Premiere Educandum
JURNAL PENDIDIKAN DASAR DAN PEMBELAJARAN
PE

Premiere Educandum: Jurnal Pendidikan Dasar dan Pembelajaran
Volume 13 (2) 118 – 131 December 2023
ISSN: 2088-5350 (Print) / ISSN: 2528-5173 (Online)
Doi: 10.25273/pe.v13i2.16895
The article is published with Open Access at: http://e-journal.unipma.ac.id/index.php/PE

Effectiveness of TPACK types based on constructionist activities on students technological literation ability

Fauzatul Ma'rufah Rohmanurmeta ✉, Universitas Negeri Malang
Herawati Susilo, Universitas Negeri Malang
Mohammad Zainuddin, Universitas Negeri Malang
Syamsul Hadi, Universitas Negeri Malang

✉ fauzatul@unipma.ac.id

Abstract: The TPACK type is very much needed in learning activities to support students' technological literacy skills. This study aims to compare the effectiveness of the TPACK types which include TPACK-IK, TPACK-TK, TPACK-VK, and TPACK-V on students' technological literacy abilities. This type of research is pure experimental research. The research design used was pretest-posttest with nonequivalent groups. The population in this study amounted to 272 students. The research sample included 30 students in class A, 31 students in class B, 29 students in class C, and 30 students in class D. The data collection technique used in this study was a test. The research instrument used was a question sheet. The results showed that based on the results of the paired t test, it was known that there were differences in pretest and posttest in the experimental group I, experiment II, and control 1. Meanwhile, in the control group II there was no difference in pretest and posttest scores. Based on this treatment, TPACK-IK gave the best results on students' technological literacy skills. Meanwhile, based on the Two Way Anova analysis, it shows that the four types of TPACK are able to differentiate students' technological literacy levels. Based on the results of this study it can be concluded that TPACK-IK gives the best results on students' technological literacy abilities compared to other types of TPACK.

Keywords: Types of TPACK, Constructionist Activities, Technology Literacy.

Received 22 June 2023; **Accepted** 8 January 2024; **Published** 13 January 2024

Citation: Rohmanurmeta, F.M., Susilo, H., Zainuddin, M., & Hadi, S. (2023). Effectiveness of TPACK types based on constructionist activities on students technological literation ability. *Premiere Educandum : Jurnal Pendidikan Dasar dan Pembelajaran*, *13*(2), 118 – 131. Doi.org/10.25273/pe.v13i2.16895

INTRODUCTION

Developments in the digital transformation era require teachers to have technology-based teaching skills. Technology-based teaching skills are the ability to teach by utilizing the latest technology which specifically must be owned by teachers in order to carry out teaching tasks effectively, efficiently and professionally in accordance with the demands of education in the digital transformation era. The process of improving technology-based teaching skills for teachers is influenced by a significant increase in technological literacy (Simons et al., 2017; Claro et al., 2018). Technology is the result of human thought to develop certain procedures or systems and is used to facilitate the process of solving problems (McLester, 2007; Lilian, 2022). Technological literacy is the ability to use, understand, manage, and evaluate an innovation that involves processes and knowledge to solve problems and expand one's abilities (Triana et al., 2020; Reddy et al., 2023; Ali et al., 2023).

A teacher in this modern era must be technologically literate considering that the quality of a teacher who is devoid of technology will not be able to instill critical thinking skills in students to become revolutionary human beings (Cydis, 2015; Burnett, 2010). However, based on data from the Center for Information Technology and Communication for Education and Culture (Pustekkom) of the Ministry of Education and Culture (Kemendikbud) in 2021, only 40% of teachers in Indonesia are literate with technology. The remaining 60% of teachers are still stuttering with technological advances in this modern era. This problem is caused by: 1) the competence of teachers in Indonesia is very low in the world of modern technology, 2) educational technology content is still minimal, 3) there is a need for adequate facilities and infrastructure.

Primary teacher education students as one of the components related to technological literacy (Polizzi, 2020; Su, 2023) . Primary teacher education students as prospective teachers must be equipped with technological literacy to prepare future teachers who have technology-based teaching skills. Technological literacy is not only needed during lectures but is also needed when they are on duty in the field to become real teachers (Baylor & Ritchie, 2002). Technological literacy cannot be obtained instantly, but must be provided when someone is still in education to prepare teachers who have high technological literacy (Burnett, 2010; Wardana, et. al., 2023).

Preliminary studies were carried out at tertiary institutions at the PGRI Madiun University in the primary teacher education undergraduate study program in the even semester of the 2021/2022 academic year. Based on the preliminary study, the fact was obtained that students' technological literacy was still lacking. This is evident from the results of tests measuring technological literacy skills in the Learning Strategy course in the 2021/2022 academic year, the fact is that 65% of primary teacher education students have very low technological literacy with an average score of 48. This average score is still not enough to prepare prospective elementary school teachers who have technology-based teaching skills who are ready to compete in the digital transformation era.

This problem is because in the process of the Learning Strategy course there is no in-depth discussion of content, pedagogy, and technology. Lecturers only focus on their professional competence which includes material on learning strategies and pedagogical competencies without mastery of technology in lecture activities. Lecturers need to improve professional competence which includes not only learning materials, but also skills in mastering technology (Tomczyk, 2021; Nedeljko et al., 2022). Based on these problems, good integration is needed between learning materials, pedagogy, and also technology. This is in accordance with what was conveyed Mishra & Koehler, (2006) which is famous as a pioneer in developed countries regarding the integration of material (content), pedagogy, and also technology in the form of a learning set known as TPACK (Technological, Pedagogical, and Content Knowledge) which is a creative solution and can be developed in learning (Altun, 2019).

