

According to [34], there is a potential compromise in Liberia between the quality of education and the effective integration of technology into the curriculum. This compromise could result in a reduction in learning experiences. This problem stems from a lack of adequate ICT assistance, as well as issues with internet access, technology resources, and electricity. [40] argues that the Liberian college and university system lacks the essential components required to cultivate accomplished scholars and instructors capable of achieving global recognition in various fields. A comparative analysis, conducted by [41], suggests that online education compromises the quality of education. This is because most of the lectures may skip complex topics due to a shortage of time. Education faces specific financial constraints, like other development areas. According to the 2015 Educational Reform Act, higher education is a national priority and must receive at least 20% of the national budget. In both 2018 and 2019, education funding decreased from ten to thirteen percent, as well as from six to seven percent in 2019 [42]. The nation's declared objective of increasing investments in higher learning remains unrealized, leading to a significant decline in the quality of Liberia's educational system.

2.1.4. Non-reliable Online Exams

Most countries, including Liberia, observe differences in exam comparisons between online and traditional settings because of learners' physical presence. The virtual education system offers an advantageous approach to delivering lectures and improving student learning.

However, there is high disagreement on the online testing plans because they are not competitive in ensuring the value of material and assessing knowledge acquisition in the right manner due to a lack of effective invigilation and ensuring a sustainable environment. [43] emphasized that the use of online exams necessitates a more robust verification system to minimize the likelihood of cheating incidents. Liberian universities also agree with this point and demand traditional exams instead of online exams to ensure quality and transparency. Due to inefficiencies and gaps in the working output of online and traditional graduates in Liberia, it is not possible to compare the exam results with those of traditional students. According to [44], a genuine internet-based examination requires the fulfillment of several conditions. The conditions include aligning the taught subject matter with the examination description, understanding the student's needs, clearly defining the evaluation rule, providing adequate examination supervision at the designated time and place, utilizing appropriate technologies, and advancing the design of tests. The importance of designing learning activities that incorporate various characteristics, such as interaction, conceptual understanding, and facilitation, was emphasized in [45]. They also recommend the adaptation of evaluations to the new curriculum's demands.

2.1.5. Internet Connectivity Issue

The "techno-pedagogical" system is possible with the help of smart internet connections, which should be accessible for free or at lower costs. If the internet is active and does not fluctuate from time to time, this is positive support. [46] found that several variables, including insufficient facilities, limited connectivity, and a shortage of skilled ICT specialists, pose challenges when incorporating e-learning into the teaching of medicine in Liberia. Likewise, [47] states that the need for dependable and high-capacity connections to the internet is one of the difficulties with pursuing education online. Residential internet access typically has less connectivity, which can make it difficult for students to log in for a lesson. The online video lectures may use apps like Skype, Zoom, Google Meet, and others. These applications are quite resource-intensive and may require a reliable internet connection. This works properly with 4G and 5G connectivity.

Liberia has 4G connectivity in areas that do not cover the entire zone. This shows that the country needs to use strong 4G or 5G because connectivity matters for online lecture delivery. In addition, the high cost of maintaining internet connectivity presents a potential obstacle; consequently, long-term viability is an essential component. Due to government charges and a 2020 levy, Liberia ranked fifth in 2019 for the most expensive internet, leading many individuals to struggle to afford it [48]. Online instruction has certain drawbacks, as noted by [49]. These include piquing students' interest in studying, ensuring an adequate supply of educational resources, addressing inadequate internet connections, and maintaining ongoing interactions with students. It is necessary to have a stronger internet connection to participate in the online class; however, this could be prohibitively expensive for students from disadvantaged backgrounds who require a tablet or smartphone. However, the availability of these gadgets at affordable prices is limited, making it challenging for students with modest incomes to purchase them [47]. However, we urgently need to improve Liberia's technological infrastructure, given the significant connectivity gaps.

2.2. Theoretical Framework

The TPACK approach serves as the scientific foundation for this research. According to [50], this framework identifies three domains of knowledge necessary for the successful integration of educational technology. The three domains of knowledge are subject matter awareness, teaching technique awareness, and technology familiarity. "Intersections" refer to the relationships between each domain. "Technology, Pedagogical, and Content Knowledge," or TPACK, stands for the mastery, understanding, and skills that develop when all three domains merge and join cohesively. Those competencies are the foundation for effective technology integration.

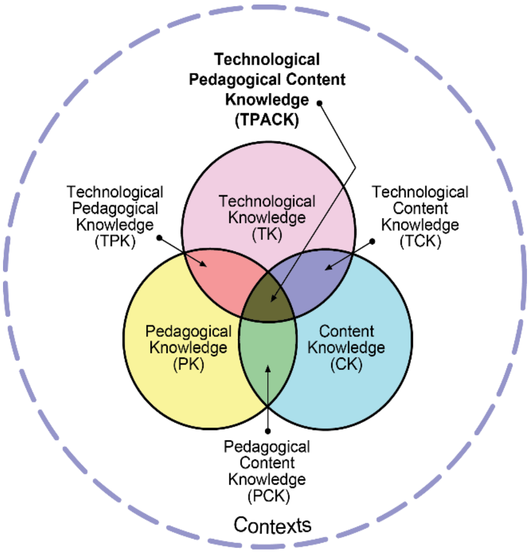

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Figure 1. Theoretical Framework

3. Methodology

This study examined lecturers' technological pedagogical content knowledge when teaching online courses. This study employed a mixed methods approach and considered 350 lecturers from three universities in the study area as its population. 170 lecturers were selected to participate in the research using a simple random sampling method. Of these, 155 lecturers responded to the survey, 5 failed to participate, and 10 instructors provided open-ended responses.

