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Research Article

The effectiveness of interactive digital content based on the TPACK model in developing the skills of educational aids production and improving cognitive achievement among early childhood university students

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ABSTRACT

The study aims to examine the effectiveness of interactive digital content based on the technological pedagogical content knowledge framework (TPACK) model in developing the skills of educational aids production and enhancing cognitive achievement among early childhood students at Jadara University. The researcher relied on the quasi-experimental approach with two groups to identify the effectiveness of the independent variable teaching method (the effectiveness of interactive digital content based on the TPACK model) on the dependent variable (educational aids production skills and cognitive achievement). This study used two instruments: an achievement test and an observation card. The study sample comprises 47 female students from Jadara University. The results showed the effectiveness of interactive digital content based on the TPACK model in developing skills for producing educational aids and cognitive achievement. Based on the results, the researcher recommends providing training courses for students on designing digital course models to develop various skills.

Keywords: digital content, TPACK, teaching aids, achievement

INTRODUCTION

Technical plays a significant role in providing teachers with tools and devices that facilitate information delivery to learners. The multimedia method is one of the modern education techniques, functioning as an interactive educational system designed to achieve specific goals. This method is based on a well-structured sequential organization, allowing each student to progress in the education process at his pace and according to his individual characteristics actively and positively (Al-Amoush, 2023; Lindner et al., 2021).

A learner can only comprehend an explanation within the limits of their knowledge and information; however, using media can provide learners with more apparent limits or the experience and activity being learned, primarily since verbal explanations do not always effectively support the learning process (Shenouda, 2022).

Students learn more effectively when more than one sense is used in learning. Multimedia simulates the majority of the senses in various forms, such as sound, images, animation, and written texts. Therefore, multimedia plays a significant role in developing teaching and learning, particularly educational content, which has been transformed into digital content instead of traditional one. Digital content enriches the education process by increasing experience, facilitating concept formation, and overcoming natural and geographical barriers that are increasing due to technological progress (Yaniafari et al., 2020).

This environment is also rich in communication methods that present the curriculum in invaluable and attractive ways. Additionally, it serves as a cost-effective educational tool, as digital content may contribute to conserving time, effort, and resources. Additionally, it helps stimulate students' focus, fulfill their desires for learning, enrich their experience, and effectively prepare them. Multimedia's varied and interactive features allow students to use more senses to participate more fully in the learning process, which enhances understanding and memory (Aldalalah, 2022; Sun et al., 2022).

Digital content does not help deliver information and facts to students easily and with minimal effort by presenting meaningful and purposeful facts, primarily if it is based on one of the theories and models that facilitated and encouraged the process of integrating technology into the educational process. Generally, the most significant of these models is the technological pedagogical content knowledge framework (TPACK) model. TPACK is a framework for understanding and describing the types of knowledge that teachers need for effective educational practices in a technology-enhanced learning environment, as it helps them raise their teaching competencies, especially for early-stage teachers such as kindergarten teachers (Adipat et al., 2023).

Kindergarten teachers are critical in nurturing children during this foundational stage, achieving the required educational goals, and considering age-stage characteristics. By exposing the child to many stimuli and experiences, the teacher manages and organizes the activities, requiring a unique set of personal, social, and educational characteristics that distinguish them from other teachers of other age levels, such as developing the skills and knowledge of kindergarten teachers and enabling them to deal optimally with children and prepare them for excellence. This development begins with comprehensive university training, where they study courses tailored to develop their cognitive competencies and skills, such as designing and producing educational aids (Dugan, 2022).

Kahina (2020) believes that educational aids are among the topics that have received considerable attention from educators and those interested in the childhood stage. Educators have realized the benefits of using educational aid in the instructional process since their effects have been proven to enhance the quality of educational outcomes and the acquisition of skills, experiences, and knowledge in a more effective and developed manner (Dwekat, 2021; Khammas & Sabhan, 2019; Kija & Msangya, 2019; Sanjaya et al., 2022). In the context of instruction, educational aids are effective since they save time and effort for both the teacher and the student, aid in knowledge transfer, stimulate students' interest and attention, and validate information. Additionally, it improves the accuracy of observation and thought continuity, improves student memorization and comprehension, and expands student participation and cooperation opportunities. Despite the multiple benefits of educational aid, they cannot fulfill their purpose and be effective without qualified, trained teachers who have proficiency in designing, producing, and using these aids. Using educational aids introduces learning experiences without boredom or indolence because it makes learning easier for both the teacher and the student.

A kindergarten teacher must use various techniques to simplify material while also comprehending the requirements and developmental traits of the learners in order to communicate knowledge to them successfully. It is challenging for old teaching methods to satisfy the exacting criteria needed for modern and future education. Digital content based on media is undoubtedly one of the most crucial resources in contemporary education. As a technological development, multimedia incorporates audiovisual components to improve learning and make knowledge more interesting and valuable (Abu Srour & Al-Mistarihi, 2022).

Therefore, this study came to identify the effectiveness of interactive digital content based on the TPACK model in developing the skills of producing educational aids and cognitive achievement among students at Jadara University.

