

## The Effect of TPACK-Based Learning Using Avenza Maps on Student Learning Activities in Mapping Materials

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### ABSTRACT

While studying geography, students work to develop a theoretical grasp of the subject as well as practical skills in spatial reasoning and analysis through hands-on experience with real-world phenomena. There has been little use of GIS technology in Indonesian geography classes, despite its widespread accessibility. This research examines the deployment of TPACK-based learning in mapping materials using the Avenza Maps program and its influence on student learning activities. Proposive sampling was used to choose XE-7 pupils from Senior High School 13 Semarang as part of the descriptive quantitative methodology. We used descriptive and inferential statistics to examine the link and its effects based on data gathered through structured observation, surveys, and documentation. The findings show that, overall, students' learning activities, instructors' TPACK-based techniques, and the use of Avenza Maps are all excellent. Specifically in the areas of visual, motor, and emotional processing, as well as oral skills that need reinforcement, students' engagement levels rose from 73.33% to 75% between the first and second sessions, according to observations. Strong positive correlations among TPACK competency, Avenza Maps use, and student engagement are shown by Pearson correlation ( $r=0.894, 0.888, 0.771$ ;  $p<0.01$ ). Multiple regression also demonstrates that TPACK and Avenza Maps have substantial beneficial impacts. These factors account for 89.7 percent of the variation in student activity, as indicated by the coefficient of determination ( $R^2 = 0.897$ ). The results of this research show that a smart way to encourage active, practical, and student-centered geography learning is for instructors to combine their TPACK expertise with effective use of geospatial technology.

### INTRODUCTION

Learning can be defined as a facilitative process, organized by educators, that creates conditions enabling learners to acquire knowledge and understanding, develop skills, and cultivate attitudes and belief systems in a structured and continuous manner (Djamaluddin et al., 2019). Efforts to enhance the quality of education in the 21st century have led to a number of strategic innovations, one of which is a rethinking of the framework for developing curricula that incorporates ICT and the TPACK method (Hayani & Utama, 2022). Despite the availability of geospatial.

However, its use of this technology in geography education remains low, and there is a dearth of research and academic papers on its deployment in Indonesia. The situation is in stark contrast to the methods used in nations where geospatial technology is widely employed to help pupils grasp spatial concepts (Khairurraziq, 2024).

TPACK is a framework of educational education that integrates understanding across seven interrelated components of subject-matter knowledge within a specific educational context (Purwaningtyas et al., 2024). Students' many senses may be stimulated by the use of technology in the

classroom, thereby allowing instruction to accommodate the diversity of individual characteristics and preferences, including varying learning styles aligned with each learner's tendencies and inclinations (Tekege, 2017). Through TPACK-based instruction, technology is not merely a supporting tool; rather, it serves as a medium that greatly promotes interactive learning, increases engagement, and offers considerable learning opportunities. The use of application-based digital learning materials is one example of technology integration anchored in the TPACK framework (Azizah et al., 2022).

The implementation of interactive learning media within the framework of Geography instruction facilitates students' understanding more effectively. It supports educators in delivering instructional content, thereby enabling the learning process to take place more engagingly and effectively (Suharini & Kurniawan, 2020). Eighty-6.2 percent of eighth graders at SMA Negeri 13 Semarang agreed or strongly agreed that classroom instruction should make use of technological tools to pique students' interests and foster critical thinking. Based on the results and the kids' reactions, it's evident that technology has to be a part of the classroom experience. One of the main goals of media-based digital learning is to provide students with greater agency by teaching them to make effective use of digital resources, such as cellphones and the internet (Juhadi et al., 2021). Teachers rely on media as a primary channel for disseminating lesson plans, student work, and other learning messages to their pupils (Jayusman & Shavab, 2020). Knowledge, theoretical understanding, and a variety of geographical abilities are essential components of a modern geography curriculum (Silviariza et al., 2021). A significant majority of students (72.4%) would prefer to learn about mapping through hands-on activities, and an even larger percentage (86.2%) would benefit from media that explains how to make and analyze maps. The results show that students are eager to learn about

geography in ways that are both relevant and technologically advanced.

Because a wide variety of learning materials is accessible, learning activities aim to cultivate knowledge, competence, and optimism across diverse contexts (Hayati & Fauzi, 2023). The Avenza Maps app is a technology-based learning medium that shows great promise for use in high school seniors' Geography classes. This program, created by Avenza Systems Inc., includes a digital mapping tool that can be used offline. It has unique characteristics that make it a good tool to supplement learning activities. It provides several features that make GPS on mobile devices easier to use (Supriyanto & Effendi, 2020). The implementation of instructional strategies in Geography is not confined solely to classroom activities; rather, it can also be developed through fieldwork or outdoor-based learning (outdoor study). In order for students to become sensitive to the physical and cultural environments that make up the subjects of geographical inquiry, they must participate in activities like these (Subhani et al., 2024).

To make sure that learning isn't only theoretical but also applied and contextual, students may use the Avenza Maps app to evaluate digital maps while they're at the observation location. Students can easily find their location on the map, measure distances between points, and compute the area of a given spot using the program's GPS tools. Furthermore, they can annotate key areas, document information, and monitor routes during field operations (Priambodo et al., 2023). In addition, students may gain a better grasp of how maps relate to real-world contexts by using Avenza Maps to explore georeferenced satellite or aerial imagery. In addition to honing their skills in making direct observations of geographical occurrences, these exercises help students recognize key map features such as symbols, scale, coordinates, and orientation.

Additionally, students may use Avenza Maps to access georeferenced satellite imagery or aerial photos, which help them understand how maps relate to real-world field settings. With the app's offline

functionality, this exercise helps students practice recognizing key map features, including symbols, scale, coordinates, and orientation. It also improves their observational skills for geographical occurrences. Plus, 75% of students said they were interested in learning more about using the Avenza Maps app. Regarding students' interest in and preparedness to use geospatial technology for mapping education, the survey findings are encouraging. By combining the development of students' conceptual knowledge with the enhancement of their actual abilities in geographic mapping activities, the Avenza Maps application shows great promise as an effective tool.

When it comes to teaching geography, maps play a key role as a medium. By connecting geographical data with social and ecological variables in the field, maps not only help to visualize abstract ideas but also give tangible learning experiences. Thematic maps, which group data into predetermined categories such as population, climate, or economic activity, can be very useful in the classroom (Ikhsan et al., 2025). There is great potential for Geographic Information System (GIS) applications to serve as instructional media, enhancing teachers' performance throughout the learning process and helping students attain curriculum-based skills. The goal of incorporating geographic information systems (GIS) into the classroom is to provide students with more engaging, relevant, and authentic learning experiences that will improve their motivation and retention of course material. However, to date, the implementation of GIS by educators has not been optimized (Subhani et al., 2024).

One way it is put into practice is through a mapping exercise in which students complete a task on the placement of TPSs near schools. They are instructed to gather the exact coordinates of the TPSs. Enter them into Avenza Maps, and it uses this data to create a data-driven thematic map. Students may enhance their understanding of geographical and regional concepts through a Project-Based Learning

(PBL) approach that encourages autonomous investigation of geospatial data (Santoso et al., 2025).