The data collection activity was the distribution of survey questionnaires that comprised demographic information, awareness of TPACK, online teaching experience, and in-depth interviews. Quantitative analysis used SPSS to analyze the distribution, variance, and correlations. Cronbach's alpha was employed to establish the importance of the model, the reliability of the model, and the reliability of the instrument, and thematic analysis was employed to analyze the unstructured questions from the interview.

4. Quantitative Results

The survey questionnaire selected about 160 samples for data collection. Of 160 respondents, five declined to participate in the survey. Therefore, the data analysis below applies to 155 lecturers.

The above table represents Cronbach's alpha statistics for both overall and individual components related to the study's objectives. This interpretation of the table indicates the level of internal consistency or reliability of the different TPACK components used in the instrument. The overall Cronbach's alpha coefficient of 0.911 for the entire instrument suggests that the items in the TPACK questionnaire are consistently measuring the same construct, indicating excellent internal consistency. The

The technological knowledge component has a Cronbach's alpha of 0.875, indicating high internal consistency among the six items that measure this construct. The content knowledge component shows excellent internal consistency, with a Cronbach's alpha of 0.782 for the seven items that assess this construct.

Table 1. Reliability Statistics

Reliability Statistics		
	Cronbach's Alpha	**No. of Items**
Overall	0.911	38
Technology Knowledge	0.875	6
Content Knowledge	0.782	7
Subject Specialization (Mathematics)	0.974	2
Subject Specialization (Social Science)	0.876	2
Subject Specialization (Science)	0.942	2
Pedagogical Knowledge	0.790	4
Pedagogical Content Knowledge	0.794	3
Technology Content Knowledge	0.907	3
Technology Pedagogical Knowledge	0.905	3
Technology Pedagogical Content Knowledge	0.844	5

The subject specialization components (mathematics, social science, and science) all demonstrate excellent internal coherence, with Cronbach’s alpha values of 0.974, 0.876, and 0.942, respectively. Each specialization includes two items designed to consistently measure the construct.

The Cronbach's alpha value for the four items that compose the pedagogical knowledge component is 0.790. Although this remains satisfactory, some variation exists in the degree to which these items assess the construct. Similarly, the Pedagogy Content Knowledge component has a slightly lower Cronbach’s alpha of 0.794 of the 3 items assessing the construct, indicating that there could be some variability in how well these items measure the construct. Cronbach's alpha for the Technology Content Knowledge component is 0.907, which means that all three items that measure this construct are very consistent with each other. Technology Content Knowledge has a Cronbach Alpha of 0.905 for the 3 items that measure this construct, indicating high internal consistency.

The other component is the technology-pedagogical content knowledge, which has a Cronbach alpha of 0.844 for the 5 items that measure this construct, also indicating high internal consistency. This generally indicates that the assessment or survey instrument for the TPACK exhibits moderate to excellent internal consistency. Most components have high reliability.

This analysis provides insights into the distribution and characteristics of university lecturers. It helps to understand the lecturers in terms of age, subject, experience, and education. The table above shows that the majority of respondents fall into the category of 38 years and older, represented by a mean of 3.19 and a mode of 4.

The left-skewed age distribution suggests a higher proportion of older respondents compared to younger ones. The mean value of 2.05 and the mode value of 2 indicate that most lecturers hold a master's degree. Only a few outliers hold exceptionally high levels of education, such as Ph.D. holders, as indicated by the positive kurtosis value of 4.71.

The lecturers have an average experience of 7.19 years, with a mean of 6 years. This implies that more university lecturers have more years of experience than those with fewer. According to the table above, social science has the highest number of respondents, indicated by a mean of 3.63 and a mode of 1. The distribution of subject expertise is right-skewed, with less variability across different subject areas. The data suggests that older lecturers with master's degrees and substantial teaching experience dominate the sample, particularly in the field of social science.

Table 2. Age, Education level, Experience, and subject area

	Description	Mean	Mode	Min.	Max.	Skewness	Kurtosis
Demographic	Age	3.19	4	1	4	-0.82	-0.27
	Education	2.05	2	1	4	1.53	4.71
	Experience	7.19	6	2	19	0.97	1.03
	Subject Expert	3.63	1	1	7	0.14	-1.49