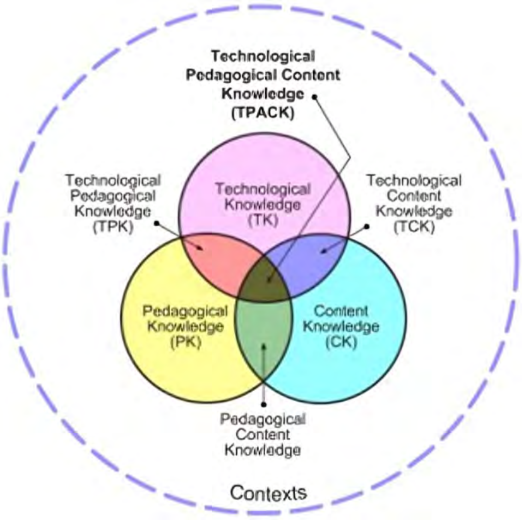

Figure 1. The TPACK model (Source: Koehler and Mishra, 2009)

TPACK Model

The TPACK model is a conceptual framework that defines the nature of the knowledge teachers require in the modern era (Mishra & Koehler, 2006). It serves as an extension of the idea introduced by Shulman regarding the essential knowledge for teachers, which he categorized into two distinct domains: content knowledge (CK) and pedagogical knowledge (PK). Mishra and Koehler (2006) expanded Shulman's dual framework by incorporating a third domain: technological knowledge (TK), recognizing technology as an integral aspect of contemporary education. This addition resulted in a more comprehensive model that identifies the competencies, skills, and knowledge required for an effective teacher in alignment with the demands of the 21st century.

The TPACK model is a technological educational model based on integrating the elements of the instructional process and digital technology. The knowledge emerges from the interaction of CK, knowledge of education, and technology during the teaching process. It focuses on TK, PK, and CK (Tanka, 2018). Therefore, it is considered a good approach to solve many of the obstacles that teachers face in applying technology in classrooms; in addition to that, it emphasizes the integration between aspects of teacher preparation. It is one of the leading theories of integrating technology into education (Al-Dasouki, 2022).

The researcher defines the TPACK model as the totality of knowledge and skills that must be available to kindergarten teacher students. It contributes to developing some of their teaching competencies through integrating knowledge of content, pedagogy, and technology. Additionally, it enables them to integrate technology with education and enhance their pedagogical practices in educational situations through their kindergarten teaching. The TPACK model is also linked to the teacher's ability to understand the relationship between the topics of scientific content, education, and TK to form an organized structure that clarifies the relationship between these components and addresses them in a way that refines experience and develops performance. The TPACK is a model that aims to clarify the important competencies of teachers that enable them to integrate technology into education. Knowledge of a specific subject or topic is considered insufficient, so it should include TK and its use (Trigueros & Aldecoa, 2021).

The TPACK framework outlines how content (what is taught) and pedagogy (how the teacher communicates this content) should form the basis of any effective educational technology integration in order to enhance student's learning experience and guide them toward a better and more robust understanding of the subject matter (Aziz et al., 2022). **Figure 1** shows the forms of knowledge resulting from the intersection of the three main components of the TPACK model within the educational context in which it takes place:

Any practical application of technology in education requires recognizing the relationship between content, teaching methods, and technology. Teaching is a dynamic and complex process that requires many competencies and knowledge, including the following (Adipat et al., 2023; Al-Dasouki, 2022; Ariyani et al., 2023; Fahadi & Khan, 2022; Major & McDonald, 2021):

- CK–Teachers' knowledge of the scientific content of a particular subject, which will be presented to a specific group of students.
- PK–Teachers' knowledge of methods, processes, and strategies related to the educational process. This includes developing values, considering emotional aspects, understanding student learning styles, classroom management skills, lesson planning, and assessments.
- TK–Teachers' knowledge and ability to use various technological tools and related materials, in addition to their understanding of educational technology and the possibility of employing it in a specific field or classes.
- Pedagogical content knowledge (PCK)–Knowledge of teaching methods that suit a specific subject or content and the possibility of rearranging this content to improve the educational process, including developing curricula, evaluating students, and reporting results. PCK also focuses on enhancing learning and tracking the links between teaching methods and practices. It seeks to improve teaching methods through strong links between content and teaching methods.
- Technology content knowledge (TCK)–Teachers' understanding of how technology and content influence each other, how to teach a specific topic through different technology, and identifying educational technology tools best suited to the topics or grade levels. Teachers need to know the change in the educational process through technology.
- Educational technology knowledge (TPK)–Knowledge of the components of technology and its use in teaching, which justifies how teaching can change using technology and choosing the appropriate and most efficient technical tools to perform a specific task. This includes knowledge of educational teaching strategies and applying them using technology tools.

TPACK results from these different combinations and interests, from which the three core areas of content, pedagogy, and technology are drawn to create a practical foundation for teaching using educational technology (Mishra & Koehler, 2006).

In the TPACK framework, knowledge represents a comprehensive understanding that 21st century teachers must acquire and apply during lesson planning, implementation, and assessment. Teachers should begin with the content, considering the knowledge, skills, and values it encompasses, and then reflect on the most suitable teaching methods, strategies, and models. Additionally, they must integrate technological tools and resources into the learning environment, positively impacting student learning outcomes.

Therefore, pre-service teacher preparation programs should equip future teachers with CK, pedagogical expertise, and technological proficiency while addressing the intersections between these three domains to enhance their instructional effectiveness.

In order for teachers to use TPACK model effectively, they must have some key ideas (Kurt, 2019):

- Teaching content concepts taught using technology.
- Different content concepts require different skill levels from students, and educational technology can help meet some of these requirements.
- Students come to the classroom with different backgrounds, including previous educational experience and use of technology, so lessons using technology should take this into account.
- Educational technology can be used in conjunction with students' existing knowledge.

The TPACK model is an effective way to integrate technology into the educational process. In addition to the ability to judge the level of the teacher, this requires training, professional development, and knowledge of the best ways technology can be used to increase educational interaction. Teachers need to understand that the best educational methods are formed through good knowledge, content, educational methods, and the use of technology in different educational situations (Abu Diya et al., 2021). Understanding how to develop teachers and apply their knowledge of technological integration across different educational environments requires development within the TPACK framework by proposing a new conceptual synthesis.

