Volume 16 Number 1 (2024)
January-June 2024
Page: 583-594

E-ISSN: 2656-9779
P-ISSN: 1907-6355
DOI: 10.37680/qalamuna.v16i1.5469

QALAMUNA
JURNAL PENDIDIKAN, SOSIAL, DAN AGAMA

Improving Vocational School Students' Skills in Land Surveying with Team-Based Projects Using Augmented Reality

Abdul Haris Setiawan [1], Rima Sri Agustin [2], Eko Supri Murtiono [3], Lilis Trianingsih [4], Hiroyuki Mitsuhara [5]

[1] Universitas Sebelas Maret, Surakarta, Indonesia; aharis@staff.uns.ac.id
[2] Universitas Sebelas Maret, Surakarta, Indonesia; rimaagustin@staff.uns.ac.id
[3] Universitas Sebelas Maret, Surakarta, Indonesia; ekosupri@staff.uns.ac.id
[4] Universitas Sebelas Maret, Surakarta, Indonesia; lilistrianingsih@staff.uns.ac.id
[5] Tokushima University, Japan; mituhara@is.tokushima-u.ac.jp

Received: 16/03/2024 Revised: 26/05/2024 Accepted: 28/06/2024

Abstract

This research aims to determine the increase in land surveying competency of Civil Engineering Vocational School students through team-based project strategies and augmented reality learning media. This research is vital because land surveying competency is critical for Civil Engineering Vocational School students in facing the demands of the ever-growing construction industry. This research uses two different classes of data: class A (35 students) as the experiment and class B (36 students) as the control class. Data analysis was done using descriptive statistical methods and independent samples t-test. The results showed that the survey competency score for class A increased from 53.57 (pre test) to 85.36 (post-test) on a scale 100. Meanwhile, the competency score for class B increased from 53.89 (pre-test) to 72.22 (post-test). An N-gain score of 0.6962 shows an increase in competency of 69.62%. The independent sample t-test shows that the pre-test for both classes is the same with a t-count of 0.104 < t-table = 1.997 and a Sig. (2-tailed) 0.917 > probability 0.05. The post-test results show that there is a significant difference between class A (experimental class) and class B (control class) with a calculated t-value of 8.649 > t-table = 1.997 and a Sig. (2-tailed) 0.000 < 0.05. In conclusion, team-based project strategies and augmented reality learning media significantly increase students' land surveying competency. The implications of this research indicate that the application of augmented reality technology in civil engineering learning can effectively increase student competency. Future research recommendations are to explore the use of augmented reality in other engineering fields and evaluate its impact on students' practical competencies. The research can also be expanded to involve more schools and classes to strengthen these findings.

Keywords

Augmented Reality; Land Surveying; Team-Based Projects; Total Station; Vocational Education

Corresponding Author
Abdul Haris Setiawan
Universitas Sebelas Maret, Surakarta, Indonesia; aharis@staff.uns.ac.id

Published by Institut Agama Islam Sunan Giri (INSURI) Ponorogo; Indonesia
Accredited Sinta 2

1. INTRODUCTION

A substantial problem in vocational education is the competency gap between graduates and industry needs (Setiawan, 2022; Setiawan et al., 2020, 2021; Setiawan & Takaoka, 2020; UNESCO-UNEVOC, 2013). Vocational education is essential in preparing students with practical skills relevant to industry. Land surveying skills in civil engineering are crucial because they are the main foundation in construction and infrastructure development. While traditional teaching methods have effectively taught the basics, integrating cutting-edge technology, such as augmented reality, can change how students understand and practice their skills. The use of this technology not only enhances the learning experience with more realistic simulations but also prepares students to face real-world challenges with more competence and confidence (Mulyana et al., 2020; Sari et al., 2022; Tasrif et al., 2020; Yulianti et al., 2022).

Team-based projects offer a dynamic and engaging educational approach, encouraging academic growth and the development of essential life and career skills. By effectively addressing challenges and harnessing the benefits of collaboration, educators can create meaningful learning experiences that prepare students for the complexities of the modern world. Students collaborate as a team to achieve a common goal, often involving the application of knowledge and skills in real-world scenarios. This learning approach is gaining popularity in various educational environments, from K-12 to higher education, because it encourages collaborative problem-solving, communication skills, and a deeper understanding of the subject matter. Augmented reality has emerged as a transformative force in education, bridging the physical and digital worlds to create immersive learning experiences (Arena et al., 2022; Elmqaddem, 2019; Indahsari & Sumirat, 2023; Kamińska et al., 2023). As the industry increasingly relies on accurate and efficient land surveying skills, traditional teaching methods often need to be able to capture the complexity of real-world scenarios. This study presents a unique opportunity to revolutionize vocational education, offering a dynamic and interactive platform that goes beyond the traditional classroom setting. Integrating team-based projects and AR in land surveying can provide students with hands-on experience, fostering a deeper understanding of theoretical concepts and practical applications.

