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Fostering Pedagogical Content Knowledge through Integrating Digital Lectures with Teaching for Undergraduate Science Teachers

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Abstract
This research aimed to reveal the nature of Pedagogical Content Knowledge (PCK), as well as to integrating the digital lectures into teaching for fostering student teachers' PCK. The digital lectures were designed in streaming videos. The procedures were conducted for eight weeks on undergraduate science teachers at the Faculty of Education. A quasi-experimental, pre-test–post-test, comparison group design was used. The results exhibited that capturing science teachers' PCK requires rethinking of the PCK term itself, and modifying it to become more comprehensive, accurate and expressive of all its dimensions.The educators and researchers' view of the PCK should change from mere knowledge to an integrated set of academic and educational experiences. The ANCOVA results demonstrated that there were no significant differences between the experimental and comparison groups for both content analysis and lesson planning topics. While the results of ANCOVA demonstrated significant differences between two groups for the educational objectives topic and overall test, but these differences were very slight.It can be concluded that both digital lecture and traditional method had influenced student teachers' performance equally. Therefore, the author suggests integrating digital lecture and e-learning techniques with face-to-face learning methods to benefit from the advantages of both of them and achieve effective and successful teaching.The current research highlights the new term of pedagogical content experience (PCE) and further research is needed to outline it to provide further evidence for its validity.

Keywords: Digital Lectures, Pedagogical Content Knowledge, Prospective Science Teachers, Teacher Professional Development, Undergraduate Science Teachers

INTRODUCTION

Before fostering the pedagogical content knowledge (PCK), the nature of PCK should be revealed. Although there is an inclusive agreement among the educators about the components of PCK, there is no unified accepted concept (Zahang&Birdsall, 2016, p. 50). The question that arises now: Is PCK only a cognitive domain or does it involve other domains? Loughran, Mulhall and Berry (2004) stated that PCK resides in the body of science teachers as a whole while still carrying important individual diversity in teaching and learning practices (p. 374). Hanuscin (2011) indicated that PCK is developed through an integrative process embedded in teachers' classroom practice (p. 149). Consequently, whether PCK is knowledge or practices, this is what the current research attempts to explore. In addition, the research purposes to utilize the digital lectures for fostering the student teachers' PCK.

Bates (2015) demonstrated that the lecture remains the prevalent method for teaching in many institutions, even in a digital age, where information is available at a click of a button. He presented some questions related to the current research topic: If most students have mobile phones, tablets, or laptops, why do they still have physically to come to a lecture hall? Why cannot they get a video of the lecture? (p. 79)

The educational technologies including learning websites, instructional forums and platforms, digital lectures and presentations appear to have meaningful effects on science education. Pletka (2007) reported that digital technology has been embedded into every domain of society. This new world has fostered most to become relaxing multitasking and to expect experiential and collaborative activities facilitated through information and communication technologies (p. 21).

It is not possible to expect novice teacher to own developed knowledge about educational theory and teaching strategies (Bindernagel&Eilks, 2009). Teachers begin their profession with a limited concentration on single components that become more detailed and profound through training and practice. As teachers become more experienced, their Pedagogical Content Knowledge (PCK) develops and becomes more effective (Zahang&Birdsall, 2016, p. 51).

Although there are several studies that have been conducted on PCK (Barnett &Handson, 2001; Usak, 2011; Suryawati, 2017; Drummond, 2017), few concrete examples of PCK emerged in science subject areas.

It is necessary to take teacher behavior more seriously and to emphasize the development of adequate gestalts. This requires pedagogy of teacher education different from the theory-based strategies at present used in many programs. The teaching is an extensive gestalt activity. Therefore, the theory is not sufficient and there is a need for pedagogy of teacher education that combines practical experiences, and rethinking of teacher education practices for effective professional development (Korthagen, 2010, p. 103).