The Learning Strategy course is a course that discusses the basic concepts of planning and learning strategies, the relation of learning planning, the steps of learning planning, learning strategies, and making product designs and implementing them in learning (McLoughlin & van Kampen, 2019; (de Koning et al., 2020). Through these courses students also learn various approaches, models, strategies and methods in active learning and are able to teach them in accordance with the demands of the digital transformation era(Grønlien et al., 2021; Cheshire & Strickland, 2018). Learning Strategy is a course that examines the components of the learning system to develop a learning approach in elementary school so that the learning process occurs in students to achieve optimal learning(Schroeder et al., 2021; Marcela, 2015). Not many people know about and apply the TPACK approach in the process of presenting these courses in the primary teacher education study program at PGRI Madiun University. Lecturers only present Learning Strategy learning material accompanied by presentation activities from students using simple technology via power point. There is no element of innovation in this activity, so there is no increase in technological literacy for prospective elementary school teachers.

TPACK learning has long existed in the world of education but not many are aware of its existence, especially for elementary school education lecturers in Indonesia. TPACK became known in Indonesia in the 2019/2020 academic year, although not many elementary school lecturers know and apply it. In lecture activities several prospective teachers/students have been given learning activities using the conventional type of TPACK (TPACK-V). TPACK-V only involves the last component of TPACK, namely Technological Pedagogical Content Knowledge (TPCK). TPCK is carried out by lecturers when teaching using technology in learning to present lecture material using appropriate methods or models (Nilsson & Loughran, 2012). Even though there are several types of models that can be applied in lecture activities. The model is an integrative and transformative model(Jang & Chen, 2010). Integrative models and transformative models are expected to provide more effectiveness in learning (Jimoyiannis, 2010).

Schmidt, *et al*. (2009) explained that the TPACK integrative model views the central component of TPACK (TPCK) as emerging from the integration of each component domain. In this view, high levels of Technological Pedagogical Content Knowledge (TPCK) will be based on high levels of Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK). Meanwhile, the TPACK transformative model describes the intersection of knowledge components to generate unique knowledge with a combination of core components. According to a transformative perspective, TPACK cannot be simply explained by adding up the components of TPACK. TPACK transformative model as a different form of knowledge that transforms beyond its basic components. The TPACK transformative model is influenced by Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), and Pedagogical Content Knowledge (PCK) but not directly by Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK). The results of this research were carried out to compare the TPACK structure of integrative and transformative models in developing teacher assessment instruments. The results of this research indicate that the questionnaire consisting of 28 items is considered a valid and reliable instrument
to assess teachers' TPACK abilities. Furthermore, the knowledge component supports the transformative TPACK model. The results of this research do not yet show the effectiveness of implementing this type of TPACK. Meanwhile, this research was carried out to reveal the effectiveness of this type of TPACK based on constructionist activities which are linked to technological literacy skills.

Types of TPACK which include integrative TPACK models, transformative TPACK models, and conventional TPACK can be implemented through constructionist activities. Ackermann, (2001)explains that constructionist activities are a form of activity in learning that focuses on developing students' abilities, skills, and thinking. Constructionist activity is an approach to learning which believes that people actively build or create their own knowledge and reality is determined by the person's own experiences as well (Kynigos, 2012). Experience can be built through a learning activity. Constructionist theory developed by Seymour Papert refers to Piaget's constructionism with more emphasis on educational views than on overall cognitive potential (Ignatova et al., 2015).

The type of TPACK implemented in constructionist activity-based learning is expected to provide an increase in student technological literacy. The types of TPACK which include integrative model TPACK through constructionist activities (TPACK-IK), transformative model TPACK through constructionist activities (TPACK-TK), conventional model TPACK through constructionist activities (TPACK-VK), and conventional TPACK (TPACK-V) are expected to be able to provide an increase in the effectiveness of student technological literacy. However, the existence of these types of TPACK which includes TPACK-IK, TPACK-TK, TPACK-V needs to be tested for its effectiveness to see which type of TPACK is the most effective for implementing learning activities in Indonesia. This research is very important and urgent to do so that the most effective types of TPACK can be immediately implemented in learning activities in Indonesia to face the digital transformation era. Based on the background that has been described, the researcher is interested in conducting research with the title "Effectiveness of the TPACK integrative and transformative models through Constructionist Activities on Increasing Student Technology Literacy".

METHODS

Research Design

This research was conducted at the University of PGRI Madiun in the Elementary School Teacher Education study program. The research was carried out in the Even Semester Learning Strategies course for the 2021/2022 academic year. This study uses a pure experimental approach. Pure experimental research is a form of experimental research that is actually carried out by controlling all external variables that affect the course of the experiment (Creswell, 2017). The research design used a pretest posttest with nonequivalent groups. This design is carried out by giving a pretest before learning and a posttest after learning in each group. According to Mertler & Charles (2005:324) this design is more robust because a pretest is carried out to establish equivalence between groups.

Population and Sample

The population in this study were all undergraduate primary teacher education students at PGRI Madiun University for the 2021/2022 academic year in semester IV who were taking the Learning Strategy course. The total number of primary teacher education undergraduate students in the Madiun PGRI University area in that semester totaled 272 students consisting of 10 classes. The research sample was taken randomly using a lottery. The sample of this study was class A primary teacher education UNIPMA undergraduate students with a total of 30 people, class B with a total of 31 people, class C with a total of 30 people, and class D with a total of 30 people.Sampling is based on an equivalent population (Secolsky, 2017) (Marczyk et al., 2005). Equality testing is carried out through one way anava using the student's Grade Point Average (GPA). Prerequisite tests which include normality and homogeneity tests were carried out before the one way Anava test in 10 classes.