In addition to teaching students how to use digital mapping tools, these lessons enhance their critical understanding of local and environmental challenges (Nwedu, 2018). For pupils to develop a sense of environmental consciousness and accountability, geography classes are essential. Students are taught to appreciate the interconnectedness of all things natural and human through the study of geography, which also helps them identify how different human behaviors affect the environment (Sriyani et al., 2025). In teaching geography through practical examples. There is considerable room to improve student. Preliminary observations with the Geography instructor at SMAN 13 Semarang revealed that geospatial technology, such as Avenza Maps, has never been used in class, particularly in the mapping section. However, studies Harmelya et al., (2024) indicate that the use of geospatial technology applications as instructional media has not yet been implemented in Geography, with reliance on teachers instead. The majority of students are also not accustomed to using such applications or integrating them into learning activities.

This initiative supports goal 4 (Quality Education) because it encourages creative and interactive learning; Goal 9 (Industry, Innovation, and Infrastructure) is helped along by the use of geospatial technology; and Goal 11 (Sustainable Cities and Communities) is helped along by the improvement of students' spatial awareness in relation to environmental problems and planning for their future. Under these conditions, there is a strong opportunity to introduce new ways of teaching that make use of geospatial technology, giving students the chance to study in ways that are relevant to the real world.

Previous studies, including Putra et al., (2021), indicate that, according to geography educators in Tulungagung Regency, the TPACK model places a premium on educators' ability to skillfully

combine pedagogical, material, and technological aspects in the classroom. In the context of Geography education, which encompasses managing subject content, applying complex spatial, environmental, and regional approaches, and developing geospatial skills, the implementation of TPACK as an effective strategy for addressing the challenges of 21st-century learning (Purwaningtyas et al., 2024). Additionally, research by (Listiqowati, 2024) argues that teaching methods that use TPACK with geographic apps like Avenza Maps may help students strengthen their spatial comprehension. Rahmadi, (2019) shown that students are more engaged and have a better grasp of cartographic topics, such as map symbols, when geospatial technology is used in the classroom to teach cartography.

Based on the results, it seems that an instructional method that incorporates the TPACK framework and geographic software such as Avenza Maps may help students improve their spatial awareness. Multiple studies have shown that the TPACK framework, which stands for Technological Pedagogical Content Knowledge, holds great promise for enhancing geography education by integrating technical, pedagogical, and content knowledge. Research on the effects of digital media on student learning has mostly focused on three areas: instructors' views of TPACK, teachers' preparedness to use technology, and the effects of digital media use in general. However, most of these studies have examined technology only in theoretical terms, not in terms of its actual use in the classroom. Most of the existing literature on GIS uses a broad definition of the word without connecting it to the TPACK model.

The Avenza Maps application, as a geospatial learning medium, has considerable potential; however, it has not been systematically examined in the context of TPACK integration, particularly in mapping instruction at the senior high school level. Previous studies have not comprehensively analyzed how integrating TPACK, supported by Avenza Maps, may

influence students' learning activities, including engagement, participation, and field-based, application-oriented learning experiences. This limitation indicates a research gap that needs to be addressed through more focused empirical investigation.

This research aims to address that gap by investigating the impact of using Avenza Maps to enhance TPACK-based teaching in mapping materials on the learning activities of Xth graders at SMA Negeri 13 Semarang. Not only does the study contribute to the growing body of literature on how best to use TPACK and geospatial technology in secondary-level Geography curricula, but it also helps shape new, more contextual approaches to teaching the subject. In light of the above, the purpose of this research is to examine how students in Grade X at SMA Negeri 13 Semarang learn using the TPACK framework and Avenza Maps as a teaching tool. More realistic, tech-based, and repeatable Geography pedagogical approaches are anticipated to be advanced by the results.

## RESEARCH METHODS

### Research Location & Design

Jalan Rowo Semanding, Wonolopo Village, Mijen District, Semarang City, Central Java Province, is the location of State Senior High School 13 Semarang, where the research took place. Approximately 7°03'01" South Latitude and 110°18'42" East Longitude are the coordinates at which the school is situated. Figure 2 displays a map of the study site (Figure 2).

Using the Avenza Maps app and mapping materials as a foundation, this study employed a descriptive quantitative approach to objectively describe the planning, implementation, and contribution of TPACK-based learning to students' learning activities. We opted for the descriptive quantitative method because its systematic, organized measurement of variables makes it well-suited to studying learning processes in the field (Sugiyono, 2023).

Lesson preparation, learning implementation, and assessment were the

three primary steps of the study design, as shown in the research flow diagram. During the design stage, the researcher developed research instruments, an e-book on using Avenza Maps, and learning materials based on TPACK. Both in-class and out-of-class

learning activities were part of the implementation phase, and students' progress was assessed using descriptive quantitative analysis during the assessment phase. Figure 1 shows the research flow.