Loughran, et al. (2004) made teachers talk about their topic-specific PCK (that is about why they teach a particular content in a particular way), to access descriptions of practice of PCK. Hence, capturing and portraying science teachers' PCK requires working at both an individual and collective levels (pp. 373). The author believes that capturing and portraying science teachers' PCK requires rethinking of the PCK term itself, and modifying it to become more comprehensive, accurate and expressive of all its dimensions. Then, one of the current research questions is whether PCK reflects the cognitive domain only or it includes both the psychomotor and affective domains. This question will be answered later through reviewing and inducting the components of PCK, which the previous studies aimed to develop. The visualizing nature of PCK is important not only for educational research, but also for the current reform efforts in science education. Generally, the research can also be useful in changing the prospective views of educators and researchers about PCK term, which might be taken into consideration more comprehensively when developing teacher education programs.

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

The focus of Connectivism is on individual participants, networks and the flow of information and creating the new forms of knowledge. The main role of teacher is to help learners construct their own personal learning environments that enable them to learn automatically through exposure to the flow of information and the individual's reflection on its meaning. There is no need for formal institutions to support this kind of learning (Bates, 2015, pp. 58, 77).

Gorsky and Caspi (2005) presented a theoretical framework for viewing elements of distance education systems in terms of dialogue. Every element is viewed as a dialogue or as a resource that supports dialogue. Learning is mediated by intrapersonal dialog; this dialog type is an all-inclusive term for the mental processes engaged in by students during learning. It includes all instructional materials that students may learn from. Examples include self-instruction texts, lectures presented through audio and video cassettes, television and radio programs, and web-based instructional systems. In other words, when students listen to lectures or audio tapes, they are engaging in intrapersonal dialogue. The mental processes of intrapersonal dialogue have been described in many ways. Some examples are “assimilation”, “accommodation”, “accretion,” and “an internal didactic conversation”. Whatever the labels of these processes, they contribute to the design of structural and human resources (pp. 137- 140).

Magnusson, Krajcik and Borko (1999) defined PCK as a teachers' understanding of how to help learners understand specific content. It includes knowledge of how particular topics, ideas, concepts and issues can be reorganized, represented, and adjusted to the various interests and capabilities of learners, and then taught in the classroom (p. 96). Auerbach (2018) stated that PCK may include knowledge of learning theories, methods and approaches to instruction and assessment, lesson planning, classroom management, student motivation, and other knowledge of learners (p. 2).

Beetham and Sharpe (2007) reported that "Pedagogy involves ways of knowing as well as ways of doing. Like other applied disciplines, it is centrally concerned with how we understand practice, and how we apply that theoretical understanding in practice once again" (p. 3). Barnett and Handson (2001) mentioned that the pedagogical knowledge includes knowing how to define teaching goals, designing lesson plan, organizing a sequence of content, implementing teaching strategies and using evaluation tools. It also includes knowing of how best to display specific concepts and ideas. Loughran, et al. (2004) presented PCK as bound up in a teacher's approach to teaching particular content. It is the mixture of a teacher's pedagogy and understanding of science content where it influences their teaching to achieve students' science learning for understanding (p. 371).

Magnusson, et al. (1999) conceptualize PCK for science teaching as consisting of five components: (a) orientations toward science teaching, (b) knowledge and beliefs about science curriculum, (c) knowledge and beliefs about students' understanding of specific science topics, (d) knowledge and beliefs about assessment in science, and (e) knowledge and beliefs about instructional strategies for teaching science (p. 97).

Pajares (1992) and Richardson (1996) distinguished between knowledge and beliefs as follows:

> We expect this knowledge to be differentiable from personal beliefs. The distinction between knowledge and beliefs is typically based on the epistemic status of the

two constructs. The assumption is that knowledge has to satisfy a truth condition, whereas beliefs are based on personal evaluation and judgment (Cited in Voss, Kunter&Baumert, 2011, p. 953).

Elaborating on scholars' definitions of PCK, the author defined it as a set of academic and educational knowledge, practices and beliefs that the teacher uses in teaching specific topic. It represents academic and educational experiences that facilitate teachers' professional development to achieve effective and successful learning.