Table 3. Lecturers TPACK Level

	Description	Mean	Mode	Min.	Max.	Skewness	Kurtosis
Technology Knowledge	I have no difficulties teaching pupils online	2.81	4	1	5	-0.02	-1.58
	I am not afraid to use tablets and digital tools to integrate knowledge	1.75	1	1	5	1.51	1.38
	I am familiar with the latest applications that promote experiential learning	2.75	4	1	5	0.02	-1.57
	I readily explore new tools to integrate technology into online teaching	2.52	1	1	5	0.24	-1.45
	I believe I have all the skills to compete with modern education framework in online teaching	3.31	4	1	5	-0.62	-1.08
	I have never failed in using a new technology for teaching purposes	2.84	4	1	5	-0.09	-1.61
	Total	**2.66**	**4**	**1**	**5**	**0.17**	**-0.99**
Content Knowledge	I can answer all questions of my students promptly during lectures	1.77	2	1	4	0.68	2.51
	I can address students in the right direction who are motivated to think critically	1.73	2	1	4	0.02	1.32
	I can give direction to students regarding concepts learned in class	1.76	2	1	4	-0.07	1.76
	I can promote concept retention by creating validity in the knowledge	1.77	2	1	4	-0.32	2.52
	The concepts I teach can be readily applied by students in their real-life	1.8	2	1	4	-0.39	3.21
	I am always satisfied with the answers I provide to my students	1.81	2	1	4	0.29	3.86
	I am comfortable exploring new questions that a student might ask to clear out discrepancies in concept	1.8	2	1	4	-0.27	2.84
	Total	**1.78**	**2**	**1**	**4**	**-0.01**	**2.57**
Pedagogical Knowledge	I can always maintain discipline in class	1.81	2	1	5	1.19	10.01
	I can enhance communication regarding concepts in class online	1.9	2	1	5	1.24	2.17
	I am familiar with teaching theories including SMART goals for better learning of students	1.79	2	1	5	1.41	3.50
	I motivate my students to think critically and enhance their concept retention in online class	1.84	2	1	5	1.46	3.89
	Total	**1.84**	**2**	**1**	**5**	**1.32**	**4.89**
Pedagogical Content Knowledge	I can relate subject knowledge and my teaching knowledge effectively	1.81	2	1	2	-1.56	0.43
	I believe that without my teaching skills, I cannot provide subject knowledge effectively	1.73	2	1	5	0.90	8.18
	I believe without subject knowledge; the teaching method is of little effect in improving students' learning	1.75	2	1	5	1.31	4.93
	Total	**1.78**	**2**	**1**	**5**	**0.49**	**4.61**
Technology Content Knowledge	I can apply distinctive technology for different concepts without hesitation	2.9	4	1	5	-0.06	-1.65
	My teaching style and concept retention of students do not impact online or physical classes	3.03	4	1	5	-0.18	-1.55
	I can effectively deliver lectures and teach students with all my expertise through online or offline mediums	2.68	4	1	5	0.18	-1.52
	Total	**2.60**	**4**	**1**	**5**	**0.11**	**-0.03**
Technology Pedagogical Knowledge	I am always open to using different technologies that improve students' learning	1.95	1	1	5	1.21	0.39
	I am open to newer technologies that would help me better communicate with students online	1.98	1	1	5	1.19	0.26
	I can take students' feedback and improve their learning experience through the incorporation of technology	2.31	2	1	5	0.67	-0.92
	Total	**2.21**	**1**	**1**	**5**	**0.79**	**-0.07**
Technology Pedagogical Content	I can mix and match technology, pedagogy, and content to improve students' learning	2.85	4	1	5	0.03	-1.61
	I am aware of the TPACK framework	2.82	4	1	5	0.02	-1.54

Knowledge	I can blend my teaching style according to the requirement of the class, concept, and their generalized level of prior understanding	2.42	1	1	5	0.43	-1.41
	I am open to changing technological styles that are comfortable for students in pursuit of learning	1.95	1	1	5	1.14	0.19
	I can learn new technologies rather quickly to enhance students' experience regarding a new concept	1.87	1	1	5	1.30	0.74
	I believe my teaching methodology is effective and the grades of my students are increasing with my teaching style	1.69	1	1	5	1.43	1.96
	Total	**2.27**	**1**	**1**	**5**	**0.72**	**-0.28**

Table 4. Correlation Matrix of the relationship between the TPACK components

	TPCK	TK	CK	SSM	SSSS	SSNS	PK	PCK	TCK	TPK
TPCK	1	0.674**	-0.01	0.073	0.127	0.021	0.227**	-0.086	0.805**	0.404**
TK	0.674**	1	-0.091	0.139	0.186*	0.149	0.185*	-0.133	0.748**	0.579**
CK	-0.011	-0.091	1	0.124	0.125	-0.067	0.392**	0.220**	-0.027	-0.037
SSM	0.073	0.139	0.124	1	0.355**	0.521**	-0.069	-0.041	0.13	0.131
SSSS	0.127	0.186*	0.125	0.355**	1	0.197*	0.095	0.044	0.151	0.195*
SSNS	0.021	0.149	-0.067	0.521**	0.197*	1	-0.06	-0.149	0.085	0.051
PK	0.227**	0.185*	0.392**	-0.069	0.095	-0.06	1	0.248**	0.196*	0.216**
PCK	-0.086	-0.133	0.220**	-0.041	0.044	-0.149	0.248**	1	-0.099	-0.104
TCK	0.805**	0.748**	-0.027	0.13	0.151	0.085	0.196*	-0.099	1	0.525**
TPK	0.404**	0.579**	-0.037	0.13	0.195*	0.051	0.216**	-0.104	0.525**	1

** 1Correlation is 1significant at 1the 0.01 1level (12-tailed).

* 1Correlation is 1significant at the 0.05 1level (2-tailed).