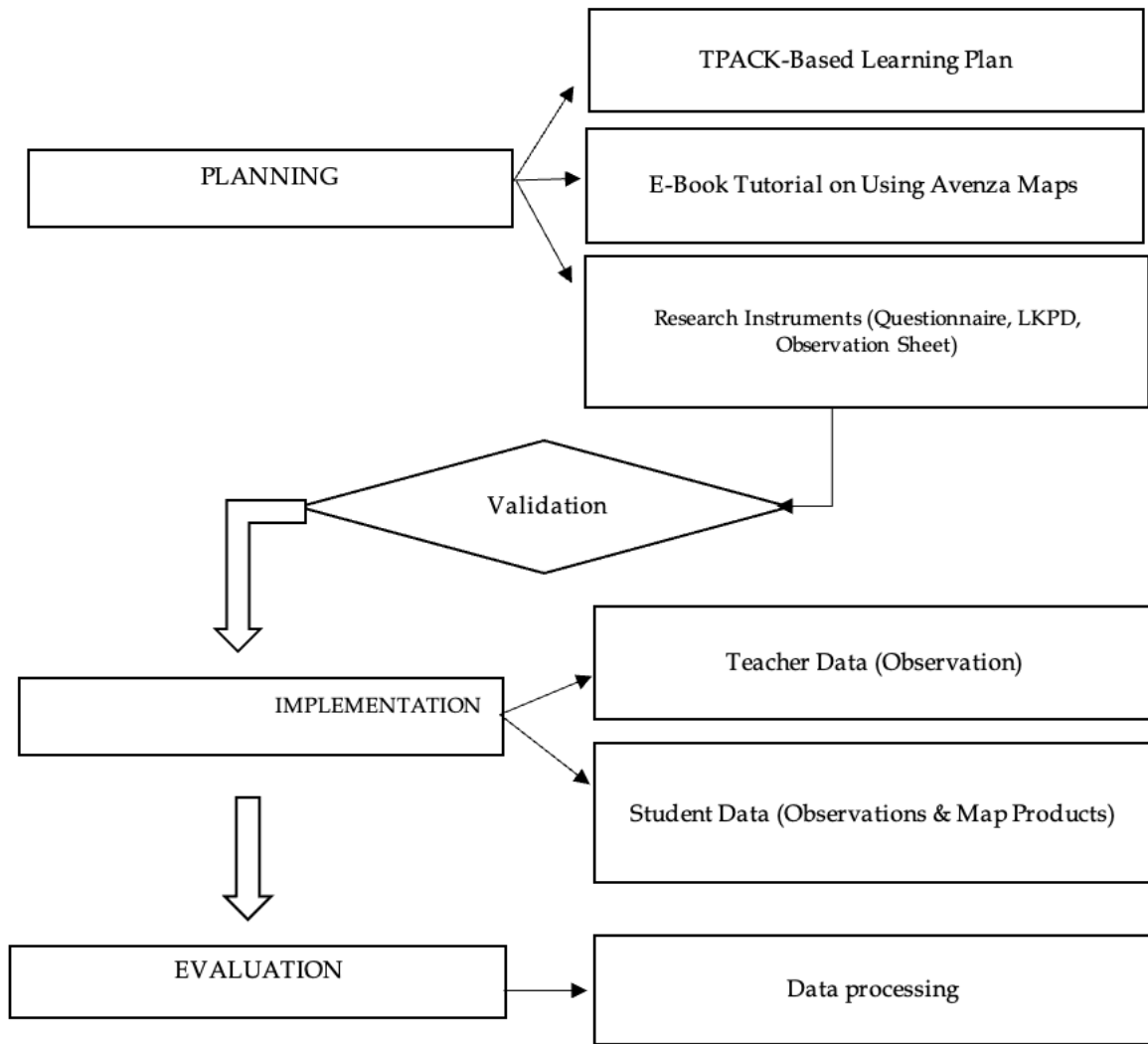


Figure 1. Research flow (Source: Research Results, 2025)

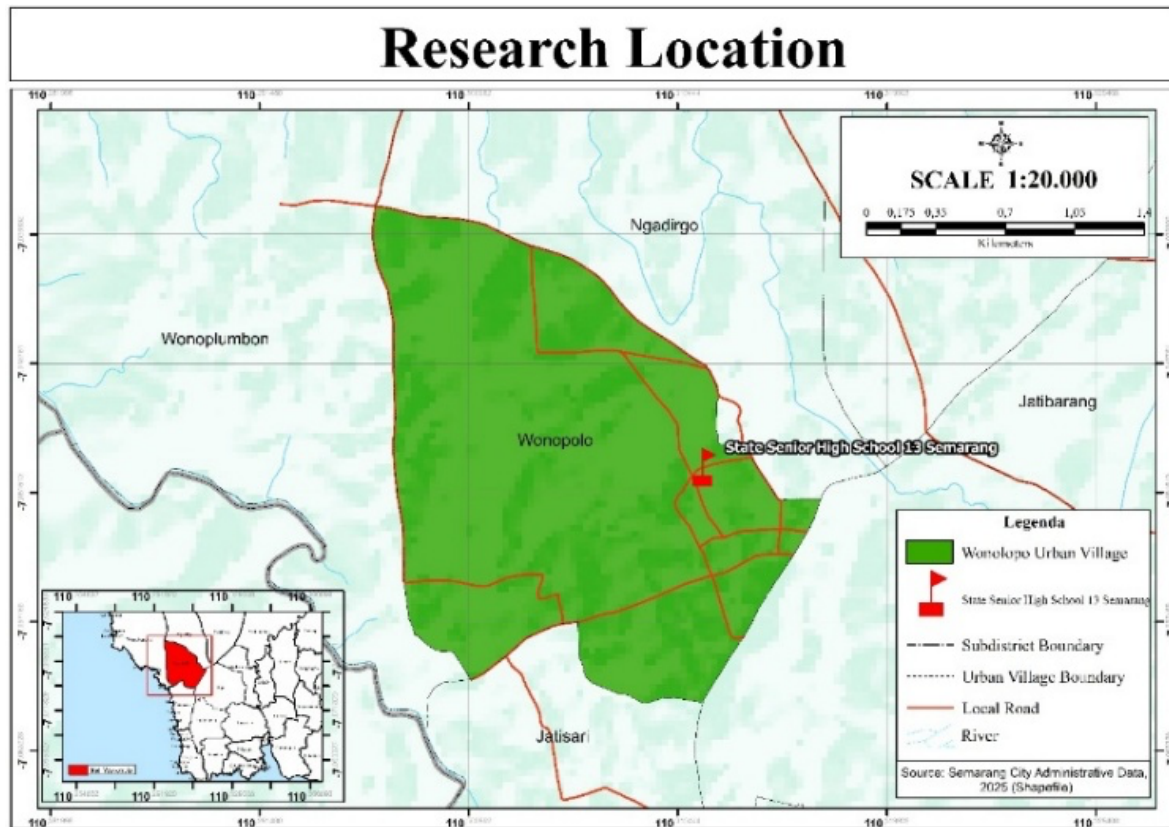


Figure 2. Research location (Source: Research Results, 2025)

### Participants

The study population comprised 288 tenth-grade students at Senior High School 13, Semarang. The tenth grade was selected because the geography curriculum at this level includes mapping-related topics that are highly relevant to implementing technology-integrated learning. Given the research objectives, purposive sampling was employed to select participants. This sampling technique allows researchers to select participants based on specific criteria aligned with the study's needs (Sugiyono, 2023).

Based on these considerations, class XE-7 was selected as the research sample following consultation with the geography teacher. The selection of this class was guided by several pedagogical and methodological considerations, including relatively consistent student attendance, stable classroom participation, and students' readiness to engage in technology-assisted learning. Class XE-7 consisted of 36 students, and more than 90% of them had smartphones capable of running the Avenza Maps application, making the class well-

suitable for implementing technology-integrated learning activities. These characteristics were considered essential for implementing TPACK-based learning with the Avenza Maps application, which requires students to actively interact with digital mapping tools throughout the learning process.

In addition, the tenth-grade classes at Senior High School 13 Semarang follow the same curriculum framework and learning objectives, indicating a relatively homogeneous academic context across classes. Therefore, class XE-7 was considered suitable to represent the characteristics of the tenth-grade cohort in examining students' learning activities during the implementation of TPACK-based geography instruction. The use of a single intact class also enabled the researcher to maintain consistency in instructional delivery and classroom conditions during the intervention, thereby reducing the influence of external variables that might affect the observation of students' learning activities.

### Validity & Reliability

Instrument validity was assessed using the Exploratory Factor Analysis (EFA) approach, based on the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test of

Sphericity, which serve to evaluate sample adequacy and to confirm that the correlation patterns among variables satisfy the assumptions required for factor extraction.

Table 1. KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.646
Bartlett's Test of Sphericity	Approx. Chi-Square	1074.764
	df	300
	Sig.	.000

(Source: Research Results, 2025)

According to the research findings, the KMO value was 0.646. The sample size and the pattern of correlations among indicators were adequate for factor extraction, as these values exceeded the minimum criterion for factor analysis adequacy (0.50). In addition, with 300 degrees of freedom (df) and a significance level of 0.000 ( $p < 0.05$ ), Bartlett's Test of Sphericity revealed an Approximate Chi-Square value of 1074.764. According to this statistically significant finding, there is a large difference between the identity matrix and the correlation matrix. Thus, there are enough correlations between the items, and the data may be used for further component analysis.