Mishra (2019) suggested renaming the outer dotted circle in the TPACK model as "contextual knowledge" (the teacher's knowledge of the context) and considering it as another knowledge domain that teachers should possess to integrate technology into teaching, which includes everything from the teacher's awareness

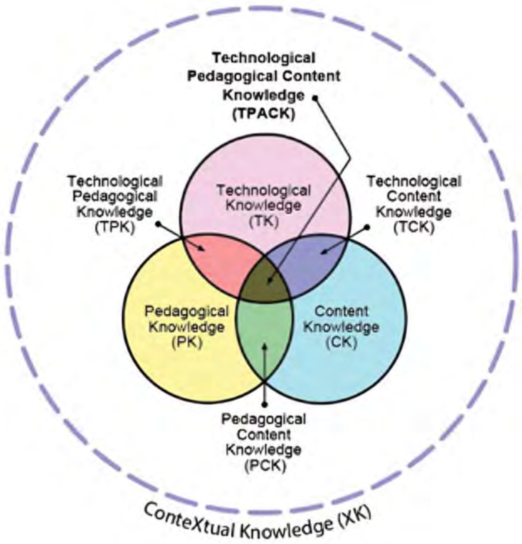

Figure 2. Revised version of the TPACK image (Mishra, 2019)

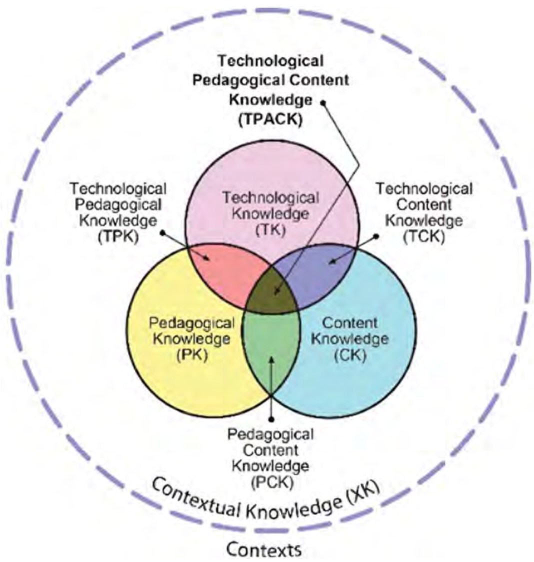

Figure 3. The updated TPACK model (Petko et al., 2025)

of available technologies to the teacher's knowledge of the school, district, or national policies within which they operate. This, in turn, means that contextual knowledge is something teachers can work on and change, helping them to integrate technology into the educational situation, as shown in **Figure 2**.

Meanwhile, Petko et al. (2025) view TPACK as a model that aligns with developments; it is a theory regarding the practical aspects of teacher knowledge. Therefore, contextual knowledge should be included within the outer framework of the dotted circle that represents aspects of teacher knowledge, which distinguishes levels of teachers. There are also external factors that influence knowledge and its application (contexts) in which teaching and learning occur, as well as types of knowledge (pedagogical, content, technological, and contextual) that teachers need to possess, as shown in **Figure 3**.

Despite this addition, TPACK remains one of the most effective models in teaching knowledge regarding integrating technology into education and providing best practices within classrooms.

Many studies have shown the effectiveness of the TPACK model in employing and integrating technology into the educational process for different levels of study and subjects.

A study by Abu Diya et al. (2021) revealed the TPACK model's effectiveness in developing some teaching competencies (PTPDI) among teacher students at the Islamic University–Gaza college of education. Al-Dasouki's (2022) study confirmed the effectiveness of adopting the TPACK model in developing the teaching

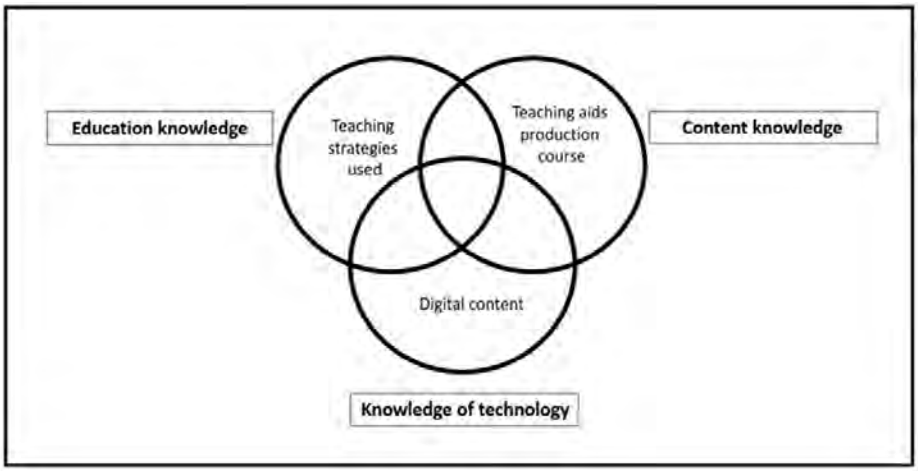

Figure 4. Knowledge of the TPACK model in digital content (Source: Authors)

performances of teacher students at the college of education–Helwan University. As for the study of Elmaadaway and Abouelenein (2022), the results identified ideas and practices for developing a learning environment based on the TPACK model for mathematics, science, and English language teachers. The study by Adipat et al. (2023) showed the effectiveness of developing and analyzing TPACK to develop a successful professional teacher.