The average score for technological knowledge questions was 2.66. Most lecturers agreed to some extent with the statements about their technological abilities. The greatest number of respondents fell into the "disagree" mode of 4. More respondents strongly disagreed with the claims related to technological knowledge (score of 1). The positive skewness suggests that there is more agreement with technological expertise, and the kurtosis suggests a dispersed distribution with a flatter peak.

Seven content knowledge questions had a mean of 1.78 and a mode of 2, indicating that lecturers generally agreed with content knowledge component questions. The reported values ranged from 1 to 4, indicating variation in the responses. The negative skewness suggests some lecturers have lower content knowledge abilities. The kurtosis indicates that there are no significant outliers.

Four pedagogical knowledge questions had an average score of 1.84, indicating that lecturers strongly agreed with pedagogical knowledge questions. The reported scores varied between 1 and 5, indicating differences in knowledge levels. The positive skewness indicates a small number of lecturers with lower pedagogical knowledge. The kurtosis indicates a peak distribution, possibly due to extreme scores or outliers.

The average score of the lecturer's pedagogical content knowledge was 1.78, indicating that the lecturers generally have a positive perception of their pedagogical content knowledge. The range from 1 to 5 indicates some variability in their responses. The skewness is a slightly left-skewed distribution, indicating that a few lecturers have lower levels. The lecturers' technology content knowledge is slightly below average, as indicated by an average score of 2.60. A mode score of 4 indicates disagreement with technology-related statements. Some lecturers show a very low score of 1, while others display a high degree of knowledge, reflected by a score of 5. The distribution is slightly right skewed.

The mode category for technology pedagogy is "agree," as indicated by the mean score of 2.21. The large spread of responses (from 1 to 5) indicates some unevenness in knowledge levels. Most of the lecturers have some expertise, while a few exhibit high technological and pedagogical knowledge. The distribution suggests that the lecturers' technological knowledge levels are similar.

The average is 2.27, and a mode score of 1 indicates agreement with TPACK knowledge. Responses run from 1 to 5, indicating that a few lecturers have quite high scores on TPACK. The distribution is left-skewed and quite variable in terms of scores.

With a correlation coefficient of 0.674, technological pedagogical content knowledge exhibits a strong and significant positive correlation with TK (technology knowledge). Content knowledge demonstrates a weak and constant association (correlation coefficient: -0.011) with TPCK, but this relationship is statistically insignificant. The correlation coefficients for subject specifications in mathematics, social studies, and science are all weak and statistically constant, with values of 0.073, 0.127, and 0.021, respectively. Yet, these relationships are insignificant statistically and indicate little or no association with TPACK. Pedagogical knowledge has a very weak but positive relationship with TPCK, which is statistically significant at a correlation coefficient of 0.227. The correlation coefficient between pedagogy content knowledge and TPCK is weak and consistent (value: -0.086), but statistically insignificant. There is a strong and constant association between technology content knowledge and technology pedagogical content knowledge (correlation coefficient: 0.805), as well as a moderate and constant association between technology pedagogical knowledge and technology pedagogical content knowledge (interdependence coefficient: 0.404), both of which are statistically significant.

The linear correlation coefficient stands at 0.842, indicating a reasonable relationship between the observed TPCK values and the model's predicted values. In this regard, the model's independent variables show a significant relationship with TPCK. The model's independent variables account for approximately 71% of the variance in TPCK, as indicated by the coefficient of determination, R-Square, of 0.71. That is a high degree of explanation; therefore, the model can capture and predict TPCK. Despite accounting for the number of predictors in the model, the adjusted R-squared remains 0.689, indicating the model's ability to explain a significant portion of the variation in TPCK. The model's ability to explain variance is not primarily due to the presence of numerous factors.

Table 5. Linear Regression Model of the TPCK components

Model Summary					
R	**R-Square**	**Adjusted R Square**	**Std. Error**	**Durbin-Watson**	
0.842	0.71	0.689	0.54974	1.703	
Analysis of Variance					
	Sum of Squares	**Df**	**Mean Square**	**F**	**Sig.**
Regression	95.275	9	10.586	35.029	0.000
Residual	38.986	129	0.302		
Total	134.261	138			
Coefficients					
	Unstandardized Coefficients		**Standardized Coefficients**		
	B	**Std. Error**	**Beta**	**T**	**Sig.**
Constant	-0.571	0.047		-12.1489	0.000
TK	0.207	0.078	0.209	2.653846	0.009
CK	-0.253	0.053	-0.249	-4.77358	0.000
PK	0.779	0.054	0.723	14.42593	0.000
PCK	-0.449	0.049	-0.421	-9.16327	0.000
TCK	0.674	0.072	0.692	9.361111	0.000
TPK	-0.672	0.058	-0.645	-11.5862	0.000
Dependent: Technology Pedagogical Content Knowledge "TPCK"					

The estimator's standard error (standard error) is 0.54974. A lower standard error indicates higher accuracy, so a value of 0.54974 suggests that the model's predictions are relatively accurate. The Durbin-Watson value of 1.703, nearing 2, indicates a lack of strong autocorrelation, indicating that the model's residuals do not exhibit systematic relationships.

