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Enhancing Scientific Attitude And Teaching Competency Of Pupil Teachers With TPACK-Aligned Teaching

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ABSTRACT

This study aimed to determine the effectiveness of the Technological Pedagogical and Content Knowledge (TPACK) approach on the scientific attitude and teaching competency of pupil teachers. The research is a quasi-experiment design of a pretest and posttest control group. The sample size was 60 pupil teachers of the science stream, who were selected using a purposive sampling technique. Two groups control and the experimental were formed from the sample for the study. For intervention, TPACK-based lesson plans were used to teach the experimental group and the control group with the conventional method. The data was collected with a standardized scientific attitude scale and a self-developed teaching competency scale. The collected data was statistically analyzed to provide meaningful descriptions, interpretations, and conclusions of investigation using the following techniques Mean scores and Standard Deviation (SD) scores were compared with paired sample t-tests for all the variables. The findings of the study showed that the TPACK approach enhanced the scientific attitude and teaching competency of pupil teachers of the science stream.

KEYWORDS

TPACK, scientific attitude, teaching competency, pupil teacher, quasi-experimental, science stream.

1. INTRODUCTION

In today's ever-changing educational scene, teachers' roles extend beyond teaching knowledge to develop critical thinking, curiosity, and adaptation among pupils. Pupil teachers, who represent the future of the teaching profession, must cultivate a scientific mindset and teaching skills. A scientific attitude, defined by curiosity, critical reasoning, objectivity, and openness to evidence, serves as the foundation for instilling a spirit of inquiry in learners. Similarly, teaching competency, which includes the knowledge, abilities, and attitudes required for effective classroom instruction, is a critical component of teacher preparation.

As technology becomes increasingly integrated into education, the demand for teacher training programs that prepare pupil teachers to navigate the complexities of modern classrooms has grown. The Technological Pedagogical Content Knowledge (TPACK) paradigm provides a comprehensive framework to address this need by combining technological expertise, pedagogical strategies, and subject-specific knowledge. This model equips teachers to design, deliver, and evaluate engaging and effective learning experiences, making it a powerful tool for improving teaching competencies, especially in science education.

The TPACK framework encompasses seven interrelated constructs: Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK). Each construct captures a unique aspect of the knowledge required for the effective integration of technology in teaching. For example, CK focuses on understanding the subject matter, PK on teaching methods, and TK on the use of technology.

Together, these constructs represent the dynamic interplay between content, pedagogy, and technology, enabling teachers to create context-specific strategies that enhance learning outcomes. UNESCO has emphasized the competencies required to integrate content, technology, pedagogy, and professional development. These include the ability to manage information, structure problem-solving tasks, and use open-ended software tools. Additionally, teachers must apply subject-specific technology with student-centered methods, fostering collaboration and deep understanding of key concepts. Such competencies not only enrich the teaching-learning process but also empower teachers to make science education more meaningful and relevant.

This study examines the impact of integrating technology into science teaching using the TPACK framework. It highlights the importance of aligning content and pedagogy with appropriate technology tools to support pre-service teachers in effectively teaching science. By focusing on the dynamic relationship between technology, pedagogy, and content, the study seeks to promote awareness among teachers and students about the significance of TPACK. Furthermore, it aims to assist educational institutions in integrating technology into their curricula and assessing the performance of learners in a technology-based educational setting. By exploring the TPACK model's potential to improve scientific attitudes and teaching competencies, this study underscores its importance in nurturing scientifically literate individuals and fostering a culture of innovation in education.

2. LITERATURE REVIEW

Sadik (2021) described the relationship between pedagogy, content, and technology, is critical for educating future instructors in technology integration and other education courses. The Technological Pedagogical Content Knowledge (TPACK) framework has emerged as a valuable model, guiding educators in seamlessly blending technology with pedagogy, and content knowledge (Koehler, 2013). Gonzalez and González-Ruiz (2017) revealed that the TPACK level of pre-service affects teachers' behavioral intention to include technology in their classroom instruction. Similarly, Huang and Lajoie (2021) highlighted the significance of Self-Regulated Learning (SRL) in achieving TPACK, a fundamental component of effective technology integration.