Studies have demonstrated the effectiveness of the TPACK model in enhancing various aspects of teacher education and instructional practices. Hassan (2020) found that TPACK significantly contributes to developing self-efficacy and reflective thinking among pre-service mathematics teachers. Similarly, Hindawi (2022) highlighted the effectiveness of a TPACK-based program in improving Arabic language teaching skills in alignment with digital learning requirements and fostering positive attitudes toward the teaching process among postgraduate diploma students in the faculty of education.

Additionally, Mohammed (2024) demonstrated the effectiveness of a TPACK-based program in enhancing digital CK, teaching performance skills, and attitudes toward the teaching profession among pre-service science teachers. Furthermore, Al-Qahtani (2021) found that the TPACK model significantly enhances creative teaching skills among female science teachers, improving students' creative thinking and academic achievement in science. These findings underscore the importance of integrating TPACK in teacher training programs to equip educators with technological, pedagogical, and content-related competencies, ultimately improving teaching effectiveness and student learning outcomes.

To achieve the integration of technology into education, the researcher applied the three pieces of knowledge in teaching the course on the production of educational aids, as shown in **Figure 4**.

Multimedia-Based Digital Content

Multimedia combines various types of files, such as text, audio, video, and images. It is considered one of the most significant educational advancements, providing students with a comprehensive learning environment that integrates diverse instructional methods from multiple sources. This typically creates an educational system that helps students achieve predefined learning objectives. Students can improve their academic performance and learning abilities by actively interacting with various media (Aldalalah, 2021; Han & Niu, 2019).

Using multimedia significantly captures students' interest and promotes their engagement in the instructional process. Additionally, it enhances curricula delivery to keep pace with modern developments. It solves problems facing the teacher that traditional methods cannot solve, such as considering students' individual differences and managing limited instructional time. In addition, it fosters collaboration among students, promoting a sense of teamwork and collective learning (Burgos, 2023).

Several studies Lindner et al. (2021), Krishnasamy and Ling (2020), and Shenouda (2022) have addressed the significant impact of multimedia in facilitating instructional activity, presenting relevant material and encouraging students to interact more effectively with the curriculum. This is because it includes audio-visual stimuli that engage multiple senses that help recall and comprehend different topics, considering the individual differences of the learners by motivating the self-learning strategy, whereby the learner can rely on himself in dealing with the programs, thus raising the students' efficiency. Furthermore, multimedia supports teachers by enabling them to perform other tasks, guiding and mentoring students rather than solely delivering content. It is also characterized by interaction, integration, and diversity, as it provides a series of components that help explain the educational activity to students to reach the intended goal, and all of this leads to reaching what is known as digital content (Dhaher, 2018).

Digital content delivers messages, ideas, and information on topics and specializations in different ways by encoding those ideas through various multimedia available on websites or other digital mediums (computers, mobile devices, and telephone devices). It also includes any type of data that is stored digitally (Lopes & Casais, 2022).

Al-Tawit (2022) defines digital content as the content of instructional cognitive material designed through audiovisual media that can be shared via the Internet. Al-Mutaie (2020) also believes that educational digital content is a variety of fixed and moving electronic audio-visual media and stimuli, which include sounds, graphics, pictures, shapes, video clips, texts, books, references, and interactive links, which are used to display digital content through modern electronic means based on information and communications that meet all the needs of students and facilitate the work of teachers. It is not just a traditional online course but a combination of interactive resources, performance support, and suitable learning activities (Blanchard et al., 2019).

Based on the above, there is a difference between educational content and digital content. Educational content is the most important part of the teaching process, consisting of concepts, information, and facts (Al-Ahmadi & Al-Sharif, 2022). Digital content is cognitive material incorporating textual, audio, or visual materials or forms. They are digital data circulated through the Internet or other digital mediums. However, digital content is not merely a conversion of printed books into electronic pages, but rather it must be grounded on educational strategies and theories (Yasar et al., 2019).

Digital content offers various advantages that support the achievement of the educational goal. It provides diverse multimedia tools that help present educational content in a structured, sequential manner while allowing for flexibility, update, and modification to enhance learners' motivation. Furthermore, it helps develop some characteristics of learners, such as self-learning, self-confidence, autonomy in learning, and the ability to access information anytime and anywhere. Digital content also considers the accuracy and diversity of sources of knowledge and information published, free of scientific and objective errors. It avoids bias in the topics presented, which contributes to creating an interactive learning environment that supports cooperation and eliminates routine restrictions in the educational process (Al-Mutaie, 2020).

Digital content also reduces the costs of scientific production by saving the costs of paper printing, distribution, shipping, and preservation, as no matter how much information and data in various types of knowledge increases, they will remain preserved in the devices' memory or through cloud computing (Al-Sharman, 2019). Therefore, designing digital content must be built on scientific foundations, theories, models, and principles of learning that explain the learning process and how it occurs effectively to achieve the goals. (Abu Khatwa & Hassan, 2018).

Many studies have indicated the effectiveness of digital content. Al-Khayyat et al. (2016) study confirmed the effectiveness of using digital environments in disseminating educational courses and developing various aspects of knowledge and skills. The results of a study conducted by Al-Shammari and Al-Shammari (2019) demonstrate the effectiveness of teaching computers using a program based on digital video to develop some arithmetic skills. Al-Mutaie's (2020) study confirmed the efficiency of digital content in improving the level of teaching in the printing techniques course for graphic design students. Hassan's (2018) study proved the effectiveness of the electronic learning environment in developing the skills of using electronic networks among graduate students at the college of education. Al-Taf's (2019) study showed that digital learning increases achievement and develops positive attitudes toward using digital learning through a smartphone.

