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Abstract. Technology plays an important role in the world of education. The rapid development of technology requires the world of education to also adapt to these changes. Technological Pedagogical Content Knowledge (TPACK) is important in educational research and technology. TPACK shows the relationship between technological knowledge (T), pedagogy (P), and content, (C) and how this knowledge should be integrated into teaching practice. One of the technologies that teachers can use in learning mathematics is the GeoGebra Classroom. GeoGebra Classroom is a technology-based mathematics learning tool to help teachers integrate technology into learning mathematics. In its use, it combines technology, pedagogy, and content in one learning platform. In this context, improving the TPACK competency of mathematics teachers is very important to improve the quality of learning mathematics. GeoGebra Classroom is a learning platform that allows mathematics teachers to teach interactively using GeoGebra software. By using GeoGebra Classroom, they can create interesting and challenging learning activities for students, as well as integrate technology with appropriate content and learning methods. To improve the TPACK competence of Junior High School Mathematics Teachers in Magetan, we conducted training on using GeoGebra Classroom. The training participants consisted of 16 teachers. The training materials provided include junior high school mathematics material, the use of technology in learning mathematics, and the application of GeoGebra Classroom in learning mathematics The results of the study showed (1) there was an increase in the TPACK competence of mathematics teachers using the GeoGebra Classroom, (2) the positive response of mathematics teachers to the training provided, and (3) most mathematics teachers could integrate TPACK using GeoGebra classroom in their mathematics learning designs

Keywords: TPACK, Junior High School Mathematics Teachers, GeoGebra Classroom

INTRODUCTION

Mathematics is a subject that is considered difficult and frightening by many students. They often find it difficult to learn mathematics because there are too many formulas to learn. This is based on the fact that junior high school students often experience difficulties in understanding mathematical concepts, especially because there are many formulas and complicated ways to calculate them. In addition, the use of appropriate and effective educational technology has not been fully utilized by teachers in schools.

One of the technologies that teachers can use in learning mathematics is the GeoGebra Classroom. It is a technology-based mathematics learning tool to help teachers integrate technology into learning mathematics. In its use, it combines technology (T), pedagogy (P), and content (C) in one learning platform. By using GeoGebra Classroom, teachers can design learning activities that are more interactive and interesting for students. In addition, it also allows teachers to provide real-time feedback to students and monitor their learning progress.

Technological Pedagogical and Content Knowledge (TPACK) is a model used to measure teachers' ability to integrate technology into learning. Teachers who have TPACK competence are considered capable of teaching effectively by using technology as a learning tool. This is to the results of research conducted by Herizal, Nuraina, Rohantizani, and Marhami [1] and research conducted by Sintawati and Indriani [2] which concluded that TPACK is an important ability for prospective teachers, as future teachers especially in the era of society 5.0 and also as demand for 21st-century learning.

In the content knowledge aspect, the Merdeka Curriculum emphasizes a more creative and innovative pedagogical approach to teaching. Teachers must be able to design pleasant and interesting learning for students. The TPACK concept can assist teachers in integrating appropriate technology, content, and learning strategies in the mathematics learning process. By integrating pedagogical technology, such as GeoGebra Classroom, teachers can make learning activities more interactive and support a pleasant learning experience for students. The connection between TPACK and the Merdeka Curriculum shows that the use of pedagogical technology, such as the GeoGebra Classroom, can be an effective means of achieving the goals of the Merdeka Curriculum. In addition, the TPACK concept can assist teachers in developing more creative and innovative pedagogical approaches to teaching mathematics.

In this context, improving the TPACK competency of mathematics teachers is very important to improve the quality of learning mathematics in schools. GeoGebra classroom is a learning platform that allows mathematics teachers to teach interactively using GeoGebra software. By using the GeoGebra classroom, they can create interesting and challenging learning activities for students, as well as integrate technology with appropriate content and learning methods. Thus, it is hoped that students can more easily understand mathematical concepts and improve their learning achievement. Therefore, increasing the TPACK competency of mathematics teachers with GeoGebra Classroom in junior high schools is an important step in improving the quality of mathematics learning and producing students who are more competent in mathematics.