In my country, many studies have been carried out and they have suggested the instructional programs and strategies to promote instructional practices in classical learning environments. However, empirical studies that handle student teachers' PCK and utilize E- Learning environments to enhance their PCK are virtually absent. These programs need to be developed by using the latest educational trends and technological techniques to meet the requirements of the 21st century.

The Statement of the Problem

The current research problem was determined by the low level of science student teachers' PCK, and this was confirmed by the results of many previous studies in Egypt, as well as The impression of the research emerges from the need to transfer learning from traditional environment to e- learning environment. Therefore the current research purposed to treat this deficiency through integrating the digital lectures into teaching for fostering science student teachers' PCK. Because of the ambiguity surrounding the term of PCK, the research also attempted to reveal and clarify the term of PCK. To be more specific, this research addresses the following questions:

1. What is the nature of PCK? Does it reflect the cognitive domain only or it includes both the psychomotor and affective domains?
2. What is the impact of digital lectures on science student teachers' PCK?

The Purpose of the Research

This research aimed to achieve the following objectives:

1. Reveal the nature of pedagogical content knowledge and explore its components to know Whether PCK is knowledge only or represents knowledge, practices and beliefs.
2. Foster the pedagogical content knowledge through integrating the digital lectures with teaching for undergraduate science teachers.

METHOD

a. Sample

This research was conducted on two groups of undergraduate science student teachers at the Faculty of Education. The number of the control group was (24) and the experimental group was (19), they were enrolled in a second level in the teacher preparation programs that prepare them for teaching science at both preparatory and secondary schools. The sample was selected intentionally, where the experimental group students were chosen on the basis of who has a computer, or a laptop or a mobile with access to the internet connection available to them. The content areas in which the student teachers were discussed, their PCK were related to the science subject matter at preparatory school. The quasi experimental design is two groups, pre-test–post-test, comparison group design.

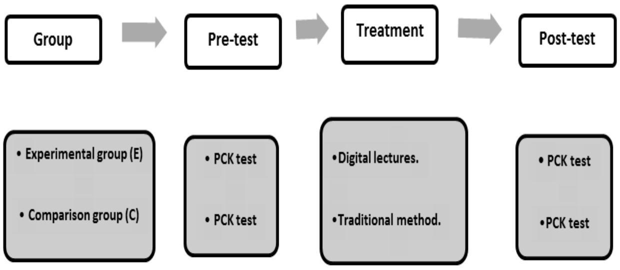

Figure 1. The Research Design

b. Instruments

The current research developed student teachers' PCK test that consisted of 32 items, distributed to the three of teaching planning topics as follows: (14) items for setting educational objectives, (10) items for content analysis, and (8) items for daily lesson planning. The test included five types of questions that required a variety of tasks: the definitions, the educational term identification, the educational applications, and completion of the concept maps. The total score of the test was (32). Test reliability was examined by administering the Cronbach's coefficient Alpha, which yielded a 0.89. Internal consistency coefficients were measured by calculating the correlation coefficients between the total score of the test and the scores of each subcategory: Correlation coefficient for educational objectives was 0.78, content analysis was 0.41, and daily lesson planning was 0.56, all of these values indicated the reliability of PCK test. The content validity was verified by presenting the test to the educational experts to judge the items to be relevant for PCK.

c. Implementation

The procedures lasted for eight weeks. The following arrangements were made in conducting the experiment: at the first session, the student teachers were told the educational goals of the course, they were given opportunities to choose between various ways that they can access the digital lectures including: watching it online or receiving it on CD or flash memory or sharing it via their mobiles. The digital lectures were designed by using the Power Point presentations and transforming it into streaming videos with voice recording of the explanations. These lectures focused on three major subjects: setting educational objectives, content analysis, and daily lesson planning. During its designing, the following were taken into account: Explaining the content of each lecture in a logical sequence, illustrating using the practical examples from the science subject matter, presenting some of the common mistakes made by the most science teachers in order to avoid them. Providing them the correct teaching performances for successful and effective teaching. Finally, the home assignments were presented to be completed and then delivered via the internet or in a hard copy. The instructor evaluated the assignments offered comments on students' performance and then provided constructive feedback.