TABLE 1. *One-way anava test results*

Grade Point Average	df	F	Sig.
Between Groups	9	.720	.690

TABLE 2. *Dimensions and indicators of technology literacy*

No	Dimensions	Indicator
1	Beyond functional skills	ICT skills
2	Creativity	Product creation or output in various formats and models by utilizing digital technology. Ability to think creatively and imaginatively in planning, content, exploring ideas.
3	Collaboration	The ability to participate in the digital space. Ability to explain and negotiate the ideas of others.
4	Communications	Ability to communicate through digital technology media. Ability to understand and understand the audience.
5	Ability to Find and SelectInformation	Ability to search and investigate information.
6	Critical Thinking and Evaluation	Ability to contribute, analyze, sharpen critical thinking skills when dealing with information
7	Cultural and social Understanding	In line with the context of socio-cultural understanding
8	E-Safety	Ensure security when users explore, create, collaborate with digital technology.

Source:Burnett, (2010)

Class A has a Do of 0.131 and an Asymp value. Sig (2-tailed) is 0.293 ($p \geq 0.05$). This means that the class A sample comes from a normally distributed population. Class B has a Do of 0.093 and an Asymp value. Sig (2-tailed) is 0.397 ($p \geq 0.05$). This means that the class B sample comes from a normally distributed population. Class C has a Do of 0.113 and an Asymp value. Sig (2-tailed) is 0.494 ($p \geq 0.05$). This means that the class C sample comes from a normally distributed population. While class D has a Do of 0.135 and an Asymp value. Sig (2-tailed) is 0.129 ($p \geq 0.05$). This means that the class D sample also comes from a normally distributed population. Furthermore, in the same way class E, F, G, H, and I. Homogeneity test of data variance is known that all classes at UNIPMA which include classes A, B, C, D, E, F, G, H, I, and J in the 2021/2022 academic year in semester 4 to take the subject The Learning Strategy course has a Fhit score of 1.634 with a Sig score of 0.105 ($p \geq 0.05$). This shows that the entire population has the same or homogeneous variance.

Based on Table 1, it shows that from the results of the 1-way anava test, it was found that the Fhit value was 0.690 ($p \geq 0.05$). This means that there is no significant difference in the Grade Point Average (GPA for students who will take the Learning Strategy course in semester 5. Based on this analysis it can be concluded that the research sample includes classes A, B, C, and D which are randomly selected random from an equivalent population. Class A and B are the experimental class, while class C and D are the control class. Class A was treated with TPACK-IK, class B was treated with TPACK-TK, class C was treated with TPACK-VK, and class D was treated with TPACK-V.

Research Instruments

The data collection technique in this study is a test. The test is a series of questions or exercises as well as other tools used to measure skills, intelligence knowledge, abilities or talents possessed by individuals or groups.(Leutner et al., 2017). The data collection instrument used was a matter of test. The test questions are arranged in a planned manner to reveal students' technological literacy abilities(Leutner et al., 2017). The type of test used is a written test in the form of multiple choices, totaling 25 items. Tests were administered to determine students' technological literacy skills before and after learning with TPACK types which include TPACK-IK, TPACK-TK, TPACK-VK, and TPACK-V. The technological literacy test questions can be seen in Table 2.

Instrument validity techniques include internal and external validity. Internal validity is carried out by educational experts and material experts. Meanwhile, external validity was carried out using Pearson Product Moment correlation (Bivariate Perason) with SPSS 17.00 for windows. Reliability testing was carried out using Cronbach's Alpha with SPSS 17.00 for windows. The next step is to try out the test instrument and analyze the items. The item test was conducted on students who had previously taken a Learning Strategy course. These students are in semester 6 of class A in the 2021/2022 academic year, with a total of 33 students. The results of the analysis of the item test were carried out using SPSS 17 for windows. The results of the analysis show that based on the 25 items obtained 20 valid questions with a sig value <0.05, while 5 items are invalid with a sig value > 0.05. Items that were declared invalid were discarded and not used for research. Based on the results of the reliability test, the value of Cronbach's Alpha was 0.684. This value is in the high reliability category, so the 20 items can be used for research.

Data analysis

Data analysis is carried out to reduce data into something that can be understood and interpreted in a certain way so that the research problem can be tested (Brent & Leedy, 1990). This type of research is true experiment and the type of data obtained is in the form of numbers. Data were analyzed with descriptive and inferential statistics. Descriptive analysis to display data on students' technological literacy abilities. Inferential statistics in the form of two-way ANOVA analysis. In analyzing the data, SPSS 17.00 for windows was used.

Technological literacy data in this study were grouped into 3 (three) categories, namely high, medium, and low. The high group category consists of all students who have an average score plus 1 standard deviation (SD) and above. The medium group category consists of all students who have an average score minus 1 standard deviation (SD) and an average score plus 1 SD. While the low group consists of all students who have a score less than the average score minus 1 standard deviation (SD). This research was conducted to test the effectiveness of TPACK types which include TPACK-IK, TPACK-TK, and TPACK-VK on increasing technological literacy. Therefore, prior to data analysis, an assumption test was first carried out as a prerequisite for analysis. Prerequisite tests include normality and homogeneity tests.with the help of SPSS 17.00 for windows. The rule used to determine whether the distribution is normal is if the p value > 0.05, then the distribution is normal. Conversely, if the p value <0.05, then the distribution is not normal. Meanwhile, the homogeneity test was carried out using levene statistics with the help of SPSS 17.00 for windows. The rule used is if the p value > 0.05, then the variance is homogeneous, but if p > 0.05 the variance is not homogeneous.