(Chai, Koh, & Tsai, 2013) investigated pupil teachers while learning about different technologies that can be used for designing lessons for a specific subject and for delivery of classroom instruction, they have experienced the potentials offered by technology as well as the limitations it carries in the classroom (Koehler & Mishra, 2005). Teacher training institutes need to adopt strategies to enhance the TPACK of the teachers as the TPACK framework can assist teachers in their professional development in the era of rapid technological development (Lee et al., 2022). The TPACK model can significantly promote in teachers' training and in their educational work also(Ortiz-Colón et al., 2023) . Sharma, Hemant & Sharma, Leena. (2018) studied that there was a significant rise in the TPACK scores through ICT Programme intervention as the students learned more. Similar research by Soko and Samo (2023) stated that both teaching and training experience were found to have a positive influence on teachers' TPACK. Additionally, a shift in mindset towards embracing innovative approaches and acknowledging the importance of student-driven inquiry is essential for creating a more enriching and effective science education experience

3. OBJECTIVES

(i) To compare the mean scores of Scientific Attitude of the control and experimental group before the experiment.

(ii) To compare the mean scores of Scientific Attitude of the control and experimental group after the experiment.

(iii) To compare the mean gain scores of Scientific Attitude of the control and experimental group after the experiment.

(iv) To compare the mean scores of Teaching Competency of the control and experimental group before the experiment.

(v) To compare the mean scores of Teaching Competency of the control and experimental group after the experiment.

(vi) To compare the mean gain scores of Teaching Competency of the control and experimental group after experiment.

4. HYPOTHESIS OF THE STUDY

(i) No significant difference exists in the Scientific Attitude mean scores of the control and experimental group before the experiment.

(ii) No significant difference exists in the Scientific Attitude mean scores of the control and experimental group after the experiment.

(iii) No significant difference exists in the Scientific Attitude mean gain scores of the control and experimental group after the experiment.

(iv) No significant difference exists in the Teaching Competency mean scores of the control and experimental group before the experiment.

(v) No significant difference exists in the Teaching Competency mean scores of the control and experimental group after the experiment.

(vi)No significant difference exists in the Teaching Competency mean gain scores of the control and experimental group after the experiment.

5. RESEARCH METHODOLOGY

5.1 Research Design

The type of research was quasi-experiment. The quasi-experimental methods that involve the creation of a comparison group are most often used when it is not possible to randomize individuals or groups in treatment and control groups. The research design was required to apply pretest-posttest control group (Sugiyono, 2012). The sampling technique is purposive sampling.

5.2 Population and Sample

In the present study Pupil teachers of Gautam Budh Nagar district represent the population. In this study 60 pupil teachers of pedagogy of science studying in Teacher Education Institute were taken as sample. From the sample size, two groups of 30 pupil teachers in each group were made. One is the Control group(C) and the other is the Experimental group (E).

A figurative representation of the two groups Table 1

Groups	No. of pupil teachers
Control Group (C)	30
Experiment Group (E)	30

5.3 Variables involved

The dependent variables for this study were Scientific Attitude and Teaching Competency. The study's independent variable is TPACK, which is being directed to study its effect on Scientific Attitude and Teaching Competency.

5.4 Tools Used

5.4.1 Standardized Tools

Scientific Attitude Scale (Shailja Bhagwat, 2006)

5.4.2 Self-Developed Tools

Teaching Competency Scale

The teaching Competency Scale was developed by the researcher on a 5-point Likert Scale. There were a total of thirty items in the scale. The Spearman-Brown Split Half Method was used to calculate the reliability coefficient and came out as 0.942. The coefficient of stability was 0.965 calculated by the Test-Retest method. For Internal Consistency, Cronbach's Alpha found to be .976. All the items were prepared by the researcher and given to the experts for validation. Details of the total items, omitted items, and retained items are given below:

Showing details of total items on Teaching Competency after validation

Table 2

No. of items drafted in the main tool	No. of items retained in the main tool	No. of items changed/modified	No. of items removed	Total items
30	21	3	9	21

Experts' perusal is done and 9 items were deleted from the drafted tool since they were overlapping with other items and a few items were slightly redirected after the consideration of their valuable suggestions and feedback.

