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Pedagogical Innovation of Tpack Based K-4 Learning Transaction Model in Science and Social Sciences

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Authors' contributions

This work was carried out in collaboration among all authors. Authors PBB and BCD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors BCD and AD managed the analyses of the study. Author BKD managed the literature searches and writing of manuscripts. All authors read and approved the final manuscript.

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ABSTRACT

Technological Pedagogical Content Knowledge (TPACK) has been proposed as a 'conceptual framework' to describe the knowledge base that teacher needs for effective technology integration. Looking at the vitality of the concerns an experiment on the TPACK-based Practice Teaching Programme with reference to the learning achievement of students was carried out. The sample comprised of 40 student-teachers belonging to science and social science of the first batch integrated B.Ed program of Ravenshaw University and 341 students of CBSE-affiliated schools of Cuttack City. The scheme of the experiment was carried out by adapting Solomon Four Group Design. The quantitative data gathered through achievement tests were analyzed using Mean, SD, One-way ANOVA, and t-test. Based on the feedback given by the pre-service teachers, the project

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team brought in the innovation of the TPACK-based K-4 Learning Transaction Model (K4 -LTM). The data relating to innovation on TPACK-based K4 -LTM were collected through the reaction scale and analyzed by using percentage analysis. The findings revealed that there was a significant effect of the TPACK-based practice in teaching science and social science. The reaction of student teachers towards innovative TPACK-based K4 -LTM was found to be effective. In conclusion, further this experiment propelled to innovate TPACK based K-4 Learning Transaction Model with its unique features and practicability in the area of curriculum transaction. The results of the study have potentials to initiate reforms in teacher preparation more learner centric with support of TPACK based instruction.

Keywords: TPACK; pedagogical innovation; K-4 transaction model; science; social science; teacher education.

1. INTRODUCTION

"Information and Communication Technology (ICT) Competency Standards for Teachers (UNESCO, 2008) emphasize that teachers need the knowledge to use ICT for supporting constructivist learning which involves knowledge construction and problem-solving activities within authentic contexts" [1,2]. This can be understood as a kind of technological pedagogical content knowledge (TPACK), which has been used by Mishra and Koehler [3] to describe teachers' knowledge about information and communication technology integration. "Empirical studies show that practicing teachers do not fully exploit the affordances of ICT tools for constructivist teaching" [4,5,6]; indicating that constructivist-oriented TPACK could be an area of challenge for them. Teachers' efficacy perceptions had a significant positive influence on their adoption of ICT [7]. "Insights for teacher professional development in ICT can be derived through a better understanding of their constructivist-oriented TPACK perceptions and the factors that can influence them. Nevertheless, their perceived knowledge gaps in this area are not well understood as published studies have only examined teachers' TPACK perceptions with respect to science education, e-learning facilitation, social studies, and mathematics" (e.g., Archambault & Barnett, [8]; Graham et al., [9]; Lee & Tsai, [10]; Schmidt et al., 2009).

"Technological Pedagogical Content Knowledge (TPACK) is currently considered as an essential framework for promoting instructional competency of 21st-century teachers. Technological Pedagogical Content Knowledge (TPACK) has been proposed as a conceptual framework to describe the knowledge base teachers need for effective technology integration. The issue of what teachers need to know about technology for effective teaching has been the centre of intense debate in the recent past [11-13]. Teaching with technology for a given content matter is complex and multidimensional. It requires understanding the representation and formulation of concepts using technologies; pedagogical techniques that utilize technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help address these issues; knowledge and theories of epistemology; and an understanding of how technologies can be utilized to build on existing knowledge and to develop new or strengthen old epistemologies" (Koehler et al. 2007, p. 743). Similarly, the extension of pedagogical and content knowledge (PCK) with the integration of technology became a domain of knowledge for teaching-learning practices [14] (Shulman, 1987). However, technological integration changes the process of pedagogy, not the content. Thus, pedagogy that is practically useful in terms of how we teach? Mishra and Koehler [3] had given a hybrid concept on teachers' knowledge about technology, pedagogy, content, and its contextual influence on learning. Harris and Hofer [15] questioned how to do knowledge about technology, pedagogy, and content influences the teacher's instructional planning, activities and as a results technology integration in content enhances students' learning and classroom activities. According to Schmidt et al. (2009) and Tokmak et al. [16] pre-service teachers need to know the effective integration of technology into their teaching practices. Therefore, a symbiotic development in terms of knowledge of technology, pedagogy, and content is in need and demands of the time.