Hypothesis testing was carried out to find out the differences between the two student group data using two ways ANOVA. This test is used to analyze the main effect and interaction effect relationships between the variables used in the research, namely TPACK-IK, TPACK-TK, TPACK-VK, and TPACK-V with technological literacy. This test uses SPSS 17 for windows. Two-way Anava is used to determine the difference in the value of the dependent variable which is categorized based on the large number of independent variables and each variable consists of several groups. Hypothesis analysis using SPSS 17.0 for windows.

RESULT

The results of the descriptive analysis show that TPACK-IK has more influence on the level of students' technological literacy skills. The results of the descriptive study are shown in Table 3. Based on Table 3, it shows that in the experimental class 1 before and after treatment with TPACK-IK, the average technological literacy ability increased by 29%. Experimental class 2 before and after treatment with TPACK-TK had an average increase in technological literacy ability of 21%. Control class 1 before and after treatment with TPACK-VK has an average increase in technological literacy of 14%. Whereas Control 2 before and after treatment with TPAVK-V had a technological literacy capability of 4%. Based on these data TPACK-IK has the most significant effect compared to TPACK-TK, TPACK-VK, and TPACK-V. TPACK-TK has a more significant effect than TPACK-VK and TPACK-V. Meanwhile, TPACK-VK has a more significant effect than TPACK-V. Based on these data it can be seen that TPACK-IK makes the most positive contribution to the level of students' technological literacy skills compared to other TPACK models.

Furthermore, from the technological literacy data obtained, they are again grouped into 3 (three) groups, namely groups of students who have high, medium, and low technological literacy abilities. The grouping of students is based on the average value and standard deviation (SD). Based on the technological literacy test data before treatment is presented in Figure 1.

TABLE 3. Data on technology literacy results before and after treatment

	Experiment 1		**Experiment 2**		**Control 1**		**Control 2**	
	Beginning	**End**	**Beginning**	**End**	**Beginning**	**End**	**Beginning**	**End**
Average	57	86	55	76	53	67	59	63
Increase Percentage	29%		21%		14%		4%	
Std. Deviation	10.54	10.52	10,28	10.56	10.33	10.32	10.33	10.31