Problem Statement

The childhood stage is the cornerstone of the educational process as a whole, as it is a transitional stage for children from the informal to the formal education stage. It constitutes a stage with important dimensions that involve remarkable growth and development for children, so it needs to direct attention towards developing children emotionally, intellectually, and physically. The best means and methods in order to increase the readiness of children for the next stage, which is the school stage, requires a teacher with unique specifications that differ from teachers of other stages, given the significant role and responsibility that she bears in raising children, which calls for continuous renewal and diversification in the various sources of learning, activities and innovation from through the use of educational aids in different educational situations, experiences, and environments, as indicated by the studies of Al-Kalbaniyah and Radwan (2022), Abu Srour and Al-Mustarihi (2022), and Zawy et al. (2021).

The problem of the study stems from the researcher's practical experience and through examining the educational field in the kindergarten stage, with the necessity of developing the skills of producing different teaching aids for kindergarten teachers, as some studies have indicated (Al-Iraqi, 2022; Nawajaa, 2022; Nouri, 2020), which requires developing their teaching aids production skills before service during the university study period. Therefore, this study explored the effectiveness of interactive digital content in developing skills for designing teaching aids for female early childhood students and teachers at Jadara University, where many studies indicate the effectiveness of digital content based on multimedia. In the educational process, traditional teaching methods are based on a single source without considering the intellectual and scientific developments in life and without regard for individual differences, leading to a loss of intrinsic motivation for learning.

Research Questions

This study came to answer the following questions:

- What is the effectiveness of interactive digital content based on the TPACK model in developing the skills of producing educational aids among students?
- What is the effectiveness of interactive digital content based on the TPACK model in cognitive achievement in producing educational aid among students?

Research Hypotheses

- There are no statistically significant differences at the level of statistical significance ($\alpha = 0.05$) between the mean scores of the experimental and control groups in the observation card while producing teaching aids in the post-application.
- There are no statistically significant differences at the level of statistical significance ($\alpha = 0.05$) between the mean scores of the experimental and control groups in the cognitive achievement test in the course of producing teaching aids in the post-application.

METHODS

Research Design

In this study, the quasi-experimental approach was used to observe the impact of the independent variable (digital content based on the TPACK model) on the dependent variables (skills of producing teaching aids and cognitive achievement). The student sample was distributed into two groups: the first was taught through digital content based on the TPACK model, and the second was taught through regular presentations. At the end of the experiment, the two groups were tested statistically.

Study Population and Study Sample

The study population consisted of all kindergarten teacher students at the faculty of educational sciences at Jadara University for the second semester of the year (2022–2023). The application of the current study was limited to an accessible sample consisting of 47 students at Jadara University.

Table 1. Distribution of study sample members in the two study groups (N = 47)

Method	Number of female students in pre-test	Number of female students in post-test
Digital content based on TPACK model	23	23
Regular presentations	24	24

Table 2. Quantitative assessment of observation card

The level of performance	High	Medium	Low
Quantification	3	2	1

The study sample consisted of 47 female kindergarten student teachers at Jadara University. The researcher divided this sample into two groups randomly: one was the experimental group, consisting of (23) female students, and the other was the control group, consisting of 24 female students. **Table 1** shows the distribution of study individuals into experimental and control groups.

Study Variable

The independent variable is the teaching method and has two levels:

- Teaching through digital content based on the TPACK model.
- Teaching through regular presentations.

The dependent variable:

- Teaching aids production skills.
- Cognitive achievement.

Research Instruments

Observation card

After reviewing the educational literature and previous studies related to the research problem and polling the opinion of a sample of university professors specializing in kindergartens, the researcher designed an observation card containing skills for producing educational aids. Then, he prepared the initial version of the observation card. The researcher also identified three levels to estimate the students' performance. These levels are (high, medium, and low), where the observer places a mark (X) before the skill level. **Table 2** shows the quantitative estimate of the observation card.

After that, the total score obtained by the student is calculated, thus measuring her performance and judging her level of performance skills.

Referees validity: A panel of experts specializing in early childhood education reviewed the observation card. They were asked to assess the clarity of each item and provide feedback. The experts' insightful comments resulted in the necessary changes. Furthermore, they assessed the statements' reliability and measurement efficacy. A final observation card with 15 items was created by keeping the items the experts agreed upon and removing the ones that did not.

The validity of internal consistency: The validity of the observation card's internal consistency was verified by applying it to the exploratory sample. Then, Pearson correlation coefficients were calculated between the scores of each item and the skill to which it belongs, and **Table 3** shows this.

Table 3 shows that all correlation coefficients were substantial and statistically significant at the level 0.01, confirming that the card has high internal consistency.

Observation card reliability: To find the reliability of the observation card, the researcher used the inter-rater validity method. Then, the percentage of agreement between the observers was calculated using the "Cooper" equation. Accordingly, with the help of one of the teachers in the early childhood department, the researcher observed six female students. After applying the aforementioned equation, the reliability factor reached 85, a high percentage through which the observation card can be applied.

Table 3. Correlation coefficients for each practice with the total score of observation card

No	Correlation coefficient	Significance
1	.811**	.000
2	.754**	.000
3	.783**	.000
4	.615**	.011
5	.631**	.000
6	.621**	.005
7	.651**	.000
8	.797**	.000
9	.737**	.000
10	.604**	.007
11	.709**	.005
12	.803**	.000
13	.682**	.000
14	.814**	.000
15	.810**	.000

Table 4. Table of specifications for the test items

Subjects	Q&M	Behavioral objectives		Total questions	Total marks	Percentage (%)
		LMS	HMS			
The historical development of teaching aids	Questions	1.28	0.72	2	3	10
	Marks	1.28	0.72			
Criteria for selecting and using teaching aids	Questions	2.56	1.44	4	6	20
	Marks	2.56	1.44			
Evaluation of teaching aids	Questions	5.40	1.16	6	9	30
	Marks	5.40	1.16			
Standards for design of teaching aids & technologies	Questions	1.28	0.72	2	3	10
	Marks	1.28	0.72			
Classification of teaching aids	Questions	5.00	1.16	6	9	30
	Marks	5.00	1.16			
Total questions		15	5	20	20	
Total marks		15	5			
Percentage (%)		75	25		100	

Notes: Q&M: Questions and marks; LMS: Lower mental skills; HMS: Higher mental skills.