1.1 Review of Related Literature

Sousa, Tercariol & Christino [17] explained "the TPACK used as a theoretical framework to

address content, combined with an active (Blended Online POPBL), allowed the students, and future teachers, to improve their methodological approach to understanding how developed the teachers' pedagogical practices with knowledge in the technology use articulated with their curricular domain". Lai & Lin [18] investigated "the relationship between beliefs, values, and technological pedagogical content knowledge among teachers, and regression analysis results showed that teachers' student-centered beliefs and technology values were significantly correlated with TPACK. MANOVA results found that teachers with high student-centered pedagogical beliefs may not have high technology values, and teachers with lower student-centered pedagogical beliefs may not have lower TPACK". Saengbanchong, Wiratchai & Kitiwong (2013) undertook "a study on validating the Technological Pedagogical Content Knowledge appropriate for instructing Students (TPACK-S) of pre-service teachers. The research results indicated that the TPACK-S measurement model fit the empirical data. The implied policy implication is that the teacher equipped with TPACK-S would enhance students' achievement". Ekrem & Recep [19] conducted "a study to understand the TPACK (Technological Pedagogical Content Knowledge) competency of pre-service English teachers and to determine whether there were any significant differences in terms of gender and academic achievement found that males' technological knowledge was higher than females; however, females were better than males in pedagogical knowledge. Moreover, no significant difference was found between the TPACK mean and academic achievement in terms of the correlation between the TPACK scale and the academic achievement of the participants". Kurt, Akyel, Koçoglu & Mishra [20] focused "on understanding whether and/or how the TPACK of Turkish Pre-Service Teachers (PTs) of English was reflected in their lesson planning and presentations. The findings revealed that both during the planning and implementation processes, PTs considered the relationship among content, pedagogy, and technology and worked hard to improve the quality of their lessons by integrating technology effectively". Hutchison and Colwell [21] investigated pre-service educators' utilization of the Technology Integration Planning Cycle (TIPC) to incorporate i-Pads into proficiency guidelines. The investigation uncovered two discoveries identified with utilizing the TIPC to design direction: (a) Though the TIPC gives an organized way to deal with arranging those aids educators in utilizing their Technological, Pedagogical, and Content Knowledge (TPACK), the pre-service educators still utilized a techno-driven way to deal with arranging guideline and did not completely participate in all components of the arranging cycle. Durdu & Dag [22] conducted "a study on Pre-Service Teachers' TPACK Development and Conceptions through a TPACK-Based Course. The findings indicated that the implemented instructional processes affected pre-service teachers' TPACK development positively. There were significant differences before and after the course implementation concerning Technology Knowledge, Technological Content Knowledge, Technological Pedagogical Knowledge, and TPACK in general". Barac, Prestridge & Main [23] "underscored Stalled innovation: Examining the technological, pedagogical, and content knowledge of Australian university educators and found academic perceptions of the role that technologies play in relation to their content and their pedagogies. The initial findings indicate that the connections within these domains are limited in the academic context". Kim & Lee [24] found that "improved TPACK-P educational program added programming-based activities (analysis of curriculum based on programming, analysis of TPACK-P instructional cases, and development of the TPACK-P program in the programming environment). As a result of engaging the pre-service teachers in the improved TPACK-P educational program, the pre-service teachers' TPACK was effectively developed in all areas".