Based on the situation analysis above, the problem faced by mathematics junior high school teachers in Magetan is the lack of TPACK competence in learning mathematics. Understanding of the TPACK concept is still lacking in some mathematics teachers in Magetan. This makes it difficult for them to design and develop mathematics learning activities that use pedagogical technology, such as the GeoGebra classroom. In addition, mathematics teachers in Magetan have not received adequate training and assistance in developing their TPACK competencies. Thus, they still find it difficult to integrate educational technology into learning mathematics. This can be an obstacle to improving the quality of learning mathematics in junior high schools. Problems during the last pandemic can be used as momentum for teachers to try to strengthen the TPACK competencies needed in learning mathematics in the Merdeka curriculum.

Based on the problems above, researchers are interested in conducting research with the title: “Improving TPACK Competencies of Junior High School Mathematics Teachers Using GeoGebra Classroom” which aims to describe (1) how the increase of TPACK competence of Junior high School teachers in Magetan using the GeoGebra classroom (2) what is the teacher's response to the training of improving their TPACK competence using the GeoGebra classroom, (3) how is their mathematics learning design in using the GeoGebra classroom.

Based on the problems described, the given solution to solve this problem is to implement TPACK Mathematics Teacher mentoring and training using GeoGebra Classroom to assist teachers in using technology in learning mathematics. The activity begins with a presentation of material related to TPACK which consists of 7 components

that must be possessed by teachers, namely Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), and TPACK. The next activity is teacher practice related to learning using GeoGebra Classroom.

Much research has also been done on TPACK, such as research conducted by Restiana [3] with the title TPACK profile evaluation for junior high school mathematics teachers in Banten which shows that teachers only master one component of TPACK, namely content knowledge, which means that teachers still do not master other components in TPACK, especially those related to learning technology components. research conducted by Yurinda and Widyasari [4] entitled Analysis of Technological Pedagogical Content Knowledge (TPACK) of Professional Teachers in Learning Mathematics in Elementary Schools shows that teachers are accustomed to using technology in learning mathematics, especially during the demands of a pandemic. Based on the results of this study it can be concluded that teachers need to know, understand, and apply learning with the help of technology.

METHOD

This is descriptive research, with one group pretest and posttest design. The research subjects consisted of sixteen junior high school mathematics teachers in Magetan City. The research instruments are (1) pretest and posttest sheets, (2) teacher's response questionnaire sheet, and (3) learning device assessment sheet. The training materials used in this research are (1) the GeoGebra classroom module, (2) the Circle Concept and its Application, and (3) Technology in Mathematics learning.

In general, the activities of training that will be carried out can be described as follows: (1) Giving a Pretest, (2) Presentation of material of the circle concept and its Application, (3) Presentation of material of technology in Mathematics learning, (4) Introducing GeoGebra classroom content, (5) Workshop on using GeoGebra Classroom in designing learning devices (6) Giving Posttest and response questionnaire, and (6) Giving homework to design learning devices that use GeoGebra Classroom (7) Presenting the results of homework that have been made by the teachers in groups.

The data collection method used in this research is the test and the questionnaire methods. To analyze the test results, the t-test was used to see whether there was a significant increase between the pretest and post-test results. If there is an increase, then it is determined how much the increase is in the pretest to the posttest. Besides that, the results of the research were also analyzed using the N-gain. The increase in test results is said to be successful if the N-gain is greater than or equal to 0.3. To analyze the results of the questionnaire, quantitative descriptive analysis was used by calculating how much the teachers responded positively to this training. To analyze the results of homework, we pay attention to whether or not it involves the use of GeoGebra Classroom in the learning device, as well as whether the use of GeoGebra Classroom with the learning design that is made.