The Significance of the Research

1. By revealing the nature of PCK, the researchers will become more aware of PCK concept, so the ambiguity surrounding the use of the word "knowledge" in PCK is eliminated, and the educational research takes the right path.
2. By integrating the digital lectures into the teaching process, teachers can transfer the learning process from traditional environment to e- learning environment.
3. Learners can benefit from the advantages of digital lectures where they can choose the time and the right place for them to watch the lecture, as they can watch it more than once, they will be more comfortable and relaxing in learning via digital lectures.

RESULTS AND DISCUSSION

The first research question: What is the nature of PCK? Does it reflect the cognitive domain only or it includes both the psychomotor and affective domains? This question, due to the confusion surrounding the use of the word "knowledge" in PCK, refers to just knowledge only. Loughran, et al. (2004) showed that PCK continues to be a theoretical construct, but not an easily identifiable aspect of practice (p. 373). Voss, et al. (2011) analysed various models to find a unifying conceptualization of general pedagogical knowledge, they mentioned that:

> The definitions converge in describing general pedagogical knowledge as generic and domain general, but differ in their specifications of its components. We analysed various models of school learning to find a unifying conceptualization of general pedagogical knowledge rooted in the demands of classroom teaching (p. 953).

The results of Friedrichsen, et al. (2009) proved the need to rethink the PCK model as follows:

> Our findings cause us to rethink the Magnusson et al. PCK model as our theoretical and analytical framework. We need to find alternatives to a deficit type of thinking that occurred when teachers' and interns' knowledge was examined for each of the PCK categories (p. 375).

Shulman (1986) argued that "there are three types of propositional knowledge in teaching: disciplined empirical, practical experience and moral or ethical reasoning. These three types of propositions represent principles, maxims and norms"(p.11). The author observes a clear contradiction in this paragraph, how does practical experience represent one type of knowledge? How do ethics and morals represent one type of knowledge? Experience is more comprehensive than both knowledge and ethics. The author attributed the confusion surrounding the use of the word "knowledge" in PCK to the confusion surrounding types of propositional knowledge. If it is assumed that the teacher has full knowledge of PCK, this does not mean that he or she is able to teach effectively, the teacher needs teaching skills and improves it through the training and practice.

Shulman (1986) asked how many individuals whom we prepare for teaching biology, for example, understand well the materials for that instruction, the alternative texts, software, programs, visual materials, single concept films, laboratory demonstrations, or "invitations to enquiry?" Would we trust a physician who did not really understand the alternative ways of dealing with categories of infectious disease, but who knew only one way? (p. 10)

Then the research asks: would we trust a physician who really understood all the alternative ways of dealing with categories of infectious disease, but did not know how to examine the patient or how to diagnose the disease? What is the main goal of any educational program? To acquire the knowledge in the specialization, and only understand it or to apply this knowledge (after understanding it), and practise it in the field of work. The real problem faced by most countries is that the graduate students have a large amount of knowledge but lack the practice. Therefore, most of the educational reform attempts called for the need to connect the educational theories with the field practicum.

Masters and Park Rogers (2018) demonstrated that "Many classroom teachers' knowledge and beliefs for how to teach science do not include the scientific practice of explanations. This is because teachers do not include this scientific practice within their science curriculum or skipping over it if it is included".

The educators and researchers' view of the PCK should change from mere knowledge to an integrated set of academic and educational experiences. When we change our viewpoint from pedagogical content knowledge (PCK) to pedagogical content experience (PCE), there will be an inclusive and unified agreement among the educators about the concept of PCK. Hence, the educational experimental studies will take the right path and become likely to have more specific and clear objectives. With drawing the attention to the importance of knowledge, whether pedagogical knowledge or content knowledge, it represents the first component of the PCE followed by the teaching practices and performances that interact with teacher beliefs that reflected on the teaching and learning situation.