1.2 Rationale of the Study

The prevailed situation in pre-service teacher education has been complex with the flood of innovations around and hence it requires appropriate directions, which appears to be neglected over the recent times. There is need of trained human resources to cope up with given gamut of challenges posed on teaching learning endeavors. This project an attempt to look at certain possibilities which may give a direction on adoption of suitable technological and pedagogical approaches to deal with content. It is imperative therefore to moot the pertinent questions such as 1. What are the TPACK practices existing in practice teaching in pre-service teachers? 2. What are the existing levels of Technological Pedagogical and Content Knowledge among pre-service teachers? 3. To what extent the pre-service teachers need Technological Pedagogical and Content

Knowledge? 4. To what extent TPACK based practice teaching could be effective? 5.What could be the reaction of preservice teaching teachers belonging to science and social science discipline towards TPACK based practice teaching? This genre of study can be an attempt to look at certain possibilities which may give a direction on adoption of suitable technological and pedagogical approaches to deal with contents in practice teaching Programme.

2. OBJECTIVES AND METHODS

1. To study the effectiveness of TPACK based practice teaching in science with reference to learning achievement of students.
2. To study the effectiveness of TPACK based practice teaching in social science with reference to learning achievement of students.
3. To innovate and validate a suggestive TPACK based K-4 Learning Transaction Model (K-4 LTM) for improvement in practice teaching in science and social science with reference to reaction of pre-service teachers.

Hypotheses

1.1 There exists no significant difference between the mean Pre-test learning achievement score obtained by both experimental group-1 and control group-1 of science and social science students.

1.2 There exists no significant difference between the mean Post-test learning achievement score obtained by both experimental group-1 and control group-1 of science and social science students.

1.3 There exists no significant difference between the mean Post-test learning achievement score obtained by both experimental group-2 and control group-2 of science and social science students.

1.4 There exists no significant difference between the mean Post-test learning achievement score obtained by both experimental group-1 and experimental group-2 of science and social science students.

1.5 There exists no significant difference between the mean Post-test learning achievement score obtained by both control group-1 and control group-2 of science and social science students.

2.1 Methodology

Matching to the objectives, the study has employed mixed method design especially the embedded mixed methods design (Creswell, 2014, Morgan, 2019) used to explore the preliminary qualitative study to support for a primary quantitative study. Further this quantitative study has been supported with a qualitative study. This is a mixed methods of Quant - Qual. The study has been conducted in three phases as guided by the above design.

Phase-I: In first phase TPACK specific practices by the preservice teachers was explored during first phase of internship programme. The target population of the study comprised the pre-service teachers of secondary teacher education institutions. However, the accessible population is the per-service teachers belonging to both science and social science disciplines from five institutions in Odisha including state university, Department of Education and Teacher Education Institution. The samples comprise 300 pre-service secondary school teachers selected randomly out of 600 accessible populations. Then the existing status of TPACK knowledge and TPACK needs of social science and science pre-service teachers have been explored by classroom observation of 150 science and 150 social science pre-service teachers respectively and data have been analyzed both qualitatively and quantitatively to understand the dimensions and indicators of TPACK.

Phase-II: The first phase of the study supported to the second phase of the study in which based on the knowledge level of TPACK varying from basic, intermediate, and advance level of pre-service teachers, TPACK orientation was given to the forty selected pre-service teachers leading to experiments in their practice teaching in both science and social science. After orientation the pre-service teacher practiced the TPACK based module in simulation teaching.

In this phase the sample comprised 20 science and 20 social science pre-service teachers' of 4years integrated B.A/B.Sc.-B.Ed. involved in practice teaching programme and 341 students from four practicing schools by using simple random sampling technique. Solomon four group experimental design was adopted for effectiveness of TPACK based practice teaching programme with reference to learning achievement. The four random groups out of which two were experimental and two were

control groups. Each group/ section was selected randomly out of existing sections. In total 170 students were randomly selected for experiment by the science pre-service teachers. Similarly, 171 students were randomly selected for experiments by social science pre-service teachers. In each school there were 5 science and 5 social science preservice teachers. Likewise, 20 (10 science + 10 social science) preservice teachers carried out practice teaching in two control group schools. TPACK based lesson plan was practiced in teaching programme and experimented at school level in real classroom situation. The pre-service teachers administered pre and post-test as instructed by Solomon Four Group Design to collect data related to learning achievement by using self-developed achievement tests.