Factor loadings for all indicators were more than 0.70, according to the Rotated Factor Matrix. The indicators of the TPACK variable (X1.1-X1.8) consistently loaded onto a single factor. A similar pattern was observed for the Avenza Maps indicators (X2.1-X2.8) and the Student Activities indicators (Y1-Y9), each clustering according to their respective theoretical constructs. The high factor loadings indicate that each indicator has strong representational power in explaining the latent construct being measured. Based on these findings, all instrument items are considered construct-valid and appropriate for use in data collection.

### Data Collection and Instrument

Methods such as documentation, surveys, and direct observation were used to gather data for this research. Using the Avenza Maps app and TPACK-based

geography instruction, these three methods compiled detailed information on students' learning activities and the mapping content they used.

Structured observation was employed in this study, in which the researcher used professionally verified equipment to conduct observations. To make sure the learning was executed according to the plan, observers were kept on hand throughout the procedure.

Student observation sheets and instructor observation sheets were the two kinds of equipment used for observation. While using the Avenza Maps app for TPACK-based learning, students' learning activities were evaluated directly using the student observation sheet. A checklist that reflected student engagement in the mapping learning process was used to develop learning activity indicators. At the same time, the instructor used the observation sheet to document the learning process, specifically noting whether the material mapping was appropriate for integrating technical, pedagogical, and content elements in line with TPACK guidelines.

After engaging in TPACK-based geography instruction with the Avenza Maps app, students' learning activities were assessed with a questionnaire. The purpose of the 25-item student questionnaire was to gather data on how Avenza Maps impacted various aspects of students' educational experiences.

To ensure that students' answers were both objective and grounded in their

learning experiences, the questionnaire was distributed after the learning activity was completed. Using a four-point Likert scale, the questionnaire collected feedback on several facets of student learning activities related to technology-based mapping.

The data collected via observation and questionnaires were supplemented with documentation. The documentation included a wide range of topics, including images from learning activities, student work in the Avenza Maps app, digital maps

made by students, group activity recordings, and administrative comments on the program's implementation.

As a form of data triangulation, the documentation provided visual evidence and archives pertinent to the learning process under study, bolstering the validity of the research conclusions. The reliability test was conducted by measuring the internal consistency of items for each variable using Cronbach's Alpha coefficient. The results are shown below.

Table 2. Reliability Test Results

Reliability Statistics		
Indicator	Cronbach's Alpha	N of Items
TPACK	.963	8
Avenza Maps	.959	8
Student's Activities	.973	9

(Source: Research Results, 2025)

With a Cronbach's Alpha of 0.963 over all eight elements, the TPACK variable is very reliable. All items demonstrated high explanatory power in reflecting the TPACK construct, as shown by the Corrected Item-Total Correlation values ranging from 0.810 to 0.898. Furthermore, all items maintained high Cronbach's Alpha values if Item Deleted, suggesting that overall dependability was unaffected. There is significant internal consistency in the TPACK instrument, which means it is quite trustworthy.

Avenza Maps' eight-item instrument had a Cronbach's Alpha of 0.959. The item-total correlation coefficients for all indicators ranged from 0.808 to 0.887. This range reflects high internal consistency among items in representing students' ability to operate digital mapping applications. Accordingly, the Avenza Maps instrument is classified as highly reliable. The Student Activities variable achieved a Cronbach's Alpha of 0.973, the highest among the three variables. The nine items demonstrated item-total correlation values ranging from 0.807 to 0.908. This very strong internal consistency indicates that all indicators effectively and consistently capture students' engagement and learning dynamics. Thus, all items within the Student

Activities variable are considered highly reliable. The reliability analysis demonstrates that all three research instruments exhibit a very high degree of internal consistency, indicating that they are stable and appropriate for use in subsequent statistical analyses.

### Data Analysis

In this study, descriptive and inferential analyses were two of the steps used to analyze the data in line with the research goals. Through it all, we hoped to uncover how Avenza Maps media impacted student learning activities in geography classes and how instructors' TPACK competency correlated with those outcomes.

Teacher TPACK Competence, Avenza Maps Media Use, and Student Learning Activities were all studied using descriptive analysis to reveal overarching tendencies. Tables were used to systematically display the data extracted from observation sheets and surveys as percentages of accomplishment. The purpose of this study is to determine how well instructors have mastered TPACK, how often and how intensely they use Avenza Maps in their lessons, and how actively students participate in their own learning. To understand the performance level for each

variable, the results of the percentage calculations were then categorized according to the evaluation criteria.

The data underwent a prerequisite analytical test before inferential analysis. To ensure that the residual data were normally distributed and met the assumptions for parametric statistical analysis, a normality test was conducted. Furthermore, the degree of association between the independent variables – specifically, teachers' TPACK competency and their use of Avenza maps – was assessed using a multicollinearity test. The residual variance was assessed for homogeneity using a heteroscedasticity test, and the relationship between the independent and dependent variables was assessed for linearity using a linearity test.

Following the fulfillment of all presumptions, the direction and strength of the association between each independent variable and the dependent variable were determined using Pearson's correlation analysis. Before being validated in a regression model, this research provides a preliminary picture of the association between teachers' TPACK competency and the use of Avenza maps in student learning activities.

Teacher TPACK Competence and Avenza Maps Media Utilization were examined using multiple linear regression to determine their impact on student learning activities, both separately and in combination. To test for significance, we used the t-test to assess the impact of each

independent variable separately and the F-test to assess the combined impact of the two. To analyze differences between study sample groups and discover associations between the investigated variables, inferential analyses were conducted using t-tests and Pearson correlations (Hayati et al., 2022). The 0.05 significance level was used for all tests.

To determine how much of the variance in Student Learning Activities was explained by Teacher TPACK Competence and Avenza Maps Media Utilization, we used the coefficient of determination. For regression models with several independent variables, the Adjusted R<sup>2</sup> value is preferable as it provides a more precise estimate. The study's variables and their interrelationships were described in detail and supported by evidence in the data analysis.

## RESULTS AND DISCUSSION

### Descriptive Overview of Teacher TPACK, Avenza Maps Utilization, and Student Learning Activity

The percentage results presented below indicate that students' engagement in mapping lessons, teachers' implementation of TPACK-based instructional strategies, and the use of Avenza Maps as a digital mapping tool have all reached a satisfactory level. These outcomes suggest that each component has been effectively implemented in the instructional process, as indicated by the percentages in Table 3.

Table 3. Descriptive Statistical Analysis

Percentage	Assessment Qualifications	Frequency
70%	Good	36
74%	Good	36
74%	Good	36

(Source: Research Results, 2025)

A respectable 70% was reached in the application of instructors' TPACK-based teaching techniques, according to the table. Despite some inequities in student mastery, teachers' TPACK has been largely deemed excellent (Wang et al., 2025). Using Avenza Maps in the classroom is an effective way to help students learn geographical,

pedagogical, and technical concepts together. The presence of ratings in the fair and poor categories indicates that the integration of TPACK in instructional practice still requires further strengthening.