RESEARCH RESULTS AND DATA ANALYSIS

Pretest and Posttest Result

The Pretest and Posttest Results of Junior High School Math Teachers are summarized in Table 1 as follows.

TABLE 1. Pretest and Posttest Results of Junior High School Math Teachers

No.	Initial Name	Pretest Score (= X_1)	Posttest Score) (= X_2)	$X_2 - X_1$ (= d)	d^2
1	DMD	64	75	11	121
2	SMN	52	80	28	784
3	TYK	65	85	20	400
4	FMY	47	77	30	900
5	PMD	55	72	17	289
6	NDN	72	80	8	64
7	RDA	60	74	14	196
8	HUP	53	89	36	1296

No.	Initial Name	Pretest Score (= X_1)	Posttest Score) (= X_2)	$X_2 - X_1$ (= d)	d^2
9	WMR	75	90	15	225
10	JYT	50	70	20	400
11	PMB	65	85	20	400
12	UYY	45	95	50	2500
13	RSW	70	85	15	225
14	TSW	60	75	15	225
15	TEV	50	98	48	2304
16	YDK	70	90	20	400
Total		953	1320	367	10729
Mean		59.5625	82.5	22.9375	

Based on the data above, the value of the standard deviation S_d = 12.50 can be calculated. Further, the t value can be calculated as follows.

$$t = \frac{\bar{d}}{\frac{s_d}{\sqrt{n}}} = \frac{22.9375}{\frac{12.50}{4}} = 7.34, \text{ whereas } t_{(0,01,\ 15)} = 2.946713$$

Because of t $t_{(0,01,\ 15)}$, it can be stated that there is an increase in the TPACK competence of junior high school Mathematics teachers in Magetan City using the GeoGebra classroom.

the n-gain value is calculated as follows. gain = $\frac{(X_{posttest} - X_{pretest})}{(X_{ideal} - X_{pretest})} = \frac{(81.8125 - 62.625)}{(100 - 62.625} = 0.513378$

Since 0.3 ≤ N-gain ≤ 0.7, it means that the increase in TPACK competency of junior high school in Magetan is in the moderate category.

Teacher Response Questionnaire Results

The results of the teacher's response questionnaire were analyzed by giving an assessment score to each student teacher's response to each questionnaire item given. Based on the results of the questionnaire, it was determined whether the teacher's response included a positive or negative response. In addition, the researcher also described the impressions and suggestions given by the teachers participating in the training.

The results of the teacher's response questionnaire to the implementation of the training "Strengthening the competence of TPACK teachers using GeoGebra Classroom" can be presented in the following table.

TABLE 2. Percentage of the Mathematics Teachers' Response

	Teacher response questionnaire statements	TDA	DA	A	SA	Response categories
1.	Instructors master the training material.	0	0	0	100	positive
2.	The training atmosphere is boring	50	50	0	0	positive
3.	The training material is presented clearly.	0	0	30	70	positive
4.	Interesting training material to be used in the process of learning mathematics.	0	0	0	100	positive
5.	This training does NOT increase my math knowledge.	0	0	40	60	positive
6.	Resource instructors LESS responding to participant questions well.	0	0	40	60	positive
7.	This training improves my understanding of using technology.	0	0	20	80	positive
8.	Presentation of learning technology material is difficult to understand	30	70	0	0	positive
9.	Using GeoGebra Classroom makes it easier for me to plan lessons.	0	0	40	60	positive
10.	The delivery time for training materials is too short.	0	0	80	20	positive

	Teacher response questionnaire statements	TDA	DA	A	SA	Response categories
11.	I am NOT interested in taking up this kind of training again.	0	0	40	60	positive

Note: DA: Disagree, TDA: Totally Disagree, A: Agree, SA: Strongly Agree

The teachers' impression of the training that has been carried out can be stated as follows.