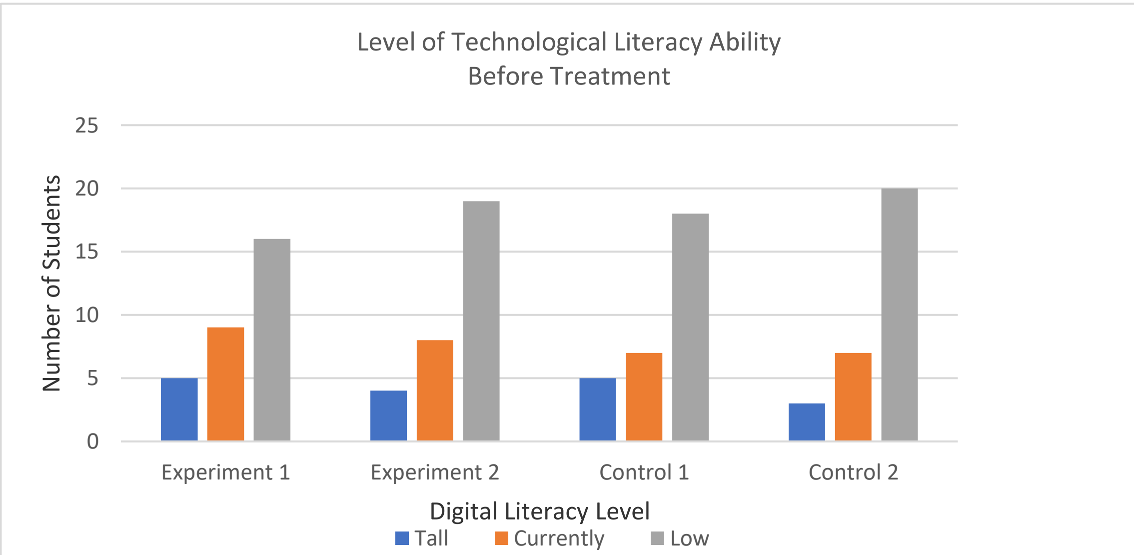

FIGURE 1. *Level of technology literacy of students before treatment*

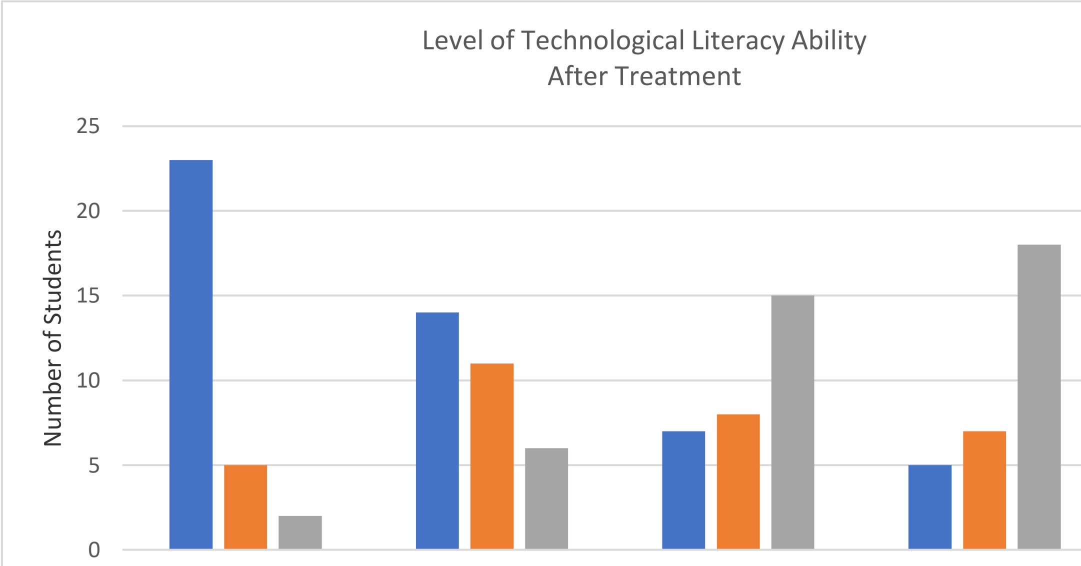

FIGURE 2. *Level of technology literacy of students after treatment*

Based on Figure 1 it shows that in the experimental class 1 before treatment with TPACK-IK there were 5 students who had a high level of technological literacy, 9 students had a moderate level of technological literacy, and 16 students had a low level of technological literacy. Experimental class 2 before treatment with TPACK-TK there were 4 students who had a high level of technological literacy, 8 students had a moderate level of technological literacy, and 19 students had a low level of technological literacy. Control class 1 before treatment with TPACK-VK there were 5 students who had a high level of technological literacy, 7 students had a moderate level of technological literacy, and 18 students had a low level of technological literacy. Control class 2 before treatment with TPACK-V there were 3 students who had a high level of technological literacy, 7 students had a moderate level of technological literacy, and 20 students had a low level of technological literacy. While the level of students' technological literacy ability after treatment is presented in Figure 2.

Based on Figure 2, it shows that in the experimental class 1 after treatment with TPACK-IK there were 23 students who had a high level of technological literacy, 5 students had a moderate level of technological literacy, and 2 students had a low level of technological literacy. Experimental class 2 after treatment with TPACK-TK there were 14 students who had a high level of technological literacy, 11 students had a moderate level of technological literacy, and 6 students had a low level of technological literacy. Control class 1 after treatment with TPACK-VK there were 7 students who had a high level of technological literacy, 8 students who had a moderate level of technological literacy, and 15 students who had a low level of technological literacy.

Results of Data Analysis

Prerequisite test is done before doing inferential analysis. Prerequisite test includes normality test and homogeneity test. The normality test was carried out to find out whether the research data to be analyzed was normally distributed or not. Based on the output results of SPSS 17 for windows, the Asymp value is obtained. Sig. (2 tailed) with the normality test for initial technological literacy (pre-test) for both experimental group I, experiment II, control I, and control II with Kolmogorof-Smirnov calculations respectively 0.878, 0.931, 0.897, and 0.756 . These four values are greater than α = 0.05 so that the initial student technology literacy data is normally distributed. While the results of the Kolmogorov-Smirnov calculations for the final learning outcomes (post-test) in the experimental group 1, experiment 2, control 1, and Control 2 respectively 0.268, 0.285, 0.198, and 0.267. These four values are greater than α = 0.05, so that the students' final technological literacy data are normally distributed. The results of the normality test for technological literacy data can be seen in Table 4. The homogeneity test of variance is used to determine whether the samples taken from the populations being compared have the same variance and do not show significant differences from each other. The results of the technological literacy homogeneity test are shown in Table 5. Based on Table 5, it shows that the results of the homogeneity of the pretest and posttest students' technological literacy variant scores in the experimental group 1, experiment II, control I, and control II were homogeneous with a P value > 0.05. This value indicates that the post-test data meets the assumptions required to use the planned statistical method.

Two Way Anova analysis used a ratio of observed differences to test the hypothesis. The hypotheses proven in this study are:

H0:α^2= 0 ;There are no differences in technological literacy skills between students taught by TPACK-IK, TPACK-TK, TPACK-VK, and TPACK-V.

H0:$\alpha^2 \neq$ 0 ;There are differences in technological literacy abilities between students taught by TPACK-IK, TPACK-TK, TPACK-VK, and TPACK-V.

The ratio, called the F-ratio, uses the variance (α2) of the group mean used as a measure in determining group differences. Data analysis using SPSS 17 for windows. Based on this analysis, the Univariate Analysis of Variance is obtained which is presented in Table 6.

Based on Table 6 in the TPACK row, it shows that the Fcount > Ftable with an acquisition score of 9.456 > 4.03 with P <0.05. Based on these data shows that H_0 is rejected. This means that the four types of TPACK which include TPACK-IK, TPACK-TK, TPACK, VK, and TPACK-V really differentiate the level of student technological literacy in the Learning Strategy course.

TABLE 4. *Data normality calculation results*

Aspect	*Kolmogorof -Smirnov*				Criteria
	Experiment I	**Experiment II**	**Control I**	**Control II**	
Early technological literacy	0.878	0.931	0.897	0.756	Normal distribution
Late technology literacy	0.268	0.285	0.198	0.267	Normal distribution

TABLE 5. *Levene test results for homogeneity of variants*

Aspect	**Level Test**							
	Experiment 1		**Experiment II**		**Control I**		**Control II**	
	F	**P**	**F**	**P**	**F**	**P**	**F**	**P**
Early technological literacy	1,089	0.352	1,092	0.287	1,084	0.356	1,098	0.374
Late technology literacy	0.754	0.584	0.673	0.876	0.873	0.762	0.565	0.957

TABLE 6. Univariate variance analysis results

Source	df	MeanSquare	F	Sig.
TPACK	1	90,765	9,456	,003
TPACK * Literacy	2	1474,314	153,001	,000

DISCUSSION

TPACK is very appropriate when implemented through constructionist activities. This is based on the fact that in the TPACK component there is technology as one of the important components in it. While constructionist activities carried out to build students' abilities can also be carried out with the help of technology (Hosseini, 2015). Based on the research conducted by Hosseini, it shows an understanding of the development of TPACK through constructionist activities. The research findings show that teachers' knowledge and conceptions of using technology to teach develop at three levels. The first tier is limited to using technology to showcase curriculum information. The second level is carried out with the use of technology to present content and materials. The third level is carried out by developing the ability to use technology to improve teaching and learning. The results of these learning activities have interactions between aspects of constructionist activities that are more influential in the development of TPACK.