The regression coefficients show the relationship between the variables and their effect on TPCK. For every unit increase in TK, there would be a 0.207 increase in TPCK, keeping all other variables constant. There is a correlation between a one-unit increase in CK and a 0.253 decrease in TPCK. A 0.779 increase in TPCK correlates with a one-unit increase in PK. A 0.449 decrease in TPCK is correlated with a one-unit increase in PCK. A 0.674 increase in TPCK correlates with a one-unit increase in TCK. A 0.672 decrease in TPCK correlates with a one-unit increase in TPK.

The distribution of standardized residuals, in blue, is bell-shaped and equal to a normal distribution. The linear regression model thus provides strong support for the assumption. The numbers in the blue bars represent how many observations were within specific intervals of standardized residuals. The closer the blue bars are to the black normal distribution curve, the better they conform to the normality assumption. The mean residuals are close to zero (1.11E-16), and the standard deviation is 0.096. Suggests well-centered residuals. There are 139 data points, so the regression model for predicting "Technology Pedagogical Content Knowledge" is ideal. The normal distribution pattern of residuals bolsters the model's validity. Its small spread suggests accurate predictions.

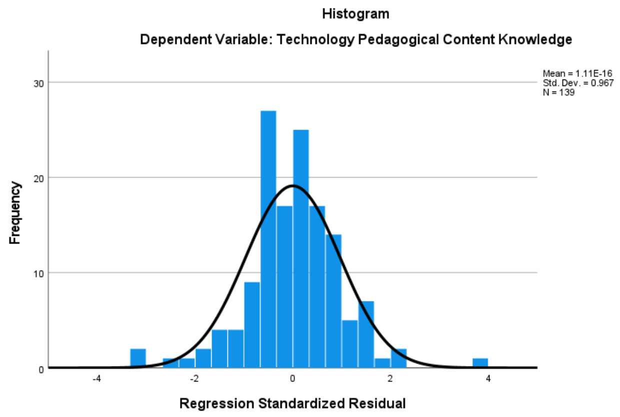

Figure 2. Residual Analysis of the TPACK

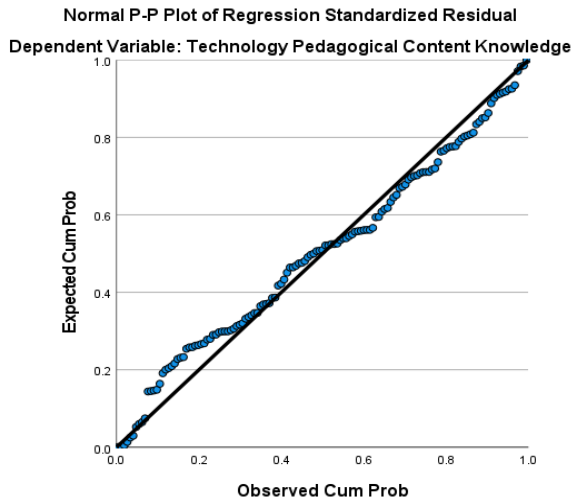

Figure 3. Normal P-P Plot of TPACK Normality

The scatter plot of the normalized residuals shows practically a 45-degree reference line, which passes through the linear regression model's normality assumption. Some residuals deviate from the line, suggesting a departure from the norm. The shallowed curves, both upward and downward, suggest that it may not fit well into a normal distribution. More significantly, the residuals are free of outliers; therefore, the regression results are valid regardless of whether the data follows a regular pattern.

The table above gives an insight into the data and underscores the need for TPACK integration in teaching methodologies that result in effective online education. Under TPCK, the regression coefficient for TK is 0.6734, with a statistically significant p = 0.000. This shows that TK is statistically significant and has a positive bearing on online teaching effectiveness. On the other hand, the regression coefficient for CK under TPCK is -0.0178 with p = 0.779. This shows that CK does not necessarily determine online teaching effectiveness.

Under CR, the z-score for TPCK is 0.0593, with a p-value of 0.953. This implies that there is no statistically important association between TPCK and CR. More surprisingly, the association between TPACK and quality lectures is not statistically significant, whereas it is for concept retention. This reveals the outstanding role of technological pedagogical content knowledge (TPACK) in the effectiveness of online teaching, especially regarding TK.

The SEM explores the relationships among various forms of knowledge, including TK, CK, and PK. Arrows connecting these variables show their influence on TPACK. More specifically, TK positively affects TPACK with a coefficient of 0.63, whereas CK does not contribute significantly to TPACK with a coefficient of -0.027. TPACK influences content retention (CR) and lecture quality (LQ). The error terms represent variability in the model that the included variables cannot explain: ε1, ε2, ε3. The interpretation is that TPACK is an important part of effectiveness in online teaching. TK, in particular, raises both CR and LQ.