5.5 Statistical Techniques

For data analysis and interpretation following techniques were used

- Mean
- Median,
- SD and t-test.

5.6 Research Procedure

In the present study, TPACK-based lesson plans were used for teaching pupil teachers of experimental group. The TPACK-based lesson plans included animated pictures, video clips, text, app links etc. Pupil teachers in the control group were taught through conventional methods i.e. using a chalkboard, Audio-visual aids, etc. Quasi-experimental research design shares a resemblance with the experimental design but quasi-experimental design specifically differs in terms of the random assignment of elements. Quasi-experimental designs typically allow the researcher to control the assignment to the treatment condition but using some criterion other than random assignment.

In the present study, a non-randomized control Group Pre-test Post-test Quasi-Experimental Design was used. The experimental group was taught through TPACK-based lesson plans and the control group was taught through the conventional method.

Table 3

Groups	Pre-test	Intervention	Post-test
Experimental	E1	Teaching with a TPACK-based lesson plan.	E2
Control	C1	Teaching with the conventional lesson plans.	C2

This experimental procedure was well organized in three phases as given here:

PHASE-I: Pre-Test: A sample of 60 pupil teachers was selected by using the purposive sampling technique to facilitate experimental intervention by using TPACK based lesson plan. From the sample size, two groups were made(control group and experiment group) of 30 pupil teachers in each group. Pre-test was administered on both groups by using research tool-I (Scientific Attitude Scale) and research tool-II (Teaching Competency scale) before initiating the planned intervention. The scores obtained through the pre-test were preserved.

PHASE-II: Intervention: The second phase of the experiment was the real execution of the experiment. In this phase, the experimental group was given treatment by teaching pedagogy of science with TPACK-based lesson plan and the control group was taught by conventional method of teaching. The intervention treatment was given for about 21 working days to the experimental group, whereas the control group was taught by the conventional method for the same period. Same content was taught to both groups.

PHASE-III: Post-test: Both the groups, control group, and experiment group were tested again after the intervention (post-test) by administering Research tool-I (scientific attitude scale) and Research tool-II (Teaching Competency scale). The scores obtained through the post-test were also preserved to compare with scores on the pre-test thereby the researcher can appraise the effectiveness of the intervention.

6. RESULTS & DISCUSSION

Objective 1: To compare the mean scores of Scientific Attitude of the control and experimental group before the experiment.

Hypothesis (H01): No significant difference exists in the Scientific Attitude mean scores of the control and experimental group before the experiment.

Table 6.1

Mean scores of Scientific Attitude of control and experimental group of pupil teachers(before experiment)

Group	N	Mean	S.D	t-value
Control Group (C1)	30	86.1	6.65	0.759
Experimental Group (E1)	30	87.53337	7.9059	

Interpretation:

From Table 6.1 above, it can be seen that the t-value 0.759 is non-significant at 0.05 level of significance. Hence, the null hypothesis "No significant difference exists in the Scientific Attitude mean scores of the control and experimental group before the experiment" was accepted. This shows that the scientific attitude scores of both the control and experimental group were same before the experimental treatment. Fig. 6.1 presented the mean scores graphically.

