Effectiveness of Technological Pedagogical and Content Knowledge Based Strategy on Enhancing Science Attitude of Secondary School Students

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***Abstract*- This study investigated the effectiveness of Technological Pedagogical and Content Knowledge (TPACK) based strategy in enhancing the science attitude of secondary school students. The population of the study consisted of secondary school students following the Kerala State Syllabus. A random sample of 120 students was selected and divided into Experimental group and Control group. Instructional materials included lesson transcripts prepared using TPACK-based strategy for the Experimental group and Constructivist Method for the Control group. A standardized Science Attitude Scale developed by the investigators was employed as the tool for data collection. Pre-test and post-test scores were analysed using descriptive statistics, t-test, and ANOVA. Findings indicated that both groups were comparable in science attitude prior to the intervention, but the Experimental group showed significantly higher post-test scores. The TPACK based instruction is effective to enhance the science attitude of secondary school students than that of with presently practising constructivist method. The results highlight the effectiveness of TPACK-based strategies and suggest implications for teachers and policymakers in integrating technology-supported pedagogy into regular science instruction.**

Keywords- TPACK, Science Attitude, Secondary school students, Pedagogical Strategies, Constructivist method. TPACK, Science Attitude, Pedagogical Strategies, Constructivist method.

I.INTRODUCTION

Science education is one of the most important subjects in schools due to its relevance in people's daily life. Technological literacy, critical thinking skills, and problem-solving skills acquired through science education give students the competence and knowledge they need to succeed in school and beyond. Developing a positive attitude towards science is the fundamental aim of science education. In recent years, particularly when STEM introduced, studies focusing on students' attitudes toward science have gained significant attention. Attitude towards science is an individual's organization of beliefs and cognitive schemas, leading to the affective reactions of that individual towards science (Akeela & Ashok, 2018; Bunyamin, & Phang, 2012; Reid, 2006). To identify the sources of negative attitude towards science and strategies for enhancing science attitude and provide quality science education is very important (Meenakshi & Nirmala, 2016; Sickel, 2016). There are several factors contribute for an individual's attitude towards science. Factors such as motivation, anxiety, enjoyment, career interest, personal beliefs, and the application of science in daily life play a key role in shaping students' attitudes toward science (Archambault & Barnett, 2010) The use of effective teaching methods and learning strategies can significantly enhance these attitudes and foster a greater interest in the subject (Anderson & Krathwohl, 2001). Technology has entered all spheres of human life and has become a vital aspect of the modern educational system. In particular, modern technologies have empowered teachers to make science classes more interactive, engaging, and effective (Khan, 2011). For effective teaching-learning process a perfect balance between technological knowledge, pedagogical knowledge and content knowledge is necessary. For this, the frame work called Technological Pedagogical Content Knowledge (TPACK) was developed (Mishra & Koehler, 2005 & 2006). Research studies across different contexts have shown that when teachers adopt TPACK-based strategies, students display improved engagement,

motivation, and achievement in various subject areas (Angeli, Valanides, & Christodoulou 2016; Harris, Mishra, & Koehler, 2009).

In science education, which demands inquiry, experimentation, and critical thinking, TPACK offers a practical approach to making concepts more accessible and engaging. Studies have reported that technology-enhanced science classrooms foster better attitudes towards science learning and reduce anxiety associated with abstract concepts (Binwal, 2020; Narmadha, & Chamundeswari, 2013). Further, collaborative and project-based learning environments supported by digital tools have been found to enhance curiosity and problem-solving skills among students.

In the Indian context, principally in Kerala, public sector schools are increasingly adopting ICT-enabled instruction under initiatives like the IT@School Project and Samagra Shiksha Abhiyan. However, the effectiveness of systematic TPACK-based interventions in developing students' attitudes towards science has not been sufficiently explored. Since student attitude plays a vital role in shaping interest, motivation, and future career choices in science, research in this area is both timely and necessary. The present study, therefore, was undertaken to examine the effectiveness of a TPACK-based strategy on enhancing the science attitude of secondary school students in Kerala.

II.OBJECTIVE OF THE STUDY

The objectives of the study are,

- To develop the Technological Pedagogical and Content Knowledge (TPACK) based teaching strategy for science teaching at secondary schools of Kerala state.
- To find out the effectiveness of Technological Pedagogical and Content Knowledge based strategy on enhancing Science Attitude among secondary school students.

III.METHODOLOGY

The study is experimental in design. It is followed control group- experimental group intervention method. Comparison of pre and post test results was adopted to analyze the output of the experiment.