Table 6. The Interconnections between TPACK and other Variables in terms of Online Teaching

Endogenous Variables: TPCK CR LQ						
Exogenous Variables: TK CK PK						
Fitting Target Model: **Iteration 0:** log-likelihood = -1057.6856 **Iteration 1:** log-likelihood = -1057.6856 **Log Likelihood =** -1057.6856						
Structural Equation Model: Estimation Method: Maximum Likelihood						
Number of Obs. = 139						
	Coefficient	**OIM Std. Err.**	**Z**	**P> |z|**	**[95% conf. interval]**	
Structural						
TPCK						
TK	0.6734	0.0611	11.02	0.000	0.5536	0.7932
CK	-0.0178	0.0638	-0.28	0.779	-0.1431	0.1072
PK	0.1053	0.0647	1.63	0.104	-0.0215	0.2323
Cons	-0.0712	0.5887	-1.21	0.226	-0.1866	0.0441
CR						
TPCK	0.0593	0.0882	0.67	0.502	-0.1136	0.2322
Cons	0.0067	0.0867	0.08	0.938	-0.1632	0.1768
LQ						
TPCK	0.8062	0.0538	14.98	0.000	0.7007	0.9117
Cons	0.0531	0.0529	1.00	0.315	-0.0505	0.1568
var(e.TPCK)	0.4794	0.0575			0.3791	0.6065
var(e.CR)	1.0456	0.1254			0.8265	1.3227
var(e.LQ)	0.3891	0.0466			0.3075	0.4921
LR test of Model vs. saturated: Chi. Sq. (7) = 17.02					Prob > Chi. Sq. = 0.0173	

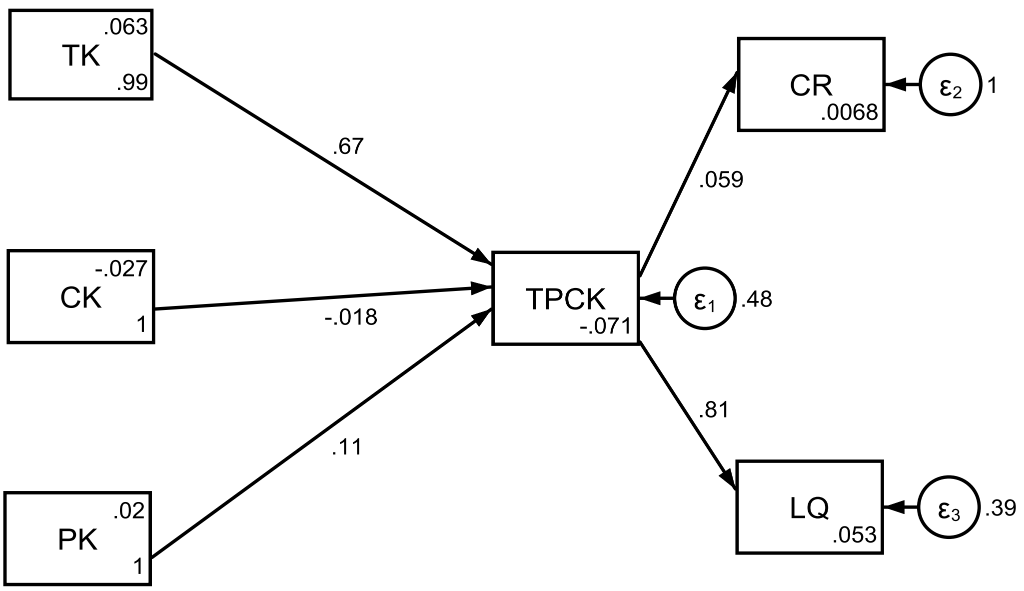

Figure 4. Connections in TPACK Knowledge

4.1. Qualitative Analysis

To analyze the qualitative data, a thematic analysis was followed. Among them were themes like the role of technology in the learning environment, the perception of using technology in teaching by lecturers, and the problems ascribed to online teaching.

4.1.1. Technology in Virtual Learning

The data gathered from unstructured questions revealed the first theme, which was the role of technology in university learning environments. Therefore, lecturers were questioned about their experiences integrating technology and its support in the learning environment, particularly in university education, to examine its function.

On this question, Respondent 1 added:

"Honestly, the use of technology in teaching and learning in any university setting is essential in that it enables students to acquire creative, innovative, critical thinking, and problem-solving skills... inclusion of technology in the university education environment will help educators develop in the students' relevant abilities and expertise that is required for their professional careers…will enable instructors to teach their subjects in a demonstrative and collaborative manner so that students will take active roles in their learning activities".

Respondent 2 continued stating: *"The inclusion of technology has an enormous contribution to the learning environment at universities. Firstly, online teaching is accurate in the dissemination of coursework information. Course syllabi and lecture notes are easily accessible to students… the inclusion of technology is time distance. and finance effective."*

From the above two responses, it can be interpreted that the inclusion of technology in online learning and teaching is important as it allows the students to acquire innovative, creative, problem-solving, and critical thinking skills. It also encompasses significant contributions to learning as it offers easy accessibility to the students.

4.1.2. Perspective of Lecturers Toward Technological Incorporation

For understanding the perspective of the lecture linked with the incorporation of technology the lecturers were asked about their perspective concerning the role of technological incorporation for improvement in class. On this question, one of the lecturers argued:

"Improvement from my perspective is relative…that technology will only improve the learning environment in which meaningful technologies are selected by trained teachers and integrated into the learning environment." Other respondents stated: "Technological advancements are revolutionizing the traditional classroom, transforming it from analog to digital methods to better serve students' needs and meet the demands of modern education…"

Another respondent supported the previous statement by adding: *"Most definitely, without technology incorporation into teaching and learning, the learning environment will never improve because there are new developments in education that all educational stakeholders, instructors, and students need to embrace.*"

The findings from the these responses can be interpreted as indicating that technological advancement is significantly transforming the classroom toward digital methods to serve the students in a better way to meet, the modern education demand. Additionally, some participants argued that the improvement in the classroom is relative as technology would only enhance the environment of learning in which appropriate technologies are used by trained teachers.