Cognitive achievement test

The test aimed to measure the cognitive aspect of the skills of producing educational means intended to be developed among female students. The researcher also identified unique educational objectives to measure female students' achievement in a clear behavioral challenge, which are cognitive and educational objectives, and classified these objectives according to Bloom's classification of educational objectives. After analyzing the content and defining the objectives, the researcher prepared a specifications table in which the test questions were developed. **Table 4** shows the specifications table, and the test was formulated in its initial form.

Referees validity: The validity of the test was determined by using the face validity method by presenting it to a group of referees specialized in early childhood education "kindergartens," educational technology, curricula, and teaching methods, as well as early childhood "kindergarten" supervisors. Most of the referees' opinions and suggestions were summarized regarding the linguistic formulation of the meanings of some concepts, and some items were reformulated to suit the level of early childhood university students. The researcher made the modifications indicated by the referees, and thus, the test in its final form became ready to be applied to the exploratory experiment group.

The validity of the internal consistency of the test: After preparing the test in its initial form, the researcher applied it to an exploratory sample of 17 female kindergarten teacher students from outside the study sample to measure the strength of the correlation between the scores of each item and the overall test score. The validity of the test's internal consistency was verified, as indicated in **Table 5**.

Table 5. Correlation coefficients of the test

No	Correlation coefficient	Significance
1	0.83	.000
2	0.85	.000
3	0.68	.005
4	0.87	.000
5	0.90	.000
6	0.91	.000
7	0.66	.007
8	0.68	.005
9	0.88	.000
10	0.84	.000
11	0.91	.000
12	0.72	.002
13	0.95	.000
14	0.65	.008
15	0.84	.000
16	0.77	.001
17	0.75	.001
18	0,94	.000
19	0.95	.000
20	0.94	.000

Table 6. Difficulty and discrimination coefficients for the test items

No	Difficulty index	Discrimination index
1	0.46	0.31
2	0.31	0.46
3	0.42	0.23
4	0.42	0.38
5	0.20	0.23
6	0.35	0.38
7	0.23	0.31
8	0.42	0.38
9	0.27	0.23
10	0.27	0.38
11	0.50	0.23
12	0.46	0.31
13	0.77	0.69
14	0.20	0.31
15	0.69	0.46
16	0.54	0.23
17	0.77	0.69
18	0.27	0.31
19	0.27	0.23
20	0.31	0.31

Table 5 shows that all items of the test are statistically significant at the level of significance 0.01 and 0.05. This confirms that the test has good internal consistency, which reassures the researcher of its application to the study sample.

Test Reliability

To verify the reliability of the test, the researcher used Cronbach's alpha equation for reliability. The reliability coefficient calculated this way was 0.934, indicating that the test has a high degree of reliability that reassures the researcher to apply it to the study sample.

Difficulty and discrimination coefficient for each item of the test

Difficulty and ease coefficients were calculated for the test questions, and **Table 6** shows the results reached by applying this equation to the data collected through the survey application.

Table 7. t-test results for two independent samples to ensure the equivalence of the experimental and control groups on the two study instruments

Instruments	Groups	N	M	SD	F	df	Sig.
Observation card	Digital content based on the TPACK model	23	9.600	2.88	−0.141	45	0.890
	Regular presentations	24	9.750	4.00			
Cognitive achievement test	Digital content based on the TPACK model	23	5.130	2.15	−1.358	45	.181
	Regular presentations	24	6.160	2.98			

Note. M: Mean & SD: Standard deviation

Table 8. Post-test scores of students in groups-1

Groups	Mean	Standard deviation	N
Digital content based on the TPACK model	25.73	2.027	23
Regular presentations	21.25	2.400	24
Total	23.44	3.160	47

Table 9. ANCOVA of the post-test scores of students in groups-1

Source	Type III sum of squares	df	Mean square	F	Significance
Groups	233.600	1	233.600	51.219	.000
Error	200.674	44	4.561		
Total	26,298.000	47			

Table 6 shows that the difficulty coefficients ranged between 0.20 and 0.80, which are appropriate values, and the coefficients for distinguishing test questions ranged between 0.23 and 0.69, which are relatively high values.

Equivalence of groups

The researcher used a t-test on the pre-application of the two study instruments to ensure that the two study groups were equal.

Table 7 shows no statistically significant differences at the significance level 0.01 between the mean scores of the two groups on the two study instruments. Therefore, the two groups are equivalent before applying the experiment.

RESULTS

Verification of the First Hypothesis of the Study

No statistically significant differences at the level of statistical significance ($\alpha = 0.05$) were observed between the mean scores of the experimental and control groups in the observation car while producing teaching aids in the post-application. To validate the hypothesis, the mean and standard deviation were calculated in **Table 8**.

Table 8 shows that there is an apparent discrepancy in the means and standard deviations of the responses of the study sample on the observation card, and to show the significance of the statistical differences between the means, the ANCOVA test was used, as shown in **Table 9**.

Table 9 shows the results of the ANCOVA test of statistical significance on the differences observed in the mean scores of the post-observation card for groups with $F(1.44) = 51.219$, mean square = 233.600 and $p = 0.000$; there is a significant difference in the post-observation card scores of students who studied through digital content based on the TPACK model.