Sample for the Study

The population of the present study was IX standard students of secondary schools, who are following Kerala State School Education Syllabus. The investigators randomly selected a sample of 120 students from Four secondary schools of Kottayam district with 60 students each in the Experimental and the Control groups. Thirty (30) ninth standard students were gathered from four schools and the homogeneity of sample is assured by intelligence test and score in the summative test of the 8th standard.

IV.TOOLS AND MATERIALS USED FOR THE STUDY

The tools and materials used for the present study are;

1. Science Attitude Scale
2. Lesson transcripts on Technological Pedagogical and Content Knowledge based strategy
3. Lesson Transcripts on presently practicing constructivist method

The Science Attitude Scale constituted with 35 items. It includes both positive and negative statements with 05 Options to respond. The score for the responses varied from 05 to 01, most preferred to least preferred response. Items in the scale are developed up on seven dimensions (Fraser, 1978). They are illustrated in figure.1. The reliability of Science Attitude Scale was found out by using split-half method (Gay, 1990). The correlation between the two sets of scores gives the measure of the accuracy with which the test measures the individual. A sample of 126 students studying in Standard IX was chosen as respondents for establishing reliability. The reliability coefficient of the Science Attitude Scale, while administered the split half method of correlation analysis, was 0.78. The construct, content, and face validities of the items in the scale and of the tool in total are established through proper methods. Since the statements in the final attitude scale are 35, the maximum to minimum score varied from 175 to 35. Thus, the academic attitude scale is constituted with established validity and reliability to test the variable as it is among the secondary school students.

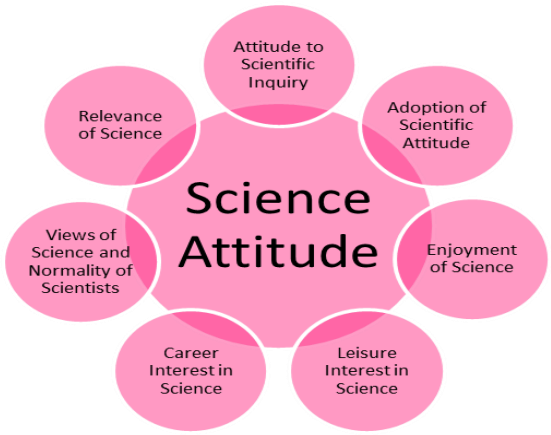

Figure 1 *Dimensions integrated in framing the Science attitude scale*

Lesson transcripts were prepared based on the procedure of development of lesson transcripts of presently practicing constructivist mode. Same topics from the Units titled Forces of fluids, Equation of motion, and Motion and laws of motion from the ninth standard Kerala - SCERT Physics text book are selected to frame the lesson transcripts for the experimental and control groups. Duration of s session was 40 minutes. The lesson transcripts for experimental groups are integrated with the TPACK elements. For control group the lesson plans remained in the practicing constructivist mode, without the integration of TPACK elements. The lesson transcripts were made in accordance with the curricular objectives and submitted to experts in the field of Physical Science education and experienced physical science teachers for adjudication and validation.

V.THE INTERVENTION

The intervention or experiment was conducted for a stipulated period of 45 days. 34 lesson transcripts were developed in the presently using constructivist mode for administering in control group and another 34 lesson transcripts with TPACK integrated mode for control group. The classes were taken by researcher as teacher in in both groups in the forenoon sessions. Duration of each class was 45 minutes. The science attitude scale was implemented to collect data before and after the experiment. Same process is administered as detention test also.

VI.ANALYSIS: SCIENCE ATTITUDE AMONG STUDENTS AT PRE-TEST LEVEL

The scores obtained by each student in the pre-test and post-test were tabulated and subjected to appropriate statistical techniques. The descriptive statistics like mean, median, standard deviation, independent sample t-test, paired sample t-test, and One way ANOVA are used in this study for analyzing the result. The collected data were properly tabulated and administered for analysis. The objective-based analysis ae given under appropriate title.

Before commencing the intervention, the pre-experimental data had been collected from the students of control and experimental groups to identify their scientific attitude. Details are given in table 1.

Table 1- *Data and result of the comparison of Mean Pre-test scores on* Science Attitude *of Experimental and Control Groups*

Stage	Groups	N	Mean	SD	t	Level of significance
Pre-test	Experimental	60	107.98	4.37	0.018	P>0.05
	Control	60	108	5.60		

When the pre-test scores on Science Attitude of the Experimental and Control groups were compared, the 't' value obtained is 0.018 which is not a significant t value. The obtained t value indicates that the Experimental and Control groups do not have significant difference on their Science Attitude before the intervention. Students in the sample groups, both control and experimental, are possessing same levels of science attitude. Considering this circumstance, the intervention with TPACK based strategy is implemented in the experimental group and teaching in the presently practicing approach in control group.