The lecturers were further asked about how the online learning environment has influenced their style of teaching. Upon this question, one of the lecturers asserted:

"The online teaching or learning environment has allowed me to relate to my students without hindrance in terms of calling individual students for advisement, computing, grades manually, and walking to my supervisors to communicate grades. In addition, it has allowed me to talk less and do more."

Another added: *"My teaching methods had to be modified by the introduction of online learning environments because these environments made it possible for me to assist my students in pursuing highly personalized learning objectives."*

In terms of teaching styles, it has been found that the lecturer believes that the teaching styles have been changed by online learning as the environment enables them to assist their student more effectively. The findings further showcase that the virtual education setting has enabled the teacher to relate with their learners without barriers making work more efficient.

After analyzing the influence of online teaching on teaching style, the lecturers were asked about their perspective on the question; if the pandemic had not occurred what would have been the case?

Respondent 4 stated: ***"****Indeed! Even before COVID-19, researchers had already devoted a lot of time to studying the potential advances of virtual learning environments, and this trend shows no signs of slowing down. Therefore, regardless of the presence or absence of COVID-19, it would still be studied to a greater extent."*

It was added by another respondent that: "The pandemic of COVID-19 is a key factor for the extensive study of virtual learning... so to a certain extent, COVID-19 is a major contributing factor to the investigation of online learning but the view that online learning wouldn't have been studied in this age had Covid-19 not come doesn't resonate with me."

Most lecturers said the epidemic is real and was the key factor for the acceleration of virtual learning. Some of the respondents also believed that virtual learning would have emerged even with the absence of the pandemic as the researchers were already studying the virtual learning environment.

4.1.3. Online Teaching Challenges

To assess the challenges of online teaching, the lecturers were asked whether online teaching has increased the barriers between teachers and students and how they marginalize those barriers. On this question, some of the respondents believe that there exist no barriers: *"I don't think there are more obstacles regarding teachers and students now that online learning is becoming more* *popular... however, the problems students face in online education include connectivity problems, electrical problems, technology problems, infrastructure problems."*

"No. In my view, there have never been any barriers between teachers and students. There have only been interactions between teachers and students, which still exist through online teaching and learning that is print or Zoom conferences." "Online teaching has not and will never be a barrier or increased barriers between teachers and students. I believe that online teaching reduces the barriers between teachers and students."

From the above responses, it can be inferred that most of the participants had showcased the usefulness of online teaching stating that there have been no barriers as it only led toward interaction between teachers and students. The responses indicate that lecturers believe that online teaching has lowered the barriers between students and teachers.

On the other hand, some of the respondents indicated the barriers by adding: "Some of those challenges are the lack of ICT resources for both teachers and students, shortage of electricity, poor internet connectivity, lack of ICT knowledge and skills, lack of online training for both the students and the teachers, lack of a proactive curriculum that promotes online teaching and learning programs and lack of financial and social support, and so on." "Lack of instant communication, timely feedback, clear instruction, lack of motivation, and cheating on exams are some of the barriers between teachers and students."

The aforementioned responses suggest numerous challenges in online teaching, such as insufficient ICT resources, poor connectivity, electricity shortages, insufficient ICT skills and knowledge, a lack of proactive curriculum, insufficient communication and motivation, and more. These findings showcase that online teaching is associated with several barriers.

5. Discussion

The empirical data on TPACK levels among the lecturers revealed that they moderately agreed that they possess high levels of technological knowledge, with a mean score of 2.66 and a mode of 4, indicating a low level of confidence in this area. This aligns perfectly with [41]'s understanding that TPACK is essential for effective technology-based teaching. A mean score of 1.78 and a mode score of 2 showed that the lecturers had a decent foundation in the subject matter, which is bound to provide a decent overall foundation for the overall TPK. This assertion received support from [20], emphasizing the significance of achieving a balanced integration of content, pedagogy, and technology. The mean score of 1.84 and mode of 2 showed high pedagogical knowledge, which was somewhat variable. [22] and [23] argued that this was essential for successful teaching and positive student outcomes.

This study agrees that acknowledging and supporting educators with high pedagogical knowledge and providing development opportunities for those in need are essential for effective teaching practices and student learning experiences. According to [24] and [18], lecturers generally had high pedagogical content knowledge, with average and moderate responses indicating agreement in support of effective teaching practices.

However, there is variability, with some lecturers having lower levels, thus indicating individual differences in the self-assessment of pedagogical competencies [18] and [25]. Technological content knowledge is a bit lower than average and requires improvement in better technology integration in teaching, as emphasized in the TPCK model [51].

Overall, lecturers have moderate technological and pedagogical knowledge. The scores are rather variable, indicating both proficiency and areas for growth, which makes TPACK of high importance in modern education. In this respect, the results are in accord with [11]. Lecturers possess a moderate level of TPK, with a mean of 2.21 and a mode of 1, representing the blend of technology and pedagogy, much as [12] advocated. Similar to [26]'s findings, skewness and kurtosis values measure the variables in TPK, while experience and training account for the variability in these attributes among educators.