Using a Total Station requires land surveying competency for civil engineering, architecture, urban planning, and environmental studies projects, acquiring developing abilities and competencies (Carbonell-Carrera et al., 2017). Total station learning media development is based on surveys and curriculum identification. After identification, competencies, and indicators are determined. The instructional design is determined for the course based on the pedagogical approach. This includes defining survey course curriculum, pedagogical approaches to determine learning experiences and strategies, defining student skill characteristics, analysis of required facilities, learning duration, mastery of competencies by defining cases and projects to be completed, teamwork, supervising, and designing learning instructions for the course. This research contributes to the development of vocational education by evaluating the integration of team-based project learning strategies with the support of augmented reality as a learning medium. It provides final recommendations for learning design and facility improvement on specific learning problems in land surveying.

Augmented Reality (AR) is a technology that combines real-world elements with virtual elements, creating a combined experience between physical reality and digital information (Fan et al., 2020; Ibáñez & Delgado-Kloos, 2018; Khan et al., 2019; Samala & Amanda, 2023) In the context of research on improving land surveying skills in Civil Engineering Vocational Schools, AR allows students to experience field simulations that are close to real situations without leaving the classroom environment. With AR, students can view virtual objects such as maps, contour lines, or instructions directly on top of the physical environment. For example, students can use AR devices to virtually map and measure areas of land while seeing and feeling their surroundings. This makes learning more engaging and interactive and provides an opportunity to practice with scenarios that might be difficult or expensive to simulate live in the field. The advantages of AR in the context of vocational education include

increasing the appeal of learning, accelerating understanding of complex concepts, and preparing students with better practical skills to enter the job market (Carmigniani et al., 2011; Gudoniene & Rutkauskiene, 2019; Rauschnabel et al., 2022; Syed et al., 2023). With this technology, educators can customize learning experiences to be more relevant to current industry needs and facilitate teaching that is more effective and responsive to technological developments and industry demands. Therefore, using AR in a team-based project to improve land surveying skills in Civil Engineering Vocational Schools not only leverages cutting-edge technology, but also embraces great potential to change how students understand and apply technical concepts in their practice. This paves the way for more innovative learning approaches and prepares students to become a more adaptive and skilled workforce in today's digital era.

This research is based on the urgent need to improve the quality of vocational education in civil engineering, especially in developing land surveying skills. Various challenges have been identified, such as the gap between the skills taught in schools and the dynamic needs of industry. Conventional teaching methods have provided a strong foundation, but integrating cutting-edge technology such as augmented Reality (AR) is expected to provide students with a more in-depth and relevant learning experience. This research also aims to respond to developments in the increasingly complex construction industry and technology developing rapidly. By utilizing AR, researchers want to bridge the gap between theory taught in class and practical application in the field. This is expected to help Civil Engineering Vocational School students to be better prepared and competent to face real-world challenges after graduating. Apart from that, this research also wants to contribute to developing new learning methodologies that can be widely applied in other vocational education institutions. By evaluating the effectiveness of team-based projects using AR in improving land surveying skills, researchers hope to provide valuable recommendations for future curriculum development and learning strategies. Thus, this research is academically relevant and has significant practical implications for vocational education and the construction industry.

2. METHODS

This research evaluates the results of development studies in implementing team-based projects using augmented reality. It aims to discover vocational students' skill enhancement in land surveying. The method involves quasi-experimental research using a quantitative approach to examine the impact of specific treatments on the experimental group in controlled conditions (Sugiyono, 2017). It calculates the improvement of vocational students' skills in land surveying through team-based projects using augmented reality in experimental classes. Control classes use regular models without augmented reality and team-based projects. Analysis was done using descriptive analysis, independent sample t-test, and normalized gain analysis. Descriptive analysis displays the land surveying skills of vocational school students in the pre-test and post-test experimental and control classes by showing the mean, frequency distribution, and histogram. The skills of vocational school students in surveying land data fall within the criteria set by Azwar (Azwar, 2018). An independent sample t-test was conducted on the experimental and control class pre-tests to demonstrate class equality. After the learning process, a post-test was carried out in the experimental and control classes. The results were then tested using the independent sample t-test to determine differences in students' skills before and after treatment. Normality and homogeneity of data variance were checked using the Shapiro-Wilk and Levene tests as analysis requirements before analyzing the data using the independent samples t-test (Morgan et al., 2019). The research hypothesis is the null hypothesis (H0). There is no significant difference in the improvement of vocational school students' skills in land surveying between the experimental class and the control class; and the alternative hypothesis (Ha), there is a significant difference in the increase in vocational school students' skills in land surveying between the experimental class and the control class. The significance level is 0.05. This aims to determine the skills attainment of vocational school students

in land surveying from the experiments carried out. The normalized gain analysis formula was used to interpret g<0.3 as low, 0.3≤g<0.7 as moderate, and g≥0.7 as high (Hake, 1998).