Based on research conducted by Prongsamrong, P., et al (2018) shows that TPACK is constructionist oriented. The constructionist-oriented TPACK approach was created and used as a framework for developing learning (Ignatova et al., 2015). The research aims to study the application of science content by combining science teaching with constructionist concepts. The use of technology is able to create content knowledge criteria that are applied in pedagogical science by using constructionist concepts. Constructionist concepts in learning are combined with content knowledge by using teaching technology that is consistent with the material and pedagogical concepts used (Csizmadia et al., 2019). The results of this study indicate that constructivism comes to create criteria of pedagogical science knowledge with technology based on constructivism concepts by adding issues related to constructionism theoretical learning management. Learning occurs when students have the opportunity to bring ideas into works that can reflect knowledge.

Based on its implementation, TPACK learning activities can be carried out through integrative models (TPACK-I) and transformative models (TPACK-T) (Prongsamrong, P., et al. 2018). The implementation of the two types of TPACK can be carried out through constructionist activities (Nilsson & Loughran, 2012). Apart from these two types of TPACK, conventional TPACK (TPACK-V) can also be implemented through constructionist activities. Constructionist activity as an activity to create new conditions in self-development. Constructionist activities can make students support each other in one activity with one another. Educators can play a role in becoming natural members of a learning community. Constructionist activities can be built through activities outside the classroom, in the classroom, or carried out through technology-based activities.

The TPACK type has a very effective impact when implemented through constructionist activities. This is based on the fact that the TPACK types which include TPACK-I, TPACK-T, and TPACK-V have technology as an important component in them. While constructionist activities carried out to build students' abilities can also be carried out with the help of technology. So based on this explanation educators can carry out integrative TPACK through constructionist activities (TPACK-IK), transformative TPACK through constructionist activities (TPACK-TK), and conventional TPACK through constructionist activities (TPCK-VK) in teaching and learning activities.

Integrating technology in the learning process can provide technological literacy for primary teacher education students who are prospective elementary school teachers (Zahoor et al., 2023). One framework that can be implemented to create such a learning atmosphere is TPACK. The TPACK framework is characterized by using technology and integrating it with pedagogy, content and knowledge. TPACK became very popular with the writing by Minta Mishra and Matthew J. Koehler (2006) in the journal Teacher College Record. TPACK is a framework that integrates technology, pedagogy and knowledge. An educator needs to combine the development of learning models in implementing TPACK for the successful achievement of learning objectives in the digital transformation era.

Based on the results of research conducted by (Altun, 2019), pointed out that the integration of technology into education is an important issue to support and renew the professional development of teachers in today's world, raising a digitally literate generation, and educated human resources. Technology integration in education is a complex and multidimensional issue (Nedeljko et al., 2022). TPACK comprises the basis for the effective integration of technology into teaching. This study understands the contribution of attitudes, use of technology, and technology literacy skills. The participants in this study were 481 early childhood education programs teachers consisting of 398 women and 83 women. The research findings reveal that pre-service teacher TPACK competence is associated with attitudes, technology use, and technology literacy skills.

The soul of the TPACK framework is the complex interaction of the three main forms of knowledge namely Content (CK), Pedagogy (PK), and Technology (TK). TPACK integrative and transformative models through constructionist activities (TPACK-IK and TPACK-TK) are learning models that have been successfully developed from the TPACK framework. TPACK forms educators' understanding starting from simple things such as searching for information with information technology (Aktas & Ozmen 2020) to complex matters such as pedagogical abilities and content (Etkina, 2010).

TPACK which includes TPACK-IK and TPACK-TK as a way that can be used to increase technological literacy for prospective elementary school teachers. This is because TPACK which includes TPACK-IK and TPACK-TK in learning activities includes using technology as an important component used by students or prospective teachers to teach certain subject matter. Through TPACK educators can use learning technology effectively and efficiently (Gonzales & Gonzales Ruiz, 2016) so that learning can be carried out properly (Jimoyiannis, 2010) .

The results of research conducted by Etkina, (2010) show that TPACK has an influence on technological literacy. Meanwhile, research conducted by Mishra & Koehler, (2006) shows that there is an integrative model of TPACK and a transformative model of TPACK but has not revealed the advantages between these types of TPACK. Akckerman, (2001) proves that constructionist activities have positive results in increasing learning activities when integrated with TPACK. Based on the results of previous research, it has not been found that there is any effectiveness of TPACK types based on constructionist activities which include TPACK-IK and TPACK-TK on students' digital technology literacy.

CONCLUSION

The results showed that based on the results of the paired t test, it was found that there was a difference in the average pretest and posttest scores in the experimental group I with a P value of 0.001, the experimental group II with a P = 0.026, and control I with a P = 0.034. Whereas in the control group II there was no difference in the average pretest and posttest scores with P = 0.283. Based on these data the treatment with TPACK-IK gave the best results on students' technological literacy skills. Meanwhile, based on the Two Way Anova analysis, it shows that Fcount > Ftable with an acquisition score of 9.456 > 4.03 with P <0.05. The data shows that the four types of TPACK are able to differentiate students' technological literacy levels.