Effectiveness of TPACK based Strategy on Enhancing Science Attitude among Secondary School Students

After collecting pre-experimental data, the intervention was administered in the control and experimental groups. The teaching experiment was pursued for the stipulated period as explained above. After conducting the experiment with the TPACK based teaching, the science attitude scale was implemented to collect responses. The collected data

tabulated and administered for analysis. The analysis was conducted, as described in table 2, for the total scores obtained with respect to Science Attitude of students in the experimental and control groups.

Table 2 *Comparison of Mean Post-test scores on Science Attitude of Experimental and Control Groups*

Stage	Groups	N	Mean	SD	t	Level of significance
Post-test	Experimental	60	129.35	4.99	12.07	P<0.01
	Control	60	118.88	5.36		

The comparison of post-test scores of Experimental and Control groups on Science Attitude shows that these groups differ significantly at 0.01 levels with a t value of 12.07. The mean post-test scores of experimental and control groups show that the experimental group scored better than that of the control group after the treatment.

The Mean scores of the experimental group at pre and post test levels also compared to find the extend of Mean differences in the scores of the group before and after the experiment. Details are given in table 3.

Table 3- *Comparison of Mean Pretest and Post test scores of experimental group*

Scores	N	Mean	SD	t	Level of significance
Pre-test	60	107.98	4.37	15.71	P<0.01
Post test		129.35	4.99		

The high scores obtained by the students of experimental group, the high Mean of the score distribution in the group, and the significant difference Mean score of the pretest and posttest are indicating that the learning through the TPACK based strategy have better effect on students in improving the Science Attitude than that of the students learning through present constructivist activity-oriented method. Furthermore, the gain score of the students on science attitude has tested to find the detention of the achievement. In the detention test also the students in the experimental group showed high level of science attitude rather than that of the control group. The Mean value of the gain scores of experimental group is highly significant with that of the control group. The Mean of the Gain scores of the experimental group is 21.68 and and of the control group is 10.68. The result is indicated in the graphic representation in the figure 2. These results also indicate the potential of the TPACK based instructional strategy on developing science attitude of the secondary school students.

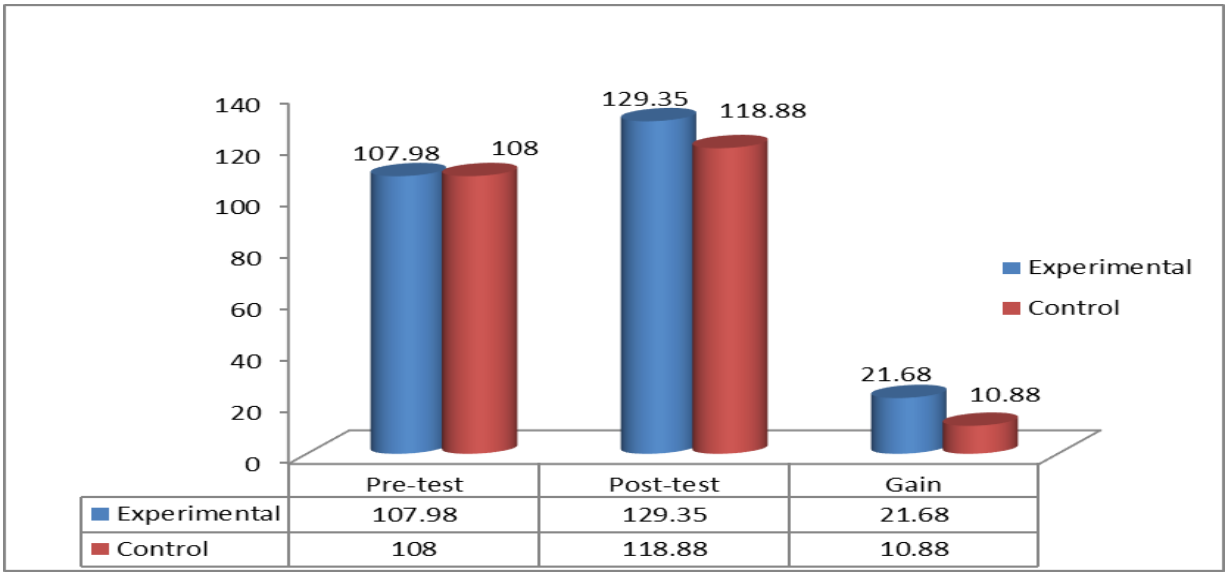

Figure 2 *The comparison of the pretest - posttest scores, and gain scores on Science Attitude of Experimental and Control Groups*

Genuineness of the Mean Difference on Science Attitude of Experimental and Control groups.