Schmid et al., (2020) Highlight the importance of teachers' confidence and instructional control efficacy, which are

strongly influenced by their content knowledge (CK). [Hardanti et al., \(2024\)](#) assert that the presence of significant pedagogical and technical skill is essential in addition to subject matter knowledge. Important steps in developing engaging and relevant learning processes include selecting and applying appropriate instructional models. The pupils' level of comprehension is a good indicator of the quality of teaching ([Wardani et al., 2020](#)). The use of appropriate models can prevent learning activities from becoming monotonous, ensuring that students are not merely passive recipients of information but are actively engaged at every stage of the instructional process ([Hayati, 2021](#)).

The TPACK achievement results indicate that teachers have attained an adequate level of competence in integrating content knowledge, pedagogical approaches, and technology. This competence is reflected in teachers' ability to master mapping subject matter while effectively managing technology use and implementing relevant instructional strategies. Geography instruction can therefore be conducted in a contextual, integrated manner oriented toward the utilization of spatial technology. Although teachers demonstrate a high level of competence, several challenges persist in practice, particularly in classroom management, stimulating student participation, time management, and aligning instructional implementation with established lesson plans ([Ratnawati et al., 2022](#)).

Geography instruction will be optimally implemented when it is designed and delivered through varied, innovative approaches that enhance students' motivation to learn. These methods not only make the classroom a more pleasant place to study but also help keep students engaged throughout ([Rahma et al., 2024](#)). This situation is consistent with constructivist educational concepts, which hold that learning is an interactive process in which students build knowledge through their own experiences, reflections, and interactions with the world around them.

According to [Apdoludin & Hiasa \(2024\)](#) constructivist approaches, students are positioned as active agents who build understanding based on their own learning experiences.

The percentage score for using Avenza Maps as a digital mapping medium was 74%, which is considered excellent. The high level of achievement in using Avenza Maps indicates that this application effectively helps students understand spatial concepts through visual, interactive, and practical digital maps. Through Avenza Maps, students are not merely passive recipients of information; rather, they actively engage in reading, interpreting, and digitally marking coordinates. This condition supports the creation of more contextual learning experiences while simultaneously increasing students' participation in the instructional process ([Hailikari et al., 2022](#)). The use of instructional media has been shown to significantly enhance students' interest and motivation and facilitate their understanding of the concepts being taught. [Kartini & Putra, \(2020\)](#) Further state that well-designed, engaging instruction tends to increase students' enjoyment and ease their comprehension and absorption of the subject matter.

A score of 74% was also achieved by the students' learning activities, which is excellent. Still, not all pupils have engaged to the same degree; some fall into the fair and low ranges. Avenza Maps has served its purpose as an educational medium to support students' learning of mapping content, as evidenced by the prevalence of reasonably excellent scores. Educational technology theory, which holds that technology can create more efficient and effective learning environments by facilitating more interactive learning experiences, aligns with efforts to increase student engagement. [Khairi & Kohar, \(2022\)](#) explain how digital and multimedia tools are part of instructional technology that help students gain better knowledge. [Alwish et al., \(2025\)](#) demonstrate that the implementation of Avenza Maps as a learning medium has a significant influence

on students' interest in learning Geography in Grade X.

Although the overall results fall within the good category, the presence of a small proportion of students in the poor category indicates differences in students' abilities and readiness to utilize instructional technology. The availability and accessibility of technology-based media remain key considerations, as effective media should accommodate diverse learning styles—visual, auditory, and kinesthetic (Wibowo et al., 2022). With further reinforcement through appropriate

instructional strategies, Avenza Maps can be optimized as a powerful learning tool. The variation in achievement levels reflects differences in students' ability to adapt to technology, particularly in how easily they install and use applications, access digital maps, and understand and operate Avenza Maps' features during the learning process. This finding highlights the need for more varied and inclusive instructional strategies to enhance the participation of all students. Observational data from the first and second instructional meetings support these results.

Table 4. Observation Results of Student Learning Activities in Class

Activity Aspects	Percentage of Student Learning Activities	
	Meeting I	Meeting II
Visual Activities	75% (Good)	75% (Good)
Oral Activities	75% (Good)	58% (Fair)
Listening Activities	58,33% (Fair)	75% (Good)
Motorik Activities	75% (Good)	75% (Good)
Emosional Activities	75% (Good)	83% (Very Good)
Total	73,33% (Good)	75% (Good)

(Source: Research Results, 2025)

Overall, observations of students' learning activities show that their engagement with geography learning using Avenza Maps is excellent and tends to improve between the first and second meetings. In the first meeting, students' learning activities accounted for an average of 73%; in the second, that figure rose to 75%. This enhancement shows that students began to adjust to learning patterns centered on technology and became more actively involved as the course progressed.

Both the first and second sessions had 75% visual activity, which is considered excellent. Throughout the lesson, students often demonstrated the ability to focus on digital map displays, take note of spatial information, and follow the instructor's directions. This regularity in visual activity demonstrates how effectively Avenza Maps helps students comprehend mapping principles through the visual presentation of information.



Figure 3. Documentation of students' visual activities (Source: Research Results, 2025)

After reaching 75% (good) in the first meeting, the oral activity element dropped to 58% (fair) in the second meeting. The fact that fewer students participated in speaking activities, such as asking questions, sharing their ideas, or describing the outcomes of group work, suggests that not all students were engaged. The nature of technology-

based learning, which often demands greater individual attention, may contribute to this condition by encouraging students to spend more time on digital media. However, this approach has not yet led to equally developed verbal interaction among students.



Figure 4. Documentation of students' oral activities (Source: Research Results, 2025)

Between the first and second meetings, there was a considerable improvement in listening activity, going from 58% (fair) to 75% (good). This enhancement suggests a higher level of preparedness for learning, as

the class progressed and students demonstrated improved listening comprehension, application follow-up, and group discussion skills.



Figure 5. Documentation of students' listening activities (Source: Research Results, 2025)

In both sessions, the proportion of students engaged in motor activity stayed about the same, at 75% (excellent). Students were able to engage in physical tasks

relevant to learning, including using the Avenza Maps app, placing items on the map, and consistently creating digital map deliverables.



Figure 6. Documentation of students motor activities (Source: Research Results, 2025)

The emotional activity aspect showed the most significant increase, rising from 75% (good) in the first meeting to 83% (very good) at the second meeting. This improvement indicates that students became increasingly enthusiastic, comfortable, and engaged in technology-based mapping learning activities. Positive

emotional responses reflect that learning with Avenza Maps is able to create an engaging and enjoyable learning environment, thereby fostering students' intrinsic motivation.

The Pedagogical Knowledge (PK) aspect achieved 82%, which, although categorized as good, is relatively lower than

the other components. According to this research, there is room for improvement in the variety of techniques, classroom interaction management, and student engagement, even if instructors can manage learning effectively. It is clear from the performance disparities across TPACK domains that there must be sustained effort to ensure that classroom instruction focuses not only on media consumption but also on strategies that encourage student engagement and autonomy.