Beetham and Sharpe (2007) supported this conclusion, where reported that "The term ‘pedagogy’ refers to the processes, experiences, contexts, outcomes and relationships of teaching and learning in higher education"(p.1) . Ozden (2008) suggested that "Pedagogical Content Knowledge should be taught during teacher training" (p. 639). Friedrichsen et al. (2009) reported that "teaching experience did appear to lead to more integration among PK components" .Hanuscin.

Cisternaand Lipsitz (2018) observed that teachers’ PCK scores tended to be higher for teachers with greater teaching experience at grade level (as opposed to teaching experience overall).

Figure 2. The Components of Pedagogical Content Experience (PCE)

Vaudroz (2105) stated that "general pedagogical knowledge (GPK) may be acquired during practical experience, such as teaching internships, substitute teaching experiences and/or the practice of teaching without certification" (p. 169). Based on extrapolation of the previous studies, the author drew the components and sub-components of PCE as demonstrated in the fig. 3:

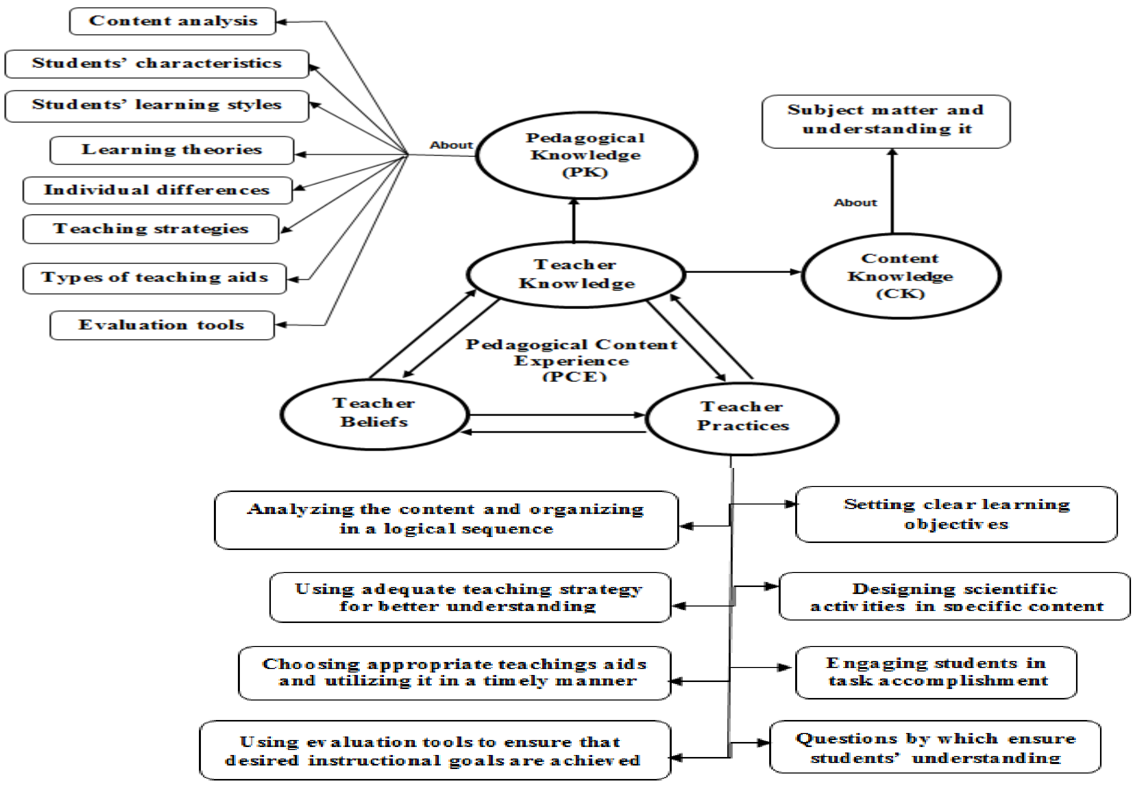

Figure 3. The Components and Sub-components of Pedagogical Content Experience (PCE)