The sample selected for this study were intact classroom groups from different schools selected from Kottayam district of Kerala. It is grim to establish whether the difference between the pre-test and post-test scores are resulted from the Experimental factors only or with the compound effect of other variables. The intervening variable may adjunct the attainment of scores in the attitude scale, and finding out any such intervening factor will prove the genuineness of the Mean difference as revealed from the t-tests. We cannot exactly say that there is significance difference between these groups only by comparing the post-test scores of the control and experimental groups by student t-test. So there arises a need to compare the scores using the technique of Analysis of Variance (ANOVA).

The summary of the analysis of variance for the pre-test scores and the post-test scores of students of both the groups, who are selected from four different schools of same category are presented in the table 4.

Table 4 *Summary of Analysis of Variance of the pre-test and post-test scores on Science Attitude (Total) of Experimental and Control groups*

Source of Variation	Df	SS_x	SS_y	MS_x	MS_y	F_x	F_y
Between groups	1	.008	3488.408	.008	3488.408	.0	145.581
Within groups	118	2974.983	2827.517	25.212	23.962		
Total	119	2974.992	6315.925				

As per the table 4, F for df 1/118 is 3.92 at 0.05 level and 6.85 at 0.01 levels. The obtained value of F_x is .0 which is not significant at 0.05 level. It shows that there is no significant difference between the Experimental and Control groups on their pre-test scores on Science Attitude. The obtained value of F_y is 145.581 which is significant at 0.01 levels. This shows that the two groups differ significantly on their post-test scores on Science Attitude. Hence, the non-difference of pretest scores and highly significant difference of post test scores of the control and experimental groups indicate that the treatment is effective. The result proved that the TPACK based instruction effectively enhanced the science attitude of secondary school students.

To prove the genuineness of result, researchers also analyzed the scores on Science Attitude of Experimental and Control groups using Adjusted Means. Result is given in table 5.

Table 5 *Adjusted Means of post-test scores on Science Attitude of Experimental and Control groups*

Group	N	M_x	M_y	$M_{yx(Adjusted)}$	SE_M	t
Experimental	60	107.98	129.35	129.673	0.369	29.26
Control	60	108	118.88	118.877		

The 't' value obtained is 29.26 which is significant at 0.01 level. This reveals that students in the Experimental group scored better than the students in the Control group in the science attitude assessment. This result of the comparison of adjusted Mean scores also proved that the TPACK based strategy is more effective than presently practicing constructivist method for enhancing Science Attitude of students at secondary level.

VII.GENERALIZATION AND CONCLUSION

The findings of this study indicate that the Technological Pedagogical and Content Knowledge (TPACK) based strategy can be effectively applied to enhance the science attitude of secondary school students. Since the study involved learners from diverse backgrounds within a district of Kerala state, the results can be generalized to similar school settings across Kerala and other regions in India, where science education follows comparable curricula and pedagogical practices. The strategy demonstrates potential not only in promoting positive attitudes towards science but also in strengthening learner engagement and motivation.

While the results are promising, the scope of the study is limited to one school subject area (science) and a specific educational stage (secondary level). Future

research may extend this approach to other subjects such as mathematics, social sciences, or languages, as well as to different educational levels like upper primary or higher secondary. Longitudinal studies can also be conducted to evaluate the sustained impact of TPACK strategies over time (Ergen, Yelken, & Kanadli, 2019). Furthermore, exploring teachers' perspectives and classroom practices will provide deeper insights into the practical integration of TPACK in diverse learning environments.

Statistical analysis through pre-test and post-test comparisons confirmed a significant improvement in learners' outlook towards science after the intervention. The integration of technology, pedagogy, and content not only enriched the teaching–learning process but also created a more engaging and motivating environment for learners (Mishra, 2019). These findings highlight the need for teachers and policymakers to promote TPACK-based approaches in science instruction, as they hold great promise in transforming science education and fostering positive learner dispositions (Schmid, Brianza, & Petko, 2020). Teachers are encouraged to integrate TPACK-based strategies into science lessons to make learning more interactive, student-centered, and relevant. Collaborative learning and project-based activities supported by digital tools should be promoted to build positive attitudes towards science. School administrators need to provide adequate infrastructure, including ICT tools, digital resources, and internet access, to support effective implementation. Curriculum planners should redesign science curricula to incorporate TPACK-based practices that foster inquiry, critical thinking, and problem-solving, while also developing materials that blend digital and traditional methods. Policymakers are advised to formulate policies that strengthen ICT integration within pedagogy across all levels of school education.

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