To determine the effect of digital content based on the TPACK model on developing the skills of producing educational aids among early childhood students at Jadara University, which is the complementary aspect of the statistical significance, the researcher used the eta coefficient (η^2) eta squared.

The value of eta squared (η^2) is interpreted according to the following division:

- The effect size is small from $0.01 \leq \eta^2 < 0.06$.
- The effect size is average from $0.06 \leq \eta^2 < 0.14$.

Table 10. t-test of the pre- and post-scores of students in groups-1

Data	Test	N	Mean	Standard deviation	F	Significance
Observation card	Pre	23	9.60	2.887	–20.522	0.000*
	Post		25.71	. 2.027		

Table 11. Blake modified gain ratio for groups-1

Data	Mean scores for the pre-measurement	Mean scores for the post-measurement	Blake modified gain ratio	Significance
Observation card	9.60	25.73	1.32	Acceptable

Table 12. Post-test scores of students in groups-2

Groups	Mean	Standard deviation	N
Digital content based on the TPACK model	18.17	1.64	23
Regular presentations	13.79	1.44	24
Total	16.00	2.65	47

- From $0.14 \leq \eta^2$, the effect size is large.
- The argument of effect was significant as the squared eta value was η^2 (0.515).

It is also clear that the eta square (η^2) value for the cognitive achievement test is more significant than 0.15, which expresses a large effect for the independent variable. This indicates that the difference reached between the two groups is a fundamental difference resulting from using digital content based on the TPACK model in teaching the production of educational aids courses.

The effectiveness of digital content based on the TPACK model was also determined in developing the skills of producing educational aid among the students through the statistical treatment of the results of the pre and post-application of the observation card for the group that studied through digital content based-on the TPACK model only, where the researcher calculated the mean and standard deviation. Moreover, the use of the t-test paired sample and its statistical significance for the differences between the mean scores of the group in the pre- and post-application on the observation card as in **Table 10**.

Table 10 reveals statistically significant differences at the level of significance 0.05 between the mean scores of the group (digital content based on the TPACK model) in the pre- and post-application on the observation card, favoring the post-application. Efficiency was calculated using the modified gain equation. This is evident from **Table 11**.

Table 11 shows the degree of effectiveness through the value of the modified gain of the observation card (1.32). That value is more significant than 1.2, which is the minimum set by Black for the effectiveness of the program. Accordingly, it can be judged that using digital content based on the TPACK model was adequate and contributed to its development. The skills of producing teaching aids among the students indicate that these differences were not a result of chance but were the effect of the teaching method using digital content based on the TPACK model.

Based on the foregoing, we reject the null hypothesis and accept the alternative hypothesis, that is, the mean scores of the post-measurement scores of the students of the group that studied through (digital content based on the TPACK model) on the observation card is greater than the average scores of the post-measurement of the students of the group that studied through (typical presentations)

Verification of the Second Hypothesis

No statistically significant differences at the level of statistical significance ($\alpha = 0.05$) were found between the mean scores of the experimental and control groups in the cognitive achievement test while producing teaching aids in the post-application. To validate the hypothesis, the mean and standard deviation were calculated in **Table 12**.

Table 12 shows that there is an apparent discrepancy in the means and standard deviations of the responses of the study sample on the cognitive achievement test, and to show the significance of the statistical differences between the means, the ANCOVA test was used, as shown in **Table 13**.

Table 13. ANCOVA of the post-test scores of students in groups-2

Source	Type III sum of squares	df	Mean square	F	Significance
Groups	212.258	1	212.258	85.450	.000
Error	109.296	44	2.484		
Total	12,356.000	47			

Table 14. t-test of the pre- and post-scores of students in groups-2

Data	Test	N	Mean	Standard deviation	F	Significance
Observation card	Pre	23	5.13	2.159	–22.707	0.000*
	Post		18.19	1.641		

Table 15. Blake modified gain ratio for groups-2

Data	Mean scores for the pre-measurement	Mean scores for the post-measurement	Blake modified gain ratio	Significance
Observation card	9.60	25.73	1.52	Acceptable

Table 13 shows the results of the ANCOVA test of statistical significance on the differences observed in the mean scores of the post-test for the groups with F (1.44) = 85.450, mean square = 212.258, and p = 0.000; there is a significant difference in the post-test scores of students who studied through digital content based on the TPACK model.

To determine the effect of digital content based on the TPACK model on developing the skills of producing educational aids among students at Jadara University, which is the complementary aspect of the statistical significance, the researcher used the eta coefficient (η^2) eta squared.

The value of eta squared (η^2) is interpreted according to the following division:

- The effect size is small from $0.01 \leq \eta^2 < 0.06$.
- The effect size is average from $0.06 \leq \eta^2 < 0.14$.
- From $0.14 \leq \eta^2$, the effect size is large.
- The argument of effect was significant as the squared eta value was η^2 (0.657).

It is also clear that the eta square (η^2) value for the achievement test is more significant than 0.15, which expresses a large effect for the independent variable. This indicates that the difference reached between the two groups is a fundamental difference resulting from using digital content based on the TPACK model in teaching the production of educational aids courses.

The effectiveness of digital content based on the TPACK model was also determined in developing the skills of producing educational aid among the students through the statistical treatment of the results of the pre and post-application of the cognitive achievement test for the group that studied through digital content based on the TPACK model only, where the researcher calculated the mean and standard deviation. Moreover, the use of a t-test paired sample and its statistical significance for the differences between the mean scores of the group in the pre and post-application on the observation card as in **Table14**.

Table 15 shows that there are statistically significant differences at the level of significance (0.05) between the mean scores of the group (digital content based on the TPACK model) in the pre and post-application on the cognitive achievement test in favor of the post-application. Efficiency was calculated using the modified gain equation. This is evident from **Table 15**.