Providing prospective teachers with the opportunities for engaging in either inquiry experiences guided by well-supervised authentic science practices could be beneficial in developing prospective teachers' views about inquiry teaching compatible with the Next Generation Science Standards (Talanquer, Tomanek&Novodvorsky, 2013, p. 205). Voss et al. (2011) found that student teachers with teaching experience had higher means on all sub-dimensions of their general pedagogical knowledge (GPK) tests than those with no teaching experience. This difference was most striking in the area of knowledge of classroom management. According to Jones and Vesilind (1996) "experiences with students are a major source of change in teacher knowledge". (Cited in Vaudroz, 2105, p. 169)

Jong, Van Driel and Verloop (2005) used particle models in teaching chemistry, the module emphasized learning from teaching by connecting authentic teaching experiences with institutional workshops. The results showed through learning from teaching, the preservice teachers further developed their PCK, although this development varied among the preservice teachers.

To answer the second research question: What is the impact of digital lectures on science student teachers' PCK? Both comparison and experimental groups were pre-tested, and post-tested. The experimental group had higher scores mean in the total pre-test than the control group. Therefore, the t-test was conducted on pre-test scores, and the results indicated that there was a significant difference between the scores mean of the experimental group and the comparison group. Consequently, the analysis of covariance (ANCOVA) was used to find out the effect of digital lectures on the student teachers' PCK. This statistical test was used to account the adjusted means of the post-test scores using the pre-test scores as the covariate, to analyze the differences between the experimental and the comparison group (Houseal, Abd-El-Khalick&Destefano, 2014, p. 98). Student's scores for setting educational objectives of PCK test were analysed using ANCOVA as shown in the Tab.1:

Table1. The Results of ANCOVA for Setting Educational Objectives of PCK Test

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	31.72a	2	15.86	6.77	.003
Intercept	4363.9	1	4363.9	1862 .9	.000
Covariate	.32	1	.32	0.14	.713
treatment	28.43	1	28.4	12.1 3	.001
Error	86.67	37	2.34		
Total	5594	40			
Corrected Total	118.4	39			

R. Squared = .268 (Adjusted R Squared = .228)

As can be observed in Tab.1 there was a significant difference between the experimental group and comparison group in student teachers' scores for setting educational objectives (F = 12.13, and the value of significance is 0.001 < 0.05). It indicated that the digital lecture has a better impact on student teachers' performance in setting educational objectives of PCK test. It can be concluded that the digital lecture led student teachers to greater understanding of setting educational objectives topic compared to the conventional method.

Table 2. The Results of ANCOVA for Content Analysis of PCK Test

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.73a	2	1.87	1.50	.235
Intercept	388.17	1	388.18	313.12	.000
Covariate	1.29	1	1.29	.000	.997
treatment	3.32	1	3.32	2.68	.110
Error	45.87	37	1.24		
Total	3218.00	40			
Corrected Total	49.60	39			

R. Squared = .075 (Adjusted R Squared = .025)

The results in Tab.2 showed no significant differences between the experimental group and comparison group in student teachers' scores for content analysis (F = 2.68, and the value of significance is 0.110 > 0.05). This is because the impact of digital lecture is equal to the impact of the traditional method on students' performance. It indicated that both the digital lecture and the traditional method had a better impact on student teachers' performance for content analysis of PCK test. These results agree with Szabo and Hastings (2000) who performed three studies to investigate the efficacy of digital PowerPoint lecturing in undergraduate classrooms. There were no significant differences between the two PowerPoint lectures both of which resulted in higher grades than the overhead lecture.