1 Very interesting, and adds motivation to continue learning
2 This training refreshed my memories regarding geometry and GeoGebra, and I understood more
3 The training is very interesting and inspires me to learn more so that I can make and plan lessons for children
4 This training is very useful because it adds to my knowledge of mathematics learning technology.
5 I am very happy to ask for more training in the geometry and GeoGebra chapters, more time.
6 Very interesting and this training can be further developed in learning
7 Alhamdulillah very inspiring spirit and provides insight. The source is very interesting
8 Training is Great Fun
9 The resource person is fun, enjoys participating in the training
10 GeoGebra Classroom material is interesting to learn and try on students

Teacher criticism/suggestions for the training that has been carried out, can be stated as follows.

1. Can be more duration of time to study
2. Please extend the training time, so that you can absorb more knowledge from the resource person/speaker.
3. Held another training
4. Time is very short, time can be added

Results of Teacher Performance in Designing Learning

Based on the results of the teacher's performance in designing group learning which they were uploaded on the given Google Drive, it can be stated that 100% of teachers can use GeoGebra Classroom in the learning tools that are made, and the use of GeoGebra Classroom is by the learning design that is made. The following provides links to some examples of teacher performance results in designing learning device components using GeoGebra Classroom.

1. https://www.geogebra.org/classroom/m5ga6qjf
2. https://www.geogebra.org/classroom/qbrq5mz8
3. http://www.geogebra.org/classroom/kvdbpazr
4. https://www.geogebra.org/m/zwgf7mfn

Based on all the results of data analysis that researchers have done, it can be stated that training on TPACK competence of junior high school Mathematics teachers using GeoGebra Classroom has a positive impact on increasing teacher TPACK competence in teaching mathematics. The teachers involved in this training have better knowledge and skills in integrating technology effectively in teaching, which in turn is expected to improve student learning outcomes. This research provides empirical support for the importance of proper TPACK training in the context of using educational technology such as the GeoGebra Classroom.

RESEARCH RESULTS AND DATA ANALYSIS

The results of this research are in line with the results of research conducted by Cerenus Pfeiffer [5] with the title "A Study of the Development of Mathematical Knowledge in A GeoGebra-Focused Learning Environment" and obtained research results that teachers had more motivation on how GeoGebra could be used as a pedagogical tool. The qualitative and quantitative results also revealed that GeoGebra allowed teachers to better teach and learn functions, circle geometry, and general solutions of trigonometric equations. The qualitative content analysis of pre- and post-tests for both transformations of functions and circle geometry showed that teachers moved to better competence

This is also in line with the research on the effects of training using the GeoGebra Classroom on teachers' TPACK competence in teaching mathematics. In the study, he compared the knowledge and skills of TPACK teachers before

and after training. The results showed that there was a significant increase in teachers' TPACK competence after attending training with GeoGebra Classroom. Before the training, the majority of teachers experienced challenges in integrating technology into mathematics learning and felt a lack of confidence in using digital tools. However, after attending the training, the teachers better understood how to integrate GeoGebra Classroom into their learning. The competency of TPACK teachers is increasing in several key aspects, including:

1. Content Knowledge (CK): Teachers demonstrated a deeper understanding of the math concepts being taught and were able to identify the most appropriate concepts to illustrate through the GeoGebra Classroom tool.
2. Pedagogical Knowledge (PK): After the training, teachers are more skilled at designing engaging and interactive learning activities using GeoGebra Classroom, which encourages student participation and critical thinking.
3. Technology Knowledge (TK): Teachers gain an understanding of how to use GeoGebra Classroom features and tools to support mathematics teaching and create effective visual models.
4. Technology Pedagogy and Content Knowledge (TPACK): Teachers improve their skills in integrating knowledge, pedagogical, and technological content to create more in-depth and meaningful mathematics learning experiences.