Phase-III: On the basis of the feedback given by the pre-service teachers the project team brought in innovation in two phases. The Project Team Innovated K-4 Instructional Design with following four stages within the framework of TPACK-5 guidelines developed by the project team. Further, this suggestive innovated K-4 instructional design based on TPACK-5 components was presented for reaction of preservice teachers. The data related to reaction of preservice teachers belonging to science and social science towards innovated TPACK based K-4 lesson plan were collected through Reaction Scale.

The study adopted both quantitative and qualitative data analysis techniques. For quantitative data analysis parametric statistics such as t-test and ANOVA were used while for qualitative analysis such as content analysis for classroom observation to explore the indicators and knowledge level of TPACK.

3. RESULTS AND DISCUSSION

The effectiveness of TPACK based practice teaching with reference to Learning achievement of students were analyzed and interpreted as follows.

TPACK based practice teaching in science the pre-learning achievement of students was found to be effective by retaining the null hypothesis between experimental and control groups. In other words, it can be said that the science students of experimental group-1 and control group-1 were found to believe to the same extent in their learning achievement score.

The post-test mean score of learning achievement of science students of experimental group-1 and experimental group-2 did not differ significantly. In other words, it can be said that the experimental group-1 taught by TPACK based practice teaching found equal to their counterpart experimental group 2 taught by the same approach TPACK based practice teaching.

The mean score of learning achievement of science students of control group-1 and control group-2 did not differ significantly. In other words, it can be said that the control group-1 taught by traditional approach-based practice teaching found equal to their counterpart control group-2 taught by same traditional approach-based practice teaching.

Table 1. Description of posttest score of experimental and control group of science and social science (full marks-25)

Test	Subject	Group	N	Mean	Std. Deviation
Pre-Test	Science	Experimental Group 1	60	14.03	1.10
		Control Group 1	35	15.24	2.55
	Social Science	Experimental Group 1	60	17.09	12.45
		Control Group 1	38	13.89	2.41
Post-test	Science	Experimental Group 1	60	21.25	.94
		Experimental Group 2	39	22.01	1.21
		Control Group 2	35	17.71	1.28
		Control Group 2	36	16.20	1.81
	Social Science	Experimental Group 1	60	22.27	1.20
		Experimental Group 2	39	22.16	1.88
		Control Group 2	38	17.59	1.99
		Control Group 2	34	17.02	2.32

Table 2. T-test for pre-test of experimental group and control group in science (N=95)

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	**Sig.**	**t**	**df**	**Sig. \ (2-tailed)**	**Mean Difference**	**Std. Error Difference**
PreTest	Equal variances assumed	16.889	.000	-3.192	93	.002**	-1.2031	.37692
	Equal variances not assumed			-2.653	41.508	.011**	-1.2031	.45346

*** Not Significant at both level*

Table 3. ANOVA for posttest of experimental group and control group in science (N=170)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	929.831	3	309.944	183.513	**.000***
Within Groups	280.366	166	1.689		
Total	**1210.197**	**169**			

**Significant at 0.05 level*

Table 4. T-test for pre-test of experimental group and control group in social science (N=98)

Group		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. \ (2-tailed)	Mean Difference	Std. Error Difference
Pre-Test	Equal variances assumed	10.764	.001	3.329	96	**.001**	1.227	.3688
	Equal variances not assumed			3.031	.001	**.004**	1.227	.4049