Table 3. The Results of ANCOVA for Daily Lesson Planning of PCK Test

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.95a	2	.97	1.16	.324
Intercept	722.13	1	722.13	861.16	.000
Covariate	.56	1	.56	.67	.420
treatment	.61	1	.61	.73	.399
Error	31.03	37	.84		
Total	2121.0	40			
Corrected Total	32.98	39			

R. Squared = .059 (Adjusted R Squared = .008)

The results in tab.3 indicated no significant differences between the experimental group and comparison group in student teachers' scores for lesson planning (F = 0.73, and the value of significance is 0.399 > 0.05). This result indicated that the impact of digital lecture was equal to the impact of the traditional method on student teachers' performance. Therefore both the digital lecture and the traditional method have had a better impact on student teachers' performance for lesson planning of

PCK test. Hanuscin, et al. (2018) proved that although teachers' lessons included the small particle model (SPM), they had difficulty identifying where this topic fits into the traditional matter unit sequence and why the SPM was important for understanding scientific phenomena.

Table 4. The Results of ANCOVA for Total PCK Test

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	26.55a	2	13.27	2.68	.082
Intercept	4814.41	1	4814.41	972.19	.000
Covariate	3.00	1	3.00	.606	.441
treatment	26.52	1	26.52	5.36	.026
Error	183.23	37	4.95		
Total	31179.0	40			
Corrected Total	209.78	39			

R. Squared = .127 (Adjusted R Squared = .079)

As indicated in Tab.4 there was a significant difference between the experimental group and comparison group in student teachers' scores for total test (F = 5.36, and the value of significance is 0.026 < 0.05). It indicated that student teachers in the experimental group performed better than in the comparison group on overall post-test; this means that the digital lecture has had a better impact on student teachers' pedagogical knowledge. It can be concluded that the digital lecture led student teachers to greater understanding of pedagogical knowledge compared to the conventional method. This result agrees with Evans (2008) who aimed at identifying the effectiveness of mobile learning in the form of podcasting, for undergraduate students in higher education. Podcasting involves downloading a series of audio or video broadcasts (files) onto a digital media player, via a computer. The study indicates that students believe that podcasts are more effective revision tools than their textbooks. They also indicate that they are more receptive to the learning material in the form of a podcast than a traditional lecture or textbook. On the contrary, the results are different with Copley (2007), where survey responses suggested little likely impact on lecture attendance as a consequence of podcasting, but they indicated that podcast recordings of lectures may not be effective in facilitating mobile learning. The graphs below confirm these results:

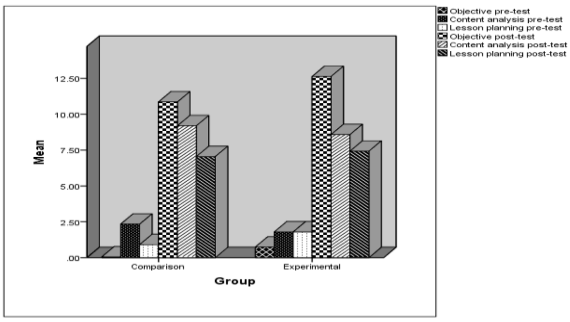

Figure 4. The Relations between Scores Means of the Comparison and Experimental Groups for Subcategories of PCK Pre and Post-Test

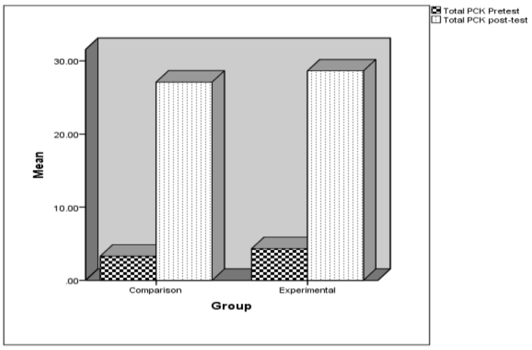

Figure 5. The Relations between Scores Means of the Comparison and Experimental Groups for Total PCK Pre and Post-Test

As demonstrated in the previous graphs, the performance of both the experimental group and comparison group increased significantly in the post-test. This indicated that both groups' performance changed from pre-test to post-test, and this presented a significant improvement over time. This means that after teaching using the digital lecture and traditional method, all student teachers (in the experimental group and comparison group) demonstrated a deeper understanding of pedagogical content knowledge. Therefore, the ANCOVA results demonstrated that there were no significant differences between the experimental group and comparison group for both content analysis and lesson planning topics. While the results of ANCOVA showed significant differences between the two groups for the educational objectives topic and overall test, but these differences were very slight as indicated in the graphs. It can be concluded that both digital lecture and traditional method had influenced student teachers' performance equally and fostering their PCK.