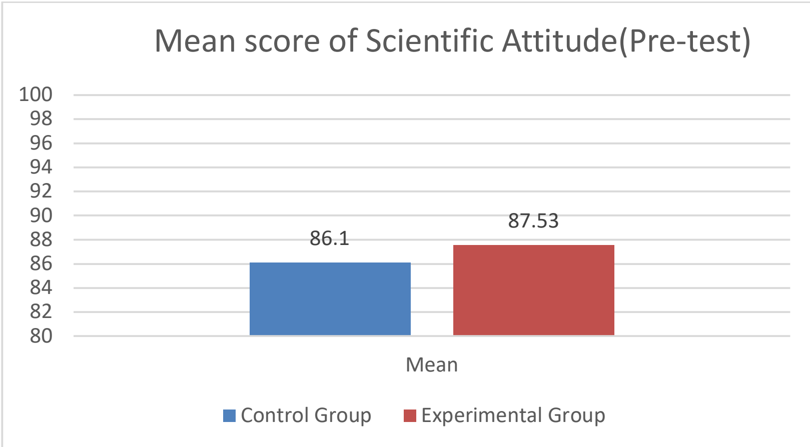

Fig. 6.1
Mean scores of Scientific Attitude of control and experimental group (before experiment)

Objective 2: To compare the mean scores of Scientific Attitude of the control and experimental group after the experiment.
Hypothesis(H_02): No significant difference exists in the Scientific Attitude mean scores of the control and experimental group after the experiment.

Table 6.2 Mean scores of Scientific Attitude of control and experimental group of pupil teachers(after experiment)

Group	N	Mean	S.D	t-value
Control Group (C2)	30	92.3	3.358	9.261
Experimental Group (E2)	30	103.867	5.954	

Interpretation:
From the above table 6.2, it is evident that t-value 9.261 is significant at 0.01 level. It shows that the Scientific Attitude scores of the control and experimental group after experiment differ significantly. Hence, the null hypothesis "No significant difference exists in the Scientific Attitude mean scores of the control and experimental group after the experiment" was not accepted. These mean scores are further been presented graphically in Fig. 6.2.

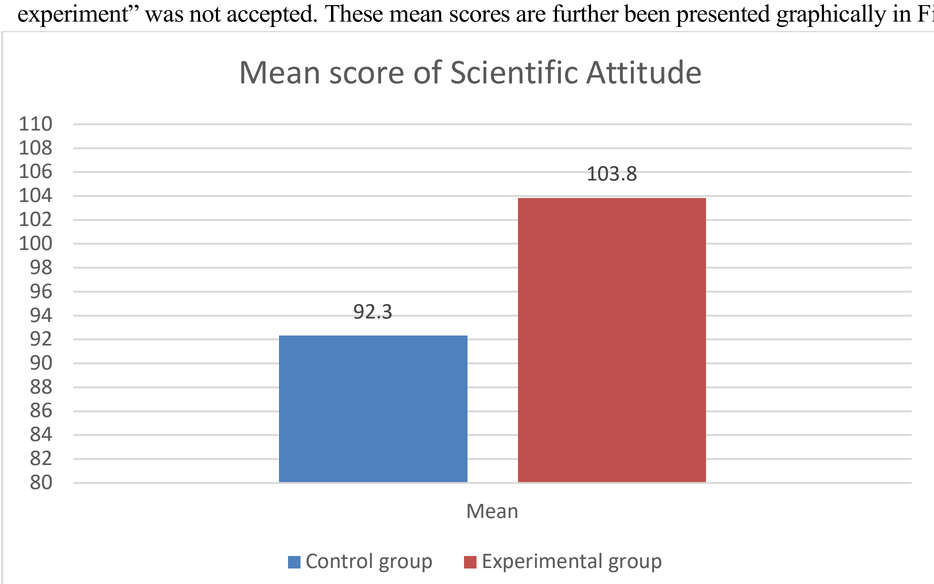

Fig. 6.2

Mean scores of Scientific Attitude of experimental and control group (after experiment)

This means that experimental treatment shows a positive influence of TPACK on the scientific attitude of the experimental group . The study of Dwianto, A., Wilujeng, I., Prasetyo, Z., & Suryadarma, I. (2017) revealed similar results that science-based learning media helps to improve science process skill and scientific attitude of students. Hence, it can be concluded that the use of TPACK in teaching enhances scientific attitude positively.