Table 5. ANOVA for posttest of experimental group and control group in social science (N=171)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1009.046	3	336.349	103.297	**.000***
Within Groups	543.775	167	3.256		
Total	**1552.821**	**170**			

**Significant at 0.05 level*

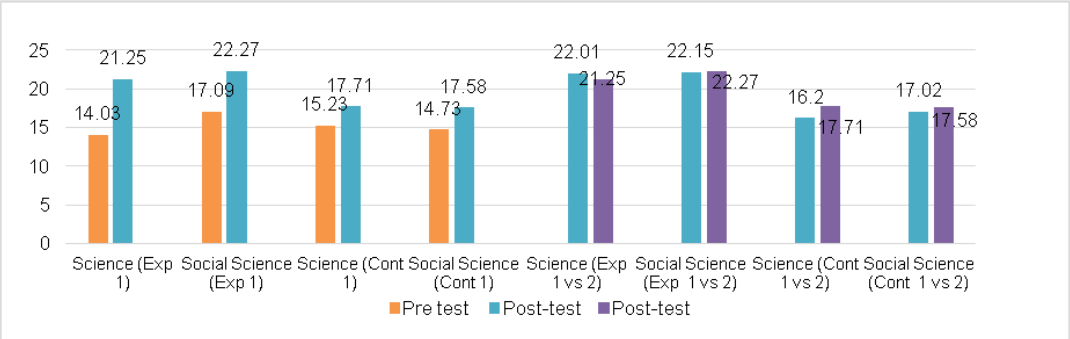

Fig. 1. Pre-test, post-test mean score in science and social science (class VII)

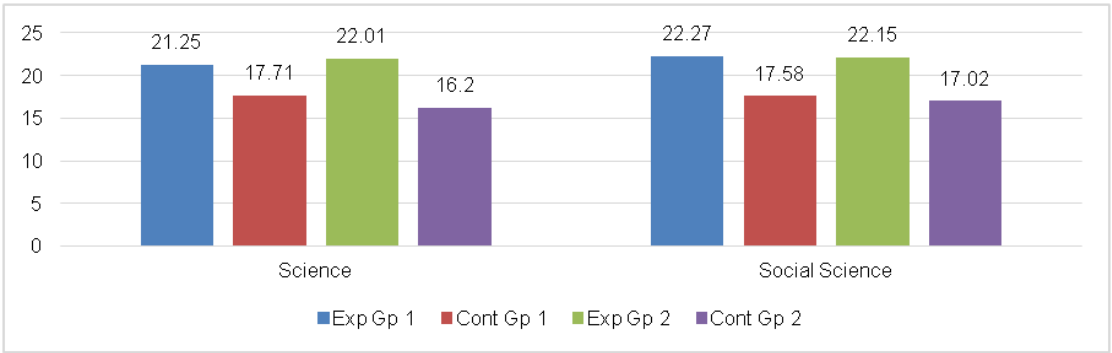

Fig. 2. Post-test mean score in science and social science (class VII)

TPACK based practice teaching in science, the post-learning achievement of students was found to be effective by rejecting the null hypothesis between experimental and control groups and did not differ significantly. Thus, it can be said that the experimental groups (1&2) taught by TPACK based practice teaching found superior to their counterpart control groups (1&2) taught by traditional approach-based practice teaching.

TPACK based practice teaching in social science with reference to the pre-learning achievement of students was found to be effective by retaining the null hypothesis between experimental and control groups. The mean score of learning achievement of science students of experimental 1 and control group-1 did not differ significantly. In other words, it can be said that the experimental group and control groups found to be equal in pre-test achievement score.

The mean score of learning achievement of social science students of experimental group-1 and experimental group-2 did not differ significantly. In other words, it can be said that the experimental group-1 taught by TPACK based practice teaching found equal to their counterpart experimental group 2 taught by the same approach TPACK based practice teaching.

The mean score of learning achievement of social science students of control group-1 and control group-2 did not differ significantly. In other words, it can be said that the control group-1 taught by traditional approach-based practice teaching found equal to their counterpart control group-2 taught by same traditional approach-based practice teaching.