To uncover the reasons behind these results, it is necessary to pay attention to the fact that although the digital lecture has many advantages, it lacks some of the traditional lecture's advantages, such as the direct interaction between the teacher and students and between students with each other. It also lacks immediate feedback and does not correct students' mistakes as soon as responses are issued. Therefore, the author suggests integrating digital lecture and e-learning techniques with face-to-face learning methods to benefit from the advantages of both of them and achieve effective and successful teaching. These results agree with Chandlera, Parkb, Levinc and Morse (2013) who indicated that a focus on online instruction combined with face-to-face, hands-on activities showed a significant improvement in the learners' understanding of the course material.

At the end of the experiment, the instructor conducted a collective interview with student teachers for recognizing their views about digital lectures. The majority of them stated that they enjoyed watching digital lectures. They can choose the best time to watch them at home without attending regularly scheduled lectures. It permitted them to pause and replay the video and stop it to review the content over and over again until they understand it. Some students tended to be shy in the classroom and did not participate in the discussions. However, they exhibited that they were more comfortable and relaxing in learning via digital lectures. The difficulties they faced were the shortage of internet speed or the network was not available.

CONCLUSIONAND RECOMMENDATIONS

The educators and researchers' view of the PCK should change from mere knowledge to an integrated set of academic and educational experiences. When we change our viewpoint from PCK to PCE, there will be an inclusive and unified agreement among the educators about the concept of PCK. The findings of Sen, Oztekin and Demirdogen (2018) indicated that "content knowledge may support knowledge of what students understand in science as well as knowledge of instructional strategies, whereas the impact of content knowledge on teachers' knowledge of the science curriculum and their knowledge of assessment in science is complicated". On realizing that both content knowledge and pedagogical knowledge are part of the teacher's PCE, it is possible to conduct studies that aim at investigating the effect of CK and/ or PK on teacher's PCE.

Aydeniz and Kirbulut (2014) mentioned that "our efforts will motivate other researchers interested in the concept of PCK to transform the concept in light of new curriculum priorities and what we have learned from studies of PCK both within and outside the science-education community". Korthagen (2010) reported the need for pedagogy of teacher education that combines practical experiences, and rethinking of teacher education practices for effective professional development (p. 103).

In addition, the results proved that the performance of both the experimental group and comparison group increased, and they presented a significant improvement at the end of experiment. It means after teaching using the digital lecture and traditional method, all student teachers demonstrated a deeper understanding of pedagogical content knowledge. Hence, both the digital lecture and the traditional method have had a better impact on student teachers' PCK. The current research highlights the new term of pedagogical content experience (PCE) and further research is needed to outline it to provide further evidence for its validity. Not only does pedagogical knowledge deserve close attention, but also the procedures and techniques by which it is possible to constitute PCE have to be taken into account in the teacher education. The findings highlight the need for integrating e-learning environment with face to face learning environment for professional development. The research recommends conducting evaluation studies to identify the current level of student teachers' PCE when enrolling in the science teacher preparation programs and at the final year. It also recommends conducting qualitative studies to identify the current level of in-service science teachers' knowledge, practices and beliefs and identify their training needs. Extensive and extended data collection should be done to identify its deficiency and propose programs for improvement.

LIMITATIONS

The current research was limited to Pedagogical Content Knowledge (PCK) that is the first component of Pedagogical Content Experience (PCE). Due to the small sample of the current research, it was likely to have limited generalizability.

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