According to the observation findings, students' visual, auditory, motor, and emotional learning activities are significantly improved when using Avenza Maps as a learning platform. Nevertheless, the oral activity aspect still requires further reinforcement through more interactive instructional strategies, such as structured discussions, group presentations, or Project-Based Learning, to promote more evenly distributed verbal participation among students. This study demonstrates that.

At the first meeting, the aspects of visual, motor, emotional, and oral activities indicated that students were able to observe the material, follow the teacher's instructions, engage in practical tasks, and respond affectively to the learning process. The listening activity was categorized as fairly good, suggesting that some students had not yet optimally focused their attention on the teacher's explanations and directions during the lesson.

Observations from the second meeting revealed an increase in the average level of students' learning activities. Visual, listening, and motor activities each showed greater student engagement in observing, listening to instructions, and carrying out mapping practices. Students' emotional activity demonstrated a significant

improvement and was classified as very good, indicating that students became more enthusiastic, felt more comfortable, and enjoyed the mapping lessons supported by Avenza Maps. Mental and emotional states influence success or failure in task performance (Altunkaya, 2017).

Oral activity declined, indicating that students' verbal participation in asking questions, engaging in discussions, and expressing opinions was unevenly distributed across groups. Toro et al., (2018) state that elicitation feedback can be provided to enhance communicative skills, enabling students to recognize their errors and receive input from the teacher through oral interaction. In addition, students demonstrated they were prepared to study using technology by autonomously resolving technical problems (Hardanti et al., 2024).

Students' learning activities were further supported by the assessment results of the map products produced during the lessons. The evaluation of digital map products was conducted across nine groups based on thirteen cartographic indicators. Findings from the recapitulation showed that most groups adhered to basic cartographic standards. These standards include properly titling the maps, accurately representing the astronomical lines, ensuring all insets and indexes are complete, correctly using the symbols, clearly displaying the legends, and using clear writing. To help students create tidy, clear, and instructive maps, the digital elements in the Avenza Maps program were sufficient. Jamaludin & Sedek, (2024) report that the use of digital tools has been shown to contribute effectively to improving the quality of classroom learning activities.



Figure 6. Documentation of student map project results (Source: Research Results, 2025)

In addition to facilitating students' understanding of spatial concepts in a more concrete way, digital mapping media also encourage engagement in various learning activities, such as observing, discussing, analyzing, and problem-solving. Kahar & Ili, (2022) found that activities embedded in the implementation procedures of Project-Based Learning (PjBL) have strong potential to enhance student engagement and learning activity. The successful implementation of this instructional model largely depends on the teacher's level of creativity, as PjBL can be applied across various subjects (Aulia et al., 2023). Other scholarly publications also support the effectiveness of PjBL, particularly its positive impact on learning. The use of projects and problems in the classroom has been associated with increased students' capacity for original thought and analytical reasoning (Anazifa & Djukri, 2017). Increased creativity within Project-Based Learning was reflected in the process of producing map projects on tracing paper, in which students collected coordinates of trash bin locations using Avenza Maps, identified the objects to be plotted, and designed the map layout through group discussions.

With an aggregate proportion of 89%, classroom observation data show a very effective level of learning application. During core activities, both topic Knowledge

(CK) and Technological Knowledge (TK) reached 96%, indicating that instructors have a deep grasp of topic mapping and are adept at using the Avenza Maps program to enhance student learning. These two areas show that the use of technology in the classroom is more than just lip service; it helps students develop mapping ideas and skills in real-world settings.

While all aspects were above average, the Pedagogical Knowledge (PK) component ranked lower, at 82%. According to this research, there is room for improvement in the variety of techniques, classroom interaction management, and student engagement, even if instructors can manage learning effectively. It is clear from the disparities in performance across TPACK domains that there must be sustained effort to ensure that classroom instruction focuses not only on media consumption but also on strategies that encourage student engagement and autonomy.

Evidence from classroom observations points to an exceptionally high degree of success. Teachers who are well-versed in mapping materials and adept at using Avenza Maps as a learning tool demonstrate their expertise in fundamental activities. Impressive performance in these two areas indicates that the use of technology in the classroom is not a fluke but a genuine tool

for enhancing the practical, real-world application of mapping knowledge and skills (Godley et al., 2021).

Although rated well, pedagogical understanding is still behind topic mastery and technology application. While teachers have done a good job of keeping students engaged and on task throughout the learning process, they might do even better if they diversified their teaching strategies, better regulated student-teacher interactions, and maximized students' opportunities for independent study. Different TPACK components' levels of success demonstrate the ongoing need to refine methods of incorporating technology into the classroom so that lessons focus on more than just media consumption and instead encourage active participation from all students (Carroll et al., 2022).

Avenza Maps-supported TPACK-based training benefits greatly from instructors' high levels of TPACK proficiency Zahra et al., (2024) , affirming that digital literacy, computational thinking, and collaborative skills are essential 21st-century competencies that may be fostered through the use of instructional technology. By adapting the presentation of course materials to each student's unique requirements and current skill level, media integration enables more engaging and effective educational experiences. Nevertheless, expertise in a particular field does not guarantee freedom from errors, limitations, or potential oversight (Khoza & Biyela, 2020). A balanced integration of content mastery, pedagogical aspects, and technological knowledge remains fundamental to delivering effective,

contextual geography instruction that prioritizes students' active participation in the learning process. The results of this research show that using Avenza Maps to support TPACK-based learning is more successful when teachers have high TPACK competency. Effective, contextual, and student-centered geography learning requires a reasonably balanced combination of material knowledge, pedagogy, and technology.

**The Relationship and Partial Influence of Teachers' TPACK Competencies and the Use of Avenza Maps on Students' Learning Activities**

TPACK is a strategy that supports learning and determines the quality of student interactions in mapping activities. Students' learning activities may be significantly enhanced by integrating TPACK training with appropriate learning technology. Table 4.18 below discusses the strength and direction of the relationship between TPACK teacher competency and the use of Avenza Maps media with student activities. In addition to facilitating learning, TPACK is a strategic component that dictates the level of student engagement in mapping activities. Mastery of TPACK, when combined with the appropriate use of educational technology, has been shown to significantly enhance students' learning. The strength and direction of the relationship between teachers TPACK competence and the utilization of Avenza Maps on students learning activities are presented in Table 5.

Tabel 5. Correlation Analysis Results

		Correlations		
		TPACK	Avenza Maps	Student Activities
TPACK	Pearson Correlation	1	.771**	.894**
	Sig. (2-tailed)		.000	.000
	N	36	36	36
Avenza Maps	Pearson Correlation	.771**	1	.888**
	Sig. (2-tailed)	.000		.000
	N	36	36	36
Student Activities	Pearson Correlation	.894**	.888**	1
	Sig. (2-tailed)	.000	.000	
	N	36	36	36

\*\* Correlation is significant at the 0.01 level (2-tailed).