TPACK based practice teaching in social science the post-learning achievement of students was found to be effective by rejecting the null hypothesis between experimental (1&2) and control groups (1&2) did not differ significantly. Hence, it can be said that the experimental group taught by TPACK based practice teaching found superior to their counterpart control group taught by traditional approach-based practice teaching.

4. INNOVATION ON $TPACK_5$ BASED 'K_4 LEARNING TRANSACTION MODEL' FOR IMPROVEMENT IN PRACTICE TEACHING IN SCIENCE AND SOCIAL SCIENCE WITH REFERENCE TO REACTION OF PRE-SERVICE TEACHERS

For $TPACK_1$ and $TPACK_2$ <60% of student teachers found it most useful, $TPACK_3$ and $TPACK_5$ <50%, and $TPACK_4$ 48% found it most useful in science teaching.

For $TPACK_3$ <60% of student teachers found it most useful, followed by $TPACK_1$ and $TPACK_5$ <50% $TPACK_2$ and $TPACK_4$,48% found it most useful in social science teaching.

4.1 Innovated Tpack Based K-4 Learning Transaction Model (K-4)

- Knowledge Tension: Contextualization *(Pedagogy involved: Situated cognition- consciously igniting cognition in learners' own observation, learning and skills)*
- Knowledge Presentation- acquisition *(Pedagogy involved: Anchored Instruction- integrating technology in learning approaches which place learning within meaningful and problem-solving context, Contextualized discursion- reflecting logically beyond the content and context)*
- Knowledge Collaboration- extension (*Pedagogy involved: Disrupted Collaboration- awakening the mind by posing questions begin with how, why and if, while contributing in group)*
- Knowledge check-evaluation (*Pedagogy involved: Constructed Manifestation- interpreting and manifesting while linking the whole to learners' own experiences and applications)*

There is significant difference between the experimental group-1 and control group-1. Further, there is significant difference between the experimental group-2 and control group-2. In both the experiments mean score of learning achievement of experimental group-1 &2 was found higher than the mean score of learning achievement of control group-1 &2. Further, there is a negligible difference found between the experimental group-1 & 2 and control group-1 & 2 as well. In other words, it can be said that TPACK based practice teaching was found superior to traditional approach-based practice teaching.

The study reveals that TPACK based practice teaching was found superior to traditional approach-based practice teaching with reference to learning achievement of students. It is imperative therefore to provide rigorous orientation exposure on TPACK practices and development and use of TPACK based Lesson Plans for preservice teachers facilitated by the teacher educators and concerned teacher education institutions.