Giving TPACK-IK, TPACK-TK, TPACK-VK treatments has a significant effect on students' technological literacy skills. The TPACK-IK treatment gave the best results. The technological literacy of students did not experience much change in the treatment with TPACK-VK. Treatment with TPACK-TK gave better results when compared to TPACK-VK, but it was still below TPACK-IK. TPACK integrative and transformative models based on constructionist activities have a significant influence in increasing students' technological literacy skills.

This research is limited to the Learning Strategy courses, digital technology literacy, technology-based teaching skills, and types of TPACK which include TPACK-IK, TPACK-TK, TPACK-VK, and TPACK-V. Due to the wide variety of technologies that can be used in learning activities, this research is limited to the use of digital technology. Based on the results of this study, lecturers should be able to apply the types of TPACK which include TPACK-IK, TPACK-TK, and TPACK-V in learning activities not only in the Learning Strategy course to improve students' technological literacy skills.

REFERENCES

1. Ackermann, E. (2021). Piaget's Constructivism, Papert's Constructionism: What's the difference? *Future of Learning Group Publication*, 5(3), 438.
2. Ah-Nam, L., & Osman, K. (2017). Developing 21st Century Skills through a Constructivist-Constructionist Learning Environment. K-12. *Stem Education*, 3(2), 205-216.
3. Altun, D. (2019). Investigating Pre-Service Early Childhood Education Teachers' Technological Pedagogical Content Knowledge (TPACK) Competencies Regarding Digital Literacy Skills and Their Technology Attitudes and Usage. Journal of Education and Learning, 8(1), 249. https://doi.org/10.5539/jel.v8n1p249
4. Ali, A., Raza, A. A., & Qazi, I. A. (2023). Validated digital literacy measures for populations with low levels of internet experiences. Development Engineering, 8, 100107. https://doi.org/10.1016/j.deveng.2023.100107
5. Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT–TPCK: Advances in technological pedagogical content knowledge (TPCK). Computers & Education, 52(1), 154–168. https://doi.org/10.1016/j.compedu.2008.07.006
6. Baylor, AL, & Ritchie, D. (2002). What factors facilitate teacher skills, teacher morale, and perceived student learning in technology-using classrooms? Computers & Education, 39(4), 395–414. https://doi.org/10.1016/S0360-1315(02)00075-1
7. Brent, E., & Leedy, PD (1990). Practical Research: Planning and Design. Teaching Sociology, 18(2), 248. https://doi.org/10.2307/1318509
8. Burnett, C. (2010). Technology and literacy in early childhood educational settings: A review of research. Journal of Early Childhood Literacy, 10(3), 247–270. https://doi.org/10.1177/1468798410372154
9. Csizmadia, A., Standl, B., & Waite, J. (2019). Integrating the Constructionist Learning Theory with Computational Thinking Classroom Activities. Informatics in Education, 18(1), 41–67. https://doi.org/10.15388/infedu.2019.03
10. Cydis, S. (2015). Authentic instruction and technology literacy. Journal of Learning Design, 8(1), 68–78. https://doi.org/10.5204/jld.v8i1.222
11. TPACK Diagramming in Practice: Using an Elaborated Model of the TPACK Framework to Analyze and Depict Teacher Knowledge. (2009). TechTrends, 53(5), 60–69. https://doi.org/10.1007/s11528-009-0327-1
12. Etkina, E. (2010). Pedagogical content knowledge and preparation of high school physics teachers. Physical Review Special Topics - Physics Education Research, 6(2), 020110. https://doi.org/10.1103/PhysRevSTPER.6.020110
13. Grønlien, HK, Christoffersen, TE, Ringstad, Ø., Andreassen, M., & Lugo, RG (2021). A blended learning teaching strategy strengthens the nursing students' performance and self-reported learning outcome achievement in an anatomy, physiology and biochemistry course – A quasi-experimental study. Nurse Education in Practice, 52, 103046. https://doi.org/10.1016/j.nepr.2021.103046
14. Harris, J., Mishra, P., & Koehler, MJ (2009). Teachers' Technological Pedagogical Knowledge and Learning Activity Types: Curriculum-Based Technology Integration Reframed. Journal of Research on Technology in Education, 41(4), 25.
15. Hosseini, Z. (2015). Development of Technological Pedagogical Content Knowledge through Constructionist Activities. Procedia - Social and Behavioral Sciences, 182, 98–103. https://doi.org/10.1016/j.sbspro.2015.04.743