(Source: Research Results, 2025)

Each of the study variables—teachers' TPACK competency, students' use of Avenza Maps, and their learning activities—has a positive and statistically significant association, according to the Pearson correlation analysis. The fact that the significance levels are lower than 0.01 and the correlation coefficients are high demonstrates this.

The correlation coefficient between instructors' TPACK competency and their students' learning activities is 0.894, indicating a very high association. This link is considered statistically significant, with a p-value of 0.000 ( $p < 0.01$ ). Geography learning activities are more effective when instructors have a strong grasp of TPACK, which integrates subject, pedagogical, and technological knowledge. Students' engagement in visual, oral, physical, listening, and emotional activities is greatly influenced by teachers' TPACK proficiency.

The association between students' learning activities and teachers' TPACK is extremely strong. A higher degree of student participation in the mapping learning process was associated with higher levels of TPACK competence among instructors, which involves integrating pedagogical, subject, and technology knowledge. One of the main reasons instructors don't have much success in incorporating technology into their lessons is that they lack access to training programs focused on technological innovation (Çam & Erdamar Koç, 2021). TPACK has an independent contribution to fostering student engagement across visual, oral, listening, motor, and emotional activities. Teachers who effectively integrate content mastery, appropriate pedagogical strategies, and instructional technology tend to create learning environments that are more interactive, engaging, and participatory.

Appropriate technology integration, the selection of suitable pedagogical strategies, and strong content mastery make instruction more engaging, interactive, and effective. Sailin & Mahmor, (2018) Stress the importance of educators having the skills to lead and create engaging learning experiences for students using digital tools,

so that the goals of education may be realized to their fullest potential. Therefore, efforts to develop teachers' TPACK competence constitute a strategic step in promoting student learning activities in geography instruction, particularly in mapping materials.

With a correlation value of  $r = 0.888$ , which is statistically significant at the 0.01 level, there is a very strong association between students' learning activities and the use of Avenza Maps. The use of Avenza Maps is strongly associated with student learning activities, indicating a positive, statistically significant influence. Avenza Maps is effective at enhancing student engagement by providing contextual, interactive, and exploration-based learning experiences. Fadillah et al., (2023) indicated that, on average, students achieved a very excellent score of 80.5% when they analyzed their learning activities using the school environment as a learning resource, according to a learning activity questionnaire. The results show that this method may encourage and facilitate greater learning among pupils.

The use of Avenza Maps by instructors and their TPACK competency is strongly correlated ( $r = 0.771$ ), indicating a statistically significant relationship ( $p < 0.01$ ). This suggests a strong connection between instructors' proficiency in integrating technology, pedagogy, and material and the successful use of Avenza Maps in the learning process. Motor activity increased when students practiced recording coordinate points obtained from plotting in the Avenza Maps application and arranging map layouts on tracing paper. Writing activities can promote higher levels of learning achievement, although activities requiring evaluative skills were reported to occur 25% less often (Graham et al., 2020).

Visual activity was strengthened as students read map symbols and layers. Listening activity improved when students paid attention to explanations of how to use the Avenza Maps application; they demonstrated focused attention driven by curiosity about how the application functioned. Visual engagement further

developed through activities involving the interpretation of map symbols and layers. The use of visualization in educational processes enhances memory retention, supports idea development, facilitates conceptual understanding, enables holistic review of material, and strengthens analytical skills, information organization, and problem-solving abilities (Malykhin et al., 2024).

Emotional activity increased as a result of more engaging learning experiences, while listening and oral activities also developed in tandem with the intensity of step-by-step instructions and classroom discussions. Through the promotion of active contact and multimodal engagement, project-based learning offers the opportunity to provide learning experiences that are more substantial and meaningful (Crawford et al.,

2024). The learning process can thus be implemented more effectively while positioning students as the central focus.

The findings indicate that the use of Avenza Maps has a significant positive effect on students' learning activities, both in terms of classroom interaction and dynamics and in statistical analysis. The implementation of digital mapping applications in geography instruction has been shown to foster a more active, participatory learning environment and provide meaningful learning experiences. Teachers with strong TPACK competence tend to optimize the use of digital mapping media in a more purposeful and meaningful way. The effect of each variable was tested individually using a t-test, with the complete data presented in Table 6.

Table 6. Partial Hypothesis Results (t-Test)

Model		Coefficients <sup>a</sup>			t	Sig.
		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta		
1	(Constant)	7.016	1.469		4.778	.000
	TPACK	.377	.064	.515	5.853	.000
	Avenza Maps	.512	.092	.491	5.584	.000

a. Dependent Variable: Student Activities

(Source: Research Results, 2025)

Students' learning activity scores rise by 0.377 points for every one-unit increase in teachers' TPACK competence and by 0.512 points for every one-unit increase in teachers' ability to use Avenza Maps, according to the regression coefficients, all else being equal. The t-test findings indicate a positive and statistically significant partial impact of TPACK ( $t = 5.853$ ;  $p < 0.05$ ) and of the use of Avenza Maps ( $t = 5.584$ ;  $p < 0.05$ ) on students' learning activities. Regarding improvements in students' learning activities, the standardized beta values indicate that TPACK ( $\beta = 0.515$ ) is slightly more influential than Avenza Maps ( $\beta = 0.491$ ). Students' involvement in learning is directly correlated to their level of TPACK proficiency. Santoso & Muhammad, (2024) state that mastery of

basic teaching skills plays a critical role in enhancing teaching practice effectiveness, as these skills encompass the entire sequence of learning activities from the opening to the closing stages. Proper integration of technology, appropriate selection of pedagogical strategies, and solid mastery of subject matter make learning more engaging, interactive, and effective. Efforts to develop teachers' TPACK competence represent a strategic step toward promoting students' learning activities in geography, particularly in mapping.

The average student engagement level reached 73.33% in the first session and grew to 75% in the second session, according to observational data from teaching practice sessions. The use of Avenza Maps has a

favorable effect on students' learning activities, as shown by more steady growth in engagement. There is a significant increase in motivation to learn when students engage with digital mapping tools. During the second session, students became more eager and comfortable engaging in mapping tasks using Avenza Maps, as evidenced by the biggest increase, reaching 83% in the emotional element. The percentage of those actively listening rose from 58% to 75%. Students can pay more attention while the instructor is speaking because the learning context is clearer and more tangible when they use Avenza Maps.

Observational findings and statistical analyses suggest that Avenza Maps effectively enhances learning activities by providing contextual, interactive, and exploration-based learning experiences. [Fadillah et al., \(2023\)](#) Based on a learning activity questionnaire, students' learning activities that used the school environment as a resource had an average score of 80.5%, considered very good. This suggests that this approach helps students learn more effectively. Motor activities increased when students practiced arranging map layouts on tracing paper, while visual activities strengthened as Students read map symbols and layers. Students' motor activities further increased during outdoor mapping of waste disposal sites using Avenza Maps, followed by indoor layout arrangement on tracing paper. Visual activities developed further through reading symbols and map layers, while emotional activities improved through

more engaging learning experiences. Listening and oral activities were also developed alongside the intensity of step-by-step discussions and teacher instructions. The study confirms that the utilization of Avenza Maps has a positive and significant effect on students' learning activities, as evidenced by both classroom activity dynamics and statistical measurements. The integration of digital mapping applications in geography learning creates a more active, participatory, and meaningful learning environment.