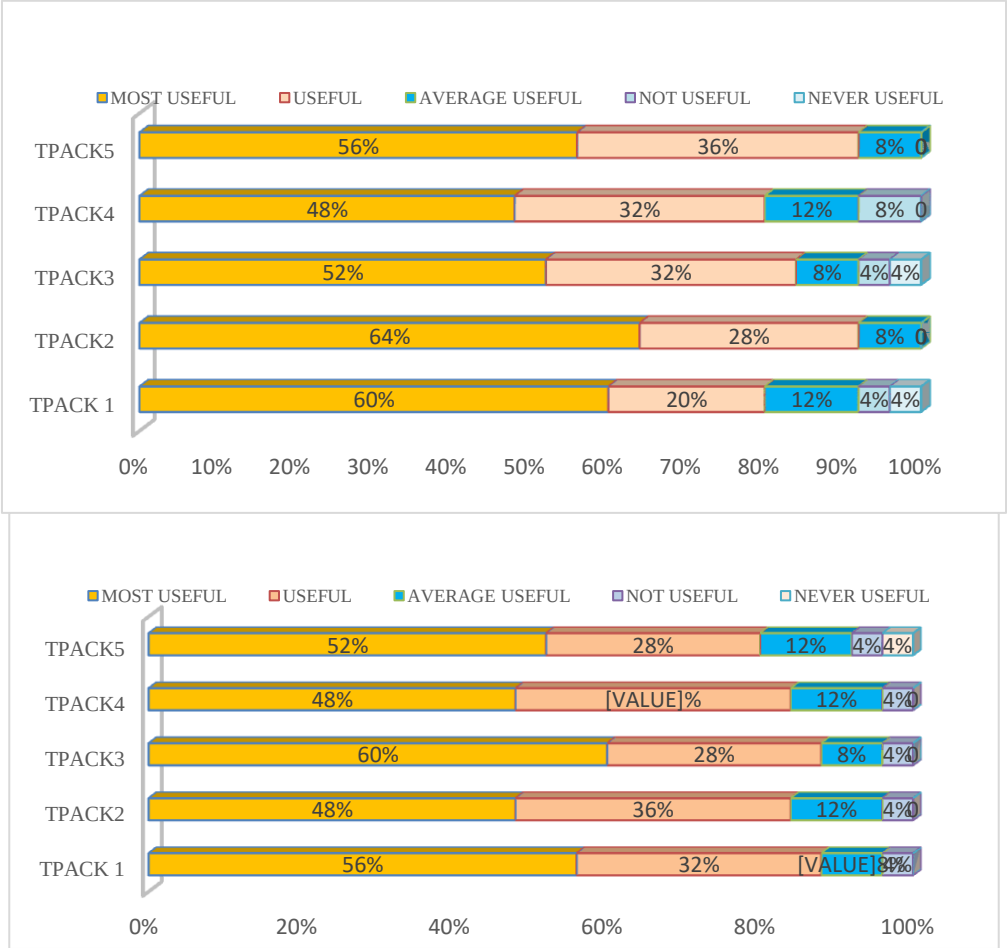

Fig. 3. Reaction of science preservice teachers towards TPACK5 components used for K4 instructional design

It was also revealed that TPACK based practice teaching was found effective in both science and social science teaching. Therefore, research and training may be undertaken to experiment TPACK based practice teaching effectiveness in other subjects like languages and mathematics.

The study also brought in an innovation in TPACK based lesson plans based on feedback given by the preservice teachers and the teacher educators engaged in the process of experiment. This innovated instructional design is K-4 Learning Transaction Model based on TPACK guidelines developed by the project team. This innovated instructional design may be called as TPACK based K-4 Learning Transaction Model (K-4 LTM). Similar innovations may be carried out by other researchers and teacher educators.

Further the study revealed that 85.6 per cent science preservice teachers and 84.8 per cent social science preservice teachers responded their favorable reaction towards TPACK based K-4 Learning Transaction Model (K-4 LTM). Hence it can be suggested that this genre of TPACK based K-4 learning transaction model may be recognized for use in practice teaching organized by teacher education programmes at secondary and even elementary level. This model may be useful in day-to-day real teaching at school level and even in education delivery at higher stage.

At policy level the NCTE, NCERT, SCERT, DIET and the PMMMNMTT need to conduct a greater number of project experiments and formulate necessary guidelines for TPACK practices at preservice practice teaching level. Also, the government agencies like state level school and mass education departments need to conduct in-service training on TPACK based teaching to empower teachers at school level. The government must provide technology infrastructure at school level and teacher education institution level to make TPACK based teaching successful and useful.

5. CONCLUSION

In conclusion, further this experiment propelled to innovate TPACK based K-4 Learning Transaction Model with its unique features and practicability in the area of curriculum transaction. The results of the study have potentials to initiate reforms in teacher preparation more learner centric with support of TPACK based instruction. In addition, it can be suggested an innovative TPACK based K-4 instructional design that could also be used to train the preservice teachers to examine whether there is a shift towards the use of technology to construct knowledge namely TPACK to strengthen the teacher education standards, which could reflect a deeper understanding for the teacher education institutions for developing insight to teaching and learning.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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