Objective 3: To compare the mean gain scores of Scientific Attitude of the control and experimental group after the experiment.

Hypothesis(H03): No significant difference exists in the Scientific Attitude mean gain scores of the control and experimental group after the experiment.

Table 6.3
Mean Gain Scientific Attitude scores of the control and experimental group

Group	N	Pre-Test	Post-test	Mean Gain	S.D	t-value
		Mean	Mean			
Control Group	30	86.1	92.3	6.2	5.2642	4.541
Experimental Group	30	87.533	103.867	16.33	10.942	

From the table 6.3, it is evident that t—value 4.541 is significant at 0.01 level. It shows that mean gain scores of Scientific Attitude of control and experimental group after intervention differ significantly. Hence, the null hypothesis "No significant difference exists in the Scientific Attitude mean gain scores of the control and experimental group after the experiment" was not accepted. It means the control and experimental group differ significantly with respect to mean gain scores of Scientific Attitude after experimental treatment. These mean scores are further been presented graphically in Fig. 6.3.

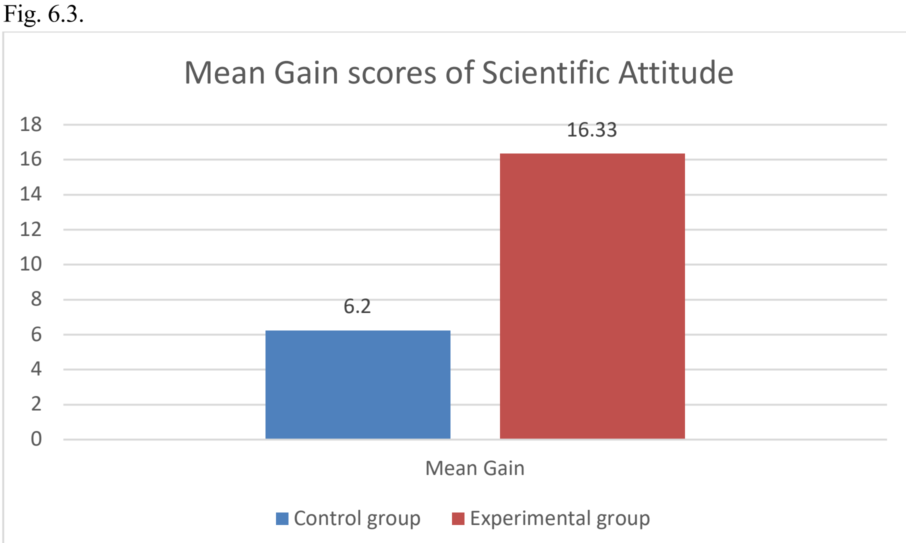

Fig.6.3
Mean Gain score of Scientific Attitude of control and experimental group (after experiment)

The findings of the study are supported by results of the study conducted by Chang, Tsai, and Jang (2014) exposed that different ICT tools and techniques creates significant impact on TPACK of science teachers. So, it can be safely concluded that teaching through TPACK is more effective than the conventional method of teaching. The study of Magen-Nagar &Ungar (2014) showed that Knowledge of technology is critical for TPACK competency. Therefore, it can be inferred that the Scientific Attitude of pupil teachers can be enhanced by using TPACK.

Objective 4: To compare the mean scores of Teaching Competency of the control and experimental group before the experiment.

Hypothesis(H04): No significant difference exists in the Teaching Competency mean scores of the control and experimental group before the experiment.

Table 6.4

Mean scores of Teaching Competency scores of control and experimental group (before experiment)

Group	N	Mean	S.D	t-value
Control Group C1	30	50.4333	5.869	0.2650
Experimental Group E1	30	50.0333	5.8222	

Interpretation:

From the above table 6.4, it can be seen that the t-value 0.2650 is non-significant at 0.05 level of significance. Hence, the null hypothesis "No significant difference exists in the Teaching Competency mean scores of the control and experimental group before the experiment" was accepted. This shows that the teaching competency scores of both the control and experimental group were same before the experimental treatment. Fig. 6.4 shows the mean score graphically.