16. Ignatova, N., Dagienė, V., & Kubilinskienė, S. (2015). ICT-based Learning Personalization Affordance in the Context of Implementation of Constructionist Learning Activities. Informatics in Education, 14(1), 51–65. https://doi.org/10.15388/infedu.2015.04
17. Jang, S.-J., & Chen, K.-C. (2010). From PCK to TPACK: Developing a Transformative Model for Pre-Service Science Teachers. Journal of Science Education and Technology, 19(6), 553–564. https://doi.org/10.1007/s10956-010-9222-y
18. Jimoyiannis, A. (2010). Designing and implementing an integrated technological pedagogical science knowledge framework for science teachers professional development. Computers & Education, 55(3), 1259–1269. https://doi.org/10.1016/j.compedu.2010.05.022
19. Lestari, S., & Santoso, A. (2019). The Roles of Digital Literacy, Technology Literacy, and Human Literacy to Encourage Work Readiness of Accounting Education Students in the Fourth Industrial Revolution Era. KnE Social Sciences, 3(11), 513. https://doi.org/10.18502/kss.v3i11.4031
20. Leutner, D., Fleischer, J., Grünkorn, J., & Klieme, E. (Eds.). (2017). Competence Assessment in Education. Springer International Publishing. https://doi.org/10.1007/978-3-319-50030-0
21. Lilian, A. (2022). Motivational beliefs, an important contrivance in elevating digital literacy among university students. Heliyon, 8(12), e11913. https://doi.org/10.1016/j.heliyon.2022.e11913
22. Marczyk, GR, DeMatteo, D., & Festinger, D. (2005). Essentials of research design and methodology. John Wiley & Sons.
23. McLester, S. (n.d.). Technology Literacy and the MySpace Generation. 7.
24. McLoughlin, E., & van Kampen, P. (Eds.). (2019). Concepts, Strategies and Models to Enhance Physics Teaching and Learning. Springer International Publishing. https://doi.org/10.1007/978-3-030-18137-6
25. Mishra, P., & Koehler, MJ (2006). Introducing Technological Pedagogical Content Knowledge. A Framework for Teacher Knowledge. *Teachers College Record*, *108*(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.
26. Nedeljko, Assist. M., Bogataj, Prof. Ddr. D., Perović, Assist. Prof. Dr. B. T., & Kaučič, Assist. Prof. Dr. B. M. (2022). Digital literacy during the coronavirus pandemic in older adults: Literature Review and Research Agenda. IFAC-PapersOnLine, 55(39), 153–158. https://doi.org/10.1016/j.ifacol.2022.12.027.
27. Nedeljko, Assist. M., Bogataj, Prof. Ddr. D., Perović, Assist. Prof. Dr. B. T., & Kaučič, Assist. Prof. Dr. B. M. (2022). Digital literacy during the coronavirus pandemic in older adults: Literature Review and Research Agenda. IFAC-PapersOnLine, 55(39), 153–158. https://doi.org/10.1016/j.ifacol.2022.12.027
28. Nilsson, P., & Loughran, J. (2012). Exploring the Development of Pre-Service Science Elementary Teachers' Pedagogical Content Knowledge. Journal of Science Teacher Education, 23(7), 699–721. https://doi.org/10.1007/s10972-011-9239-y
29. Polizzi, G. (2020). Digital literacy and the national curriculum for England: Learning from how the experts engage with and evaluate online content. Computers & Education, 152, 103859. https://doi.org/10.1016/j.compedu.2020.103859
30. Reddy, P., Chaudhary, K., & Hussein, S. (2023). A digital literacy model to narrow the digital literacy skills gap. Heliyon, 9(4), e14878. https://doi.org/10.1016/j.heliyon.2023.e14878
31. Su, Y. (2023). Delving into EFL teachers' digital literacy and professional identity in the pandemic era: Technological Pedagogical Content Knowledge (TPACK) framework. Heliyon, 9(6), e16361. https://doi.org/10.1016/j.heliyon.2023.e16361
32. Sailer, M., Stadler, M., Schultz-Pernice, F., Franke, U., Schöffmann, C., Paniotova, V., Husagic, L., & Fischer, F. (2021). Technology-related teaching skills and attitudes: Validation of a scenario-based self-assessment instrument for teachers. Computers in Human Behavior, 115, 106625. https://doi.org/10.1016/j.chb.2020.106625

33. Schroeder, S., Murray-Everett, NC, Gates, J., & Shear, SB (2021). Informing, transforming, inquiring: Approaches to elementary social studies in syllabi course methods. The Journal of Social Studies Research, 45(2), 102–117. https://doi.org/10.1016/j.jssr.2020.07.001
34. Secolsky, C. (2017). Handbook on Measurement, Assessment, and Evaluation in Higher Education (2nd ed.). Routledge. https://doi.org/10.4324/9781315709307
35. Simons, M., Meeus, W., & T'Sas, J. (2017). Measuring Media Literacy for Media Education: Development of a Questionnaire for Teachers' Competencies. Journal of Media Literacy Education, 9(1), 99–115. https://doi.org/10.23860/JMLE-2017-9-1-7
36. Tomczyk, L. (2021). Digital Literacy among Teachers – Mapping Theoretical Frameworks: TPACK, DigCompEdu, UNESCO, NETS-T, DigiLit Leicester. 10.
37. Triana, AJ, Gusdorf, RE, Shah, KP, & Horst, SN (2020). Technology Literacy as a Barrier to Telehealth During COVID-19. Telemedicine and E-Health, 26(9), 1118–1119. https://doi.org/10.1089/tmj.2020.0155
38. Wardana, L. W., Ahmad, Indrawati, A., Maula, F. I., Mahendra, A. M., Fatihin, M. K., Rahma, A., Nafisa, A. F., Putri, A. A., & Narmaditya, B. S. (2023). Do digital literacy and business sustainability matter for creative economy? The role of entrepreneurial attitude. Heliyon, 9(1), e12763. https://doi.org/10.1016/j.heliyon.2022.e12763
39. Yildiz Durak, H. (2021). Modeling of relations between K-12 teachers' TPACK levels and their technology integration self-efficacy, technology literacy levels, attitudes toward technology and usage objectives of social networks. Interactive Learning Environments, 29(7), 1136–1162. https://doi.org/10.1080/10494820.2019.1619591
40. Zahoor, N., Zopiatis, A., Adomako, S., & Lamprinakos, G. (2023). The micro-foundations of digitally transforming SMEs: How digital literacy and technology interact with managerial attributes. *Journal of Business Research*, *159*, 113755. https://doi.org/10.1016/j.jbusres.2023.113755.