The results of this study are also in line with research conducted by Bhagat, Chang, and Huang [6], with the title Integrating GeoGebra with TPACK in Improving Pre-Service Mathematics Teachers' Professional Development, and obtained research results that there were changes in teachers' TPACK after undergoing the GeoGebra workshop. Practical implications are discussed regarding how to enhance teachers' pre-service TPACK using GeoGebra in mathematics teaching.

CONCLUSION

Based on the results of the data analysis that has been done, it can be concluded that:

1. The TPACK competency of junior high school teachers in Magetan using the GeoGebra class is increasing, with a moderate increase in category
2. The teachers' response to the training of improving their TPACK competence using the GeoGebra classroom is positive.
3. All mathematics teachers can use GeoGebra Classroom in designing mathematics learning tools.

RECOMMENDATION

For Researchers who will carry out further research which:

1. Use more sophisticated performance measurement methods to assess the improvement in TPACK competency of Junior High School Mathematics teachers after training. For example, involving more intensive classroom observation and valid assessment tools.
2. Conduct in-depth case studies on teachers who have effectively integrated GeoGebra Classroom in their classrooms. This can provide more detailed insight into how the training impacts students' learning and understanding of mathematics.
3. As well as looking at improving teacher TPACK competence, research has also focused on the impact of using GeoGebra Classroom on student learning outcomes, such as increased academic achievement and interest in mathematics.
4. Should examine the inhibiting factors that teachers may face in integrating GeoGebra Classroom in mathematics learning, this is done to help design more effective training.
5. Conduct research for a longer period to observe the sustainability of improving teacher TPACK competencies and their impact on sustainable teaching practices.
6. It should investigate the comparison of the effectiveness of training using GeoGebra Classroom with other training methods in increasing the TPACK competence of Middle School Mathematics teachers.

REFERENCES

1. Herizal, Nuraina, Rohantizani, Marhami (2022) *Profil TPACK Mahasiswa Calon GuruMatematika dalam Menyongsong Pembelajaran Abad 21*. Jurnal Ilmu Sosial danPendidikan (JISIP) Vol. 6, No. 1 .Program Studi Pendidikan Matematika, Universitas Malikussaleh.
2. Sintawati, Mukti dan Indriani, Fitri. (2019). *Pentingnya Technological Pedagogical Content Knowledge (TPACK) Guru di Era Revolusi Industri 4.0*. Prosiding Seminar Nasional Pagelaran Pendidikan Dasar Nasional (PPDN). Universitas Ahmad Dahlan.
3. Ristiana, Nena. (2018). Evaluasi profil TPACK untuk guru matematika sekolah menengah pertama di Banten. Jurnal Penelitian Pendidikan, 8 (1). 16. Program Pascasarjana Pendidikan Matematika, Universitas Sultan Ageng Tirtayasa
4. Yurinda, B., & Widyasari, N. (2022). Analisis Technological Pedagogical and Content Knowledge (TPACK) Guru Profesional dalam Pembelajaran Matematika di Sekolah Dasar. Jurnal Pendidikan Matematika, 8 (1), 47–59. https://doi.org/10.24853/fbc.8.1.47-60
5. Cerenus Pfeiffer (2017), "A Study of the Development of Mathematical Knowledge in A GeoGebra-Focused Learning Environment"
6. Bhagat, K. K., Chang, C. Y., & Huang, R. (2017). Integrating GeoGebra with TPACK in Improving Pre-Service Mathematics Teachers' Professional Development. 於 R. Huang, R. Vasiu, Kinshuk, D. G. Sampson, N-S. Chen, & M. Chang (編輯), Proceedings - IEEE 17th International Conference on Advanced Learning Technologies, ICALT 2017 (頁 313-314). Article 8001791 (Proceedings - IEEE 17th International Conference on Advanced Learning Technologies, ICALT 2017). Institute of Electrical and Electronics Engineers Inc.. https://doi.org/10.1109/ICALT.2017.9