Table 15 shows the degree of effectiveness through the value of the modified gain of the cognitive achievement test (1.32). That value is more significant than 1.2, which is the minimum set by Black for the effectiveness of the program. Accordingly, it can be judged that the use of digital content based on the TPACK model was adequate and that it contributed to its development of the skills of producing teaching aids among the students, which indicates that these differences were not a result of chance but were the effect of the teaching method using digital content based on the TPACK model. Based on the foregoing, we reject the null hypothesis and accept the alternative hypothesis, that is, the mean scores of the post-measurement scores of the students of the group that studied through (digital content based on the TPACK model) on the cognitive achievement test is greater than the average scores of the post-measurement of the students of the group that studied through (typical presentations).

DISCUSSION

The results demonstrated that digital content based on the TPACK model effectively increases the skills of producing educational aids and developing the cognitive achievement of kindergarten teacher students at Jadara University.

The finding also revealed that using digital content based on the TPACK model contributed significantly to developing the skills of producing educational aids and increased cognitive achievement in producing educational aids among kindergarten teacher students at Jadara University. The high level of performance showed this in favor of the experimental group in the post-application of the instruments compared to the level of performance of the same group in the pre-application of the instruments.

This is due to the fact that digital content based on the TPACK model enhances students' ability to retrieve information. Learning through multiple modalities allows educational experiences to be stored in memory in various forms, making recall easier. Additionally, providing information through interactive multimedia increases the clarity of the presented material, in addition to the fact that the digital content considers the characteristics and inclinations of female students and contributes to developing their motivation and desire to learn.

Likewise, digital content incorporates multiple components that support the teacher in designing electronic curricula efficiently and in a structured way through the interlinks between these components. This is attained through integrating several elements such as images, ready-made models, texts, tables, and other elements with the possibility of sharing these elements comprehensively and in line with the various digital learning management systems. Besides, the curriculum can be displayed across multiple platforms on different storage tools or on the Internet. The findings are consistent with what was stated in the theoretical framework regarding the importance and impact of using digital content in the teaching and learning process and the diversity of learning strategies used in it considered the level of students and their experiences. This is consistent with what was indicated by the results of the studies of Al-Khayyat et al. (2016), Al-Shammari and Al-Shammari (2019), Al-Mutaie (2020), Hassan (2018), and Al-Taf (2019).

The TPACK model will also help students organize areas of knowledge and find links and relationships between the three areas: content, pedagogy, and technology for more effective teaching. Depending on the digital materials that facilitate communication between and with the students will also assist the students in connecting their understanding of the course material with their understanding of teaching techniques (linking theoretical knowledge and teaching performance). It also offers students a complete vision of the educational situation, enabling them to determine a suitable context for the situation and use all acquired knowledge (content, education, and technology) to design the educational situation, where students begin to think as authentic teachers, I, choosing appropriate educational knowledge that support the scientific content, in addition to selecting tools and materials appropriate to the scientific content and their capabilities to achieve the desired educational goals and produce appropriate and suitable educational means, in addition to interaction. The positive feedback among the students, their lack of absence, and their extraordinary willingness to carry out any task assigned to them or any information strongly confirm the success and effectiveness of teaching through digital content based on TPACK. This result is consistent with the results of the studies of Abu Diya et al. (2021), Al-Dasouki (2022), Elmaadaway and Abouelenein (2022), and Adipat et al. (2023).

Learning in light of the proposed digital content based on the TPACK model occupies a considerable place compared to the traditional methods. Digital content provides each student with sufficient opportunity to discuss and debate complex or new information, in addition to citing many examples and linking them to reality through the great potential of the content. Information can be presented in various ways and connected to real-world scenarios through digital content. As female students' teaching competencies gained significance beyond memorization and acceptance, the female students were persuaded of the material's significance and began to value it.

This also includes digital content on knowledge, concepts, and information, which develops students' cognitive side and prevents boredom. Its logical presentation also helped students develop performance competencies, which increased their motivation and excitement, as well as the kinds and methods of evaluation. Their psychological satisfaction and sense of comfort were mirrored in those utilized in digital content.

Due to their comprehension of the majority of the information in the digital content and the different tools the environment provided to help present the content in a multimedia form, as well as the variety of interaction patterns in the digital content, there was a significant increase in achievement rates and media production skills when the digital content was designed using the TPACK model and tailored to the characteristics of the students. Cognitive achievement and developing skills for creating instructional aids increased due to interactions with the application interface, the teacher, the content, and coworkers.

CONCLUSION AND RECOMMENDATIONS

The study aims to determine the effectiveness of interactive digital content based on the TPACK model in developing the skills of producing educational aids and enhancing cognitive achievement among kindergarten teacher students at Jadara University. The findings showed that using digital content based on the TPACK model contributed to the development of the skills of producing teaching aids and increasing the cognitive achievement in the production of educational aids among early childhood teacher students at Jadara University.

In light of the results of the current study, the following recommendations could be made:

- Training students on how to deal with digital content and employ it in education.
- Preparing training courses for female students and faculty members showing the importance of applications and digital content in teaching and learning and producing educational aids.
- Preparing training courses for faculty members and female students explaining how to integrate digital content into education, based on the TIPAC model.
- This study is considered an introduction to future research and studies dealing with other aspects that may complement or add to this study. Among the future research and studies suggested by the researcher are the following:
- Conducting a study to identify students' attitudes toward using digital content in education.
- Conducting a study to integrate digital content into education according to the TIPAC model.
- Conducting a field study to discover the obstacles to using digital content in teaching the production of educational aids.
- Carrying out similar studies on different subjects at other educational levels.

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