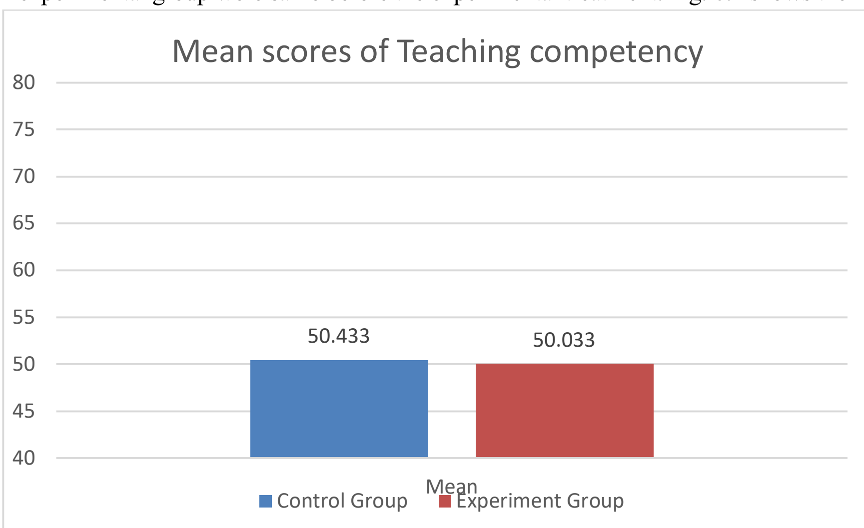

Fig. 6.4

Mean scores of Teaching Competency of experimental and control group (before experiment)

Objective 5: To compare the mean scores of Teaching Competency of the control and experimental group after the experiment.

Hypothesis (H05): No significant difference exists in the Teaching Competency mean scores of the control and experimental group after the experiment.

Table 6.5

Mean scores of Teaching Competency of control and experimental group (after experiment)

Group	N	Mean	S.D	t-value
Control Group (C2)	30	72.466	4.41	14.922
Experimental Group (E2)	30	87.867	3.537	

From the Table 6.5 above, it is evident that t-value 14.922 is significant at the 0.01 level. It shows that the Teaching Competency scores of the control and experimental groups after experiment differ significantly. Hence, the null hypothesis "No significant difference exists in the Teaching Competency mean scores of the control and experimental group after the experiment" was not accepted. Fig. 6.5 presented the mean scores graphically.

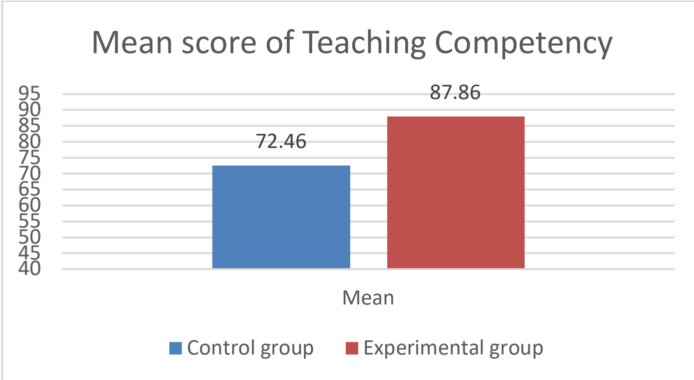

Fig. 6.5

Mean scores of Teaching Competency of experimental and control group (after experiment)

The result showed that there is a positive influence of TPACK after treatment. The same Cheung(2006) found that the integration of ICT has a positive impact on teaching effectiveness. Hence, it can be concluded that after intervention, pupil teachers' teaching competency enhanced significantly.