### Simultaneous Effect of Teacher TPACK and Avenza Maps Utilization on Student Learning Activity

The data from the two sessions show that the students' activities were getting better. In the first session, the average activity level was 73%; in the second, 75%. Students' increased involvement in map observation, digital practice, and showing interest and excitement throughout learning was most pronounced in the visual, motor, and emotional domains. Integrating mapping material, collaborative pedagogy, and geospatial technology using Avenza Maps demonstrates the teacher's use of TPACK. The effects were seen in the motor and visual domains, where scores were high (75%) throughout the two sessions. The combined influence of teachers' TPACK competence and the utilization of Avenza Maps on students' learning activities was tested through a simultaneous test (F-test). The results are presented in Table 7.

Tabel 7. Simultaneous Hypothesis Results (f-Test)

		ANOVA <sup>a</sup>				
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	901.036	2	450.518	143.041	.000 <sup>b</sup>
	Residual	103.936	33	3.150		
	Total	1004.972	35			

a. Dependent Variable: Student Activities

b. Predictors: (Constant), Avenza Maps, TPACK

(Source: [Research Results, 2025](#))

The F-test, a simultaneous test, makes the relationship among the three variables

more apparent. Together, TPACK and Avenza Maps significantly impact students'

learning activities (F-value: 143.041,  $p = 0.000$ ). The coefficient of determination ( $R^2$ ) is used to assess the impact of instructors' TPACK expertise and the use of Avenza Maps on variability in students' learning activities. Table 4.23 presents the regression

coefficients, indicating that TPACK and Avenza Maps positively impact students' actions. The  $R^2$  value in Table 8 summarizes the explanatory power of the independent factors in explaining the dependent variable's variability.

Table 8. Results of the Coefficient of Determination (r square)

Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Change Statistics			Sig. F Change
						F Change	df1	df2	
1	.947 <sup>a</sup>	.897	.890	1.775	.897	143.041	2	33	.000

a. Predictors: (Constant), Avenza Maps, TPACK

(Source: Research Results, 2025)

With an  $R^2$  of 0.897, we see that TPACK competency and Avenza Map usage account for 89.7 percent of the variance in students' learning activities. Various additional variables, including personal motivation, willingness to learn, and classroom atmosphere, account for the remaining 10.3%. The evaluation of students' map creations further supports the use of both statistical analysis and direct classroom observation. With 313 points out of 468 possible, you have achieved 66.88%, which is considered excellent. In addition to being engaged, students demonstrated competence in creating digital maps that adhere to standard cartographic practices. Teachers' implementation of TPACK is reflected in their ability to integrate content mapping, collaborative pedagogy, and geospatial technology using Avenza Maps. Its impact is evident in the motor and visual aspects, which consistently remain in the high category. The regression coefficient values indicate that Avenza Maps contributes more substantially to student learning activities than TPACK alone. Although TPACK and the use of Avenza Maps jointly exert a strong influence on student engagement, this relationship may also be affected by other factors, such as individual motivation, learning readiness, and the classroom environment. Sakir & Kim, (2020) state that the key to increasing student learning

activities lie in strengthening teaching skills and instructional quality, implementing effective classroom management, fostering interest and enthusiasm before and during instruction, providing opportunities for questioning and responding, and developing critical thinking and creativity to achieve optimal learning outcomes.

The greater the TPACK mastery and the more effectively Avenza Maps are used, the more active students become in the learning process. The results of map product assessments reinforce the value of combining statistical analysis with direct classroom observation. Students were not only active but also capable of producing digital maps that adhered to cartographic principles. Their ability to construct legends, select appropriate symbols, apply color effectively, and position insets and astronomical lines accurately reflects the successful integration of technology in geography instruction. Suharini et al., (2022) assert that student learning activities demonstrate a strong relationship with improvement in learning outcomes; increased intensity of student participation in the implementation of instructional models is directly proportional to gains in achievement.

Murni, (2021) emphasizes that students are considered active when they are directly and continuously involved in the learning process through physical activities, mental

and intellectual engagement and emotional participation, enabling them to process and compare the learning material they receive. Active students are characterized by the courage to express ideas and feelings, a willingness to participate in learning activities, involvement from preparation through follow-up, and the ability to communicate learning outcomes. The creative application of various learning strategies to achieve success, along with learning experiences that encourage students to construct knowledge independently, further strengthens an (August et al., 2024).

Juhadi et al., (2021) state that knowledge of geospatial information visualization, including an understanding of constraints within the visualization process, significantly influences the development of geospatial visualization skills, which simultaneously have a tangible impact on improving students' geospatial knowledge. Similarly, Purnomo, (2019) explains that the use of geospatial information about geographic objects can enhance students' map-making skills. Intelligent technology should therefore be positioned as a partner in the learning process rather than merely as a supporting tool (Guggemos, 2021).

This study demonstrates that, overall, TPACK and Avenza Maps simultaneously exert a strong influence on student learning activities. Celik, (2023) reveals that teachers' roles in managing instruction require mastery of technical, pedagogical, and ethical knowledge; thus, TPACK is regarded as a robust framework for explaining teaching competence and underpinning the development of the Intelligent-TPACK framework for ethical technology integration. The integration of digital mapping technology can create a more interactive, exploratory, and contextual learning process, thereby encouraging students to actively engage in mapping instruction, outcomes, and statistical analysis. The integration of digital mapping technology facilitates a more interactive,

exploratory, and contextual learning process, encouraging students to participate actively in mapping activities.

Azis et al., (2025) His study indicated that field-based learning enhances students' depth of understanding, fosters environmental awareness, and promotes active engagement in the learning process. Similarly, Suciani et al., (2025) affirmed that her field test results showed higher student activity when maps were presented with clear navigational guidance, thereby encouraging active inquiry-based learning participation.

## CONCLUSION

This research shows that students' learning activities with mapping materials are positively and significantly impacted by TPACK-based learning, supported by the Avenza Maps application. Research shows that when teachers are competent in TPACK and use Avenza Maps, students are more engaged in all aspects of the learning process, including visual, motor, emotional, listening, and oral activities. In fact, the average student learning activity score increased from 73.33% in the first session to 75% in the second. Avenza Maps ( $\beta = 0.491$ ) and instructors' TPACK ability ( $\beta = 0.515$ ) independently and favorably impact student learning activities, according to multiple regression analysis. These two variables account for 89.7 percent of the variance in students' learning activities, with additional factors such as classroom environment, learning preparedness, and motivation accounting for the remaining 10.3 percent. ( $R^2 = 0.897$ ). Students can create digital maps using Avenza Maps, following cartographic principles, which not only increases their engagement but also enables contextual, interactive, and exploration-based learning. These results provide credence to the idea that TPACK-based integration of geospatial technology is a powerful tool for fostering student-centered, active, and practical geography education.

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