The study's average and mode indicate that lecturers are capable of providing a general understanding of how to effectively use technology in the classroom. However, the left skewness indicates that certain lecturers excel in utilizing technology in the classroom, a finding that aligns with previous research [52] and [53]. This underscores the need for continuous professional development to increase TPK levels. Both pedagogical expertise and pedagogical content knowledge are required, as suggested by [29] and [26]. However, there is a weak negative correlation between content knowledge and TPCK, which means that having a lot of subject knowledge does not necessarily mean better technology integration in the classroom, as supported [13].

A relatively weak, positive correlation of 0.227 between pedagogical expertise and TPCK means that pedagogical expertise contributes somewhat to TPCK. This finding is coherent with the [15] comprehensive TPACK teaching approach. However, a relatively weak, negative correlation between pedagogical content knowledge and TPCK means that deep pedagogical understanding does not necessarily contribute to improving technology use in teaching, contrary to what [54] implied. Strong positive correlations between technology content knowledge and TPCK mean that technological content knowledge has a role in enhancing TPCK, as [16] affirms.

The study reveals that the subject area has no effect on TPCK technology integration in teaching, and most observed correlations among mathematics, social studies, and science are weak. This is in agreement with [21] argument that all the components within the TPCK framework—technological, pedagogical, and content—all co-exist as essential elements for modern education.

Lecturers at Liberian universities acknowledge the use of TPACK. They employ many online tools, like Google Classroom and Microsoft Teams. These are proactive, according to [17] and [16]. TPACK's impact on online teaching quality is not consistent, and its effectiveness may vary depending on individual lecturers' experiences and teaching contexts.

Summarized Findings

The study assessed the level of lecturers' TPACK and its application in the teaching of online courses at universities in Liberia. Results have indicated that while lecturers possess general knowledge of TPACK, they were not able to use technology in the instruction of online courses to some extent.

Generally, the lecturers have positive TPACK ratings and show moderate agreement, with a slight tendency towards disagreement. The level of high-level technological knowledge received positive scores on TPACK, though there is a slight tendency to disagree with the overall TPACK ratings. Lecturers have solid foundations in subject matter expertise and thus contribute positively to their overall TPK. Lecturers have a high degree of pedagogic expertise, though they may vary, showing diverse teaching approaches or experiences.

Despite the different profiles, most display a sophisticated level of pedagogical content knowledge, which reflects positively upon their experience of the subject matter and excellent teaching ability. The value of technology content knowledge demonstrates a complex relationship between teaching skills, online technologies, and pedagogy.

The weak correlation between pedagogical content knowledge and technology use in online education suggests that a deep understanding of pedagogical content may not significantly influence technology use. Furthermore, we detected a weak and insignificant relationship between domain-specific knowledge in mathematics, social studies, science, and TPCK. This implicates the general applicability of technology in the teaching and learning process across various disciplines.

The positive recognition of TPACK's importance, coupled with active efforts to incorporate it into teaching practices, indicates a positive trend in the adaptation of pedagogical ability to the demands of modern education.

Conclusion

The findings of TPACK levels among the lecturers provide an augural indication of Liberian universities' inclusion of technology in online education.

The lecturers show robust content and pedagogical knowledge, but there is an emerging need to enhance their technological skills, especially in their particular area of teaching. The findings suggest that the primary contribution of technological expertise is to increase technological pedagogic content knowledge.

Despite this, the findings further highlight that lecturers' strong backgrounds in pedagogy have enabled effective incorporation of technology, whereas content knowledge alone does not automatically convert to effective use of technology. The findings call for the general application of technology across disciplines, as well as continuous support and development for lecturers to fully make use of the TPACK.

The overall positive reception of TPACK and the dedication to embedding it in educational practices mean that the current trend is one of adaptability to the challenges of modern education.

The complex nature of TPACK's practical application necessitates continued augmentation and support for lecturers to fully exploit it in pedagogy.

Practical Implications

The study's findings have practical implications for lecturers' TPACK knowledge in Liberia. The implications include:

Professional Development: The findings show a need for specific CPD programs that target lecturers in their attempts to expand their knowledge of TPACK. The CPD curriculum needs to incorporate TPACK frameworks in such a way that pedagogical knowledge, content knowledge, and technology knowledge do not exist in isolation, but their existence is mutually reinforcing.

Resource Allocation: Stakeholders need to allocate the resources needed to support the integration of ICT tools into online platforms that have a bearing on online teaching. These resources could also consider technical assistance in ensuring that the lecturers remain up-to-date with new tools.

Collaborative Learning Communities: The creation of communities of practice that have a joint purpose of sharing experiences, ideas, and resources can foster the collaborative dimension of continuing learning and improvement in TPACK.

Policy and Strategy: The findings from this study demonstrate that TPACK plays a positive role in education; policymakers may want to consider strategies that make it more available for implementation. This can include incentives for those lecturers whose use of TPACK has been effective in their online teaching.

Research and Evaluation: The need for continued research and evaluation is to monitor the influence of TPACK on these teaching outcomes that matter in learning. This can inform future initiatives and adjustments in the online practice of teaching.

Encourage lecturers to use student-centered approaches that effectively integrate technology to enhance engagement and improve learning outcomes. This would include utilizing interactive media, online discussions, and digital assessments.

By addressing these areas, universities can help lecturers acquire the skills needed to adapt their pedagogy to the changing environment of online education, ultimately improving the quality of teaching and learning.

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