Objective 6: To compare the mean gain scores of Teaching Competency of the control and experimental group after experiment.

Hypothesis(H06): No significant difference exists in the Teaching Competency mean gain scores of the control and experimental group after the experiment.

Table 6.6

Mean Gain scores of Teaching Competency of experimental and control group

Group	N	Pre-Test Mean	Post-test Mean	Mean Gain	S.D	t-value
Control Group	30	50.4333	72.466	22.033	7.294	8.396
Experimental Group	30	50.0333	87.867	37.834	7.285	

From table 6.6 above, it can be seen that t—value 8.396 is significant at the 0.01 level. It shows that mean gain scores of Teaching Competency of control and experimental group after intervention differ significantly. Hence, the null hypothesis "No significant difference exists in the Teaching Competency mean gain scores of the control and experimental group after the experiment" was not accepted. It signifies that the mean gain scores of Teaching Competency of both the control and experimental group differ significantly after experimental treatment. Fig. 6.6 presented the mean scores graphically.

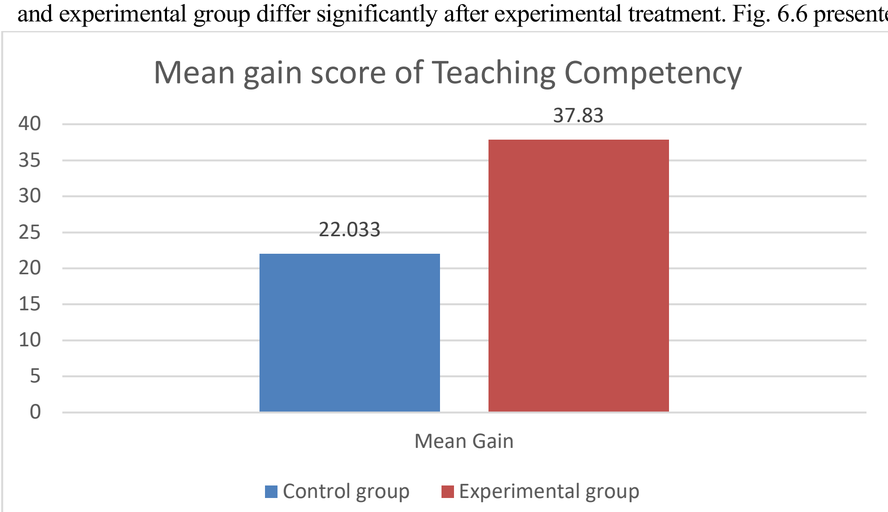

Fig. 6.6

Mean Gain score of Teaching Competency of control and experimental group (after experiment)

The results of the study were aligned by the findings of Ahmet Oguz Akturk(2019) who revealed that the teachers' use of TPACK positively impacts students' academic achievement. Hence, the findings of the study and the other research help to conclude that the use of TPACK based approach enhances teaching competency more than the conventional approach.

Conclusion

The study emphasizes the effectiveness of the TPACK approach in improving student teachers' scientific attitudes and instructional competencies. The integration of technology, pedagogy, and knowledge through TPACK resulted in dramatically enhanced learning outcomes, arming student teachers with advanced teaching skills. This framework promotes a better conceptual understanding by utilizing technology such as animations, simulations, and virtual labs, allowing students to participate in interactive and problem-solving activities that are relevant to real-world circumstances. Constructivist-based learning through TPACK promotes critical thinking, creativity, and self-directed learning in students, making it an effective way to teach science and other disciplines. Understanding how technology, pedagogy, content, and context interact is critical for instructors and students to effectively adapt to changing educational needs.

The findings give empirical support for incorporating the TPACK framework into teacher training programs, emphasizing its potential to promote innovation and digital competence. Future research might investigate the impact of TPACK on in-service and pre-service teachers at various educational levels, as well as its link to other variables such as ICT, information technology, and digital skills. Such research may provide additional insights into optimizing technology integration for effective teaching and learning practices.

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