The research subjects are all students in State Vocational High School 4 Sukoharjo, the building information modeling and design program, the 3rd grades A and B. The experimental group consisted of 35 students from class A, while the control group comprised 36 students from class B. The instrument utilized in this research is a rubric assessing vocational students' skills in land surveying with eight indicators adapted from a study on a university level (Setiawan et al., 2024), as explained in Table 1.

Table 1. Indicators of Vocational Students' Skills in Land Surveying

Performance Aspect	Indicators
Vocational school students skills in land surveying	1. Explain the development of survey tools
	2. Explain the total station theory
	3. Explain the parts of a total station
	4. Operate the total station
	5. Measure and analyze open polygon data
	6. Measure and analyze closed polygon data
	7. Transfer total station coordinate data
	8. Draw measurement results

[1] abstracted from the basic surveying competencies (Setiawan et al., 2024)

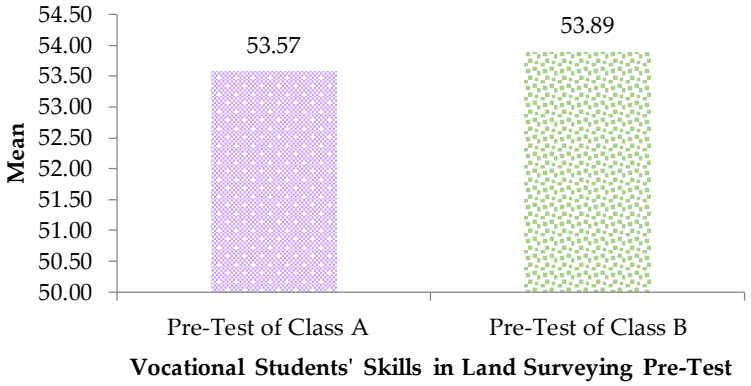
The instrument tested used a content validity test with the assessor agreement index proposed by Aiken V. The three assessors consisted of lecturers and industry practitioners. The validity assumption of a V index value ≥ 0.40 is considered valid (Aiken, 1980, 1985; Gabriela & Susana, 2021). The findings indicated a content validity of 0.89, surpassing the V index threshold of 0.40, confirming the instruments' validity. The instrument's reliability was assessed using the Interclass Correlation Coefficient (ICC) formula by Shrout and Fleiss, with an assumption of more than 0.75, ICC value ≥ 0.75 for a reliable decision (Kazimierczak et al., 2024). The reliability test of the instrument for evaluating vocational school students' skills in land surveying, conducted using IBM SPSS, revealed an ICC reliability coefficient of 0.870, exceeding the minimum requirement of 0.75. Therefore, the instrument is deemed reliable.

3. FINDINGS AND DISCUSSIONS

Results

Initial Behavior and Implementing a Team-Based Project Using Augmented Reality

The initial condition of vocational students' skills in land surveying in both classes A and B was observed using the land surveying skills assessment instrument as a pre-test. The descriptive statistics analysis indicated that the average pre-test score for vocational students' skills in land surveying in class A was 53.57 out of 100. At the same time, the pre-test score for vocational students' skills in land surveying in class B averaged 53.89 out of 100, falling within the lower category defined by Azwar's criteria, which ranges from 43.76 to 56.25 (Azwar, 2018). Graph 1 presents the initial skills of vocational students in land surveying.



Graph 1. Vocational School Students' Initial Skills in Land Surveying (Average Pre-Test Score)

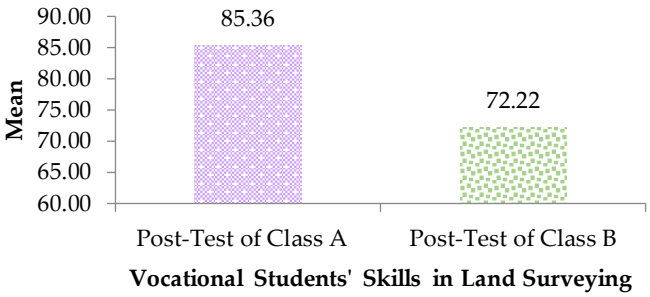
The study used an independent sample t-test to ensure equality between classes. The normality and homogeneity of variance were assessed as prerequisites before performing the independent samples t-test analysis. The Shapiro-Wilk test was used to verify that the data follows a normal distribution. The pre-test significance value for class A is 0.267, and for class B, it is 0.110. Since both values are greater than 0.05, it can be concluded that the pre-tests in both classes are normally distributed. Therefore, the assumptions for normality required for the independent samples t-test have been met. Levene's test produced a significance value of 0.203, which is greater than 0.05, indicating that the data variance for the pre-tests in class A and class B is homogeneous. Thus, the homogeneity of variance is concluded.

After confirming normality and homogeneity, an independent samples t-test was conducted. The analysis results indicate that the Sig. (2-tailed) value of 0.917 is greater than 0.05, leading to the acceptance of the null hypothesis and the rejection of the alternative hypothesis, implying no significant difference in land surveying skills between the experimental and control classes of vocational students. Subsequently, since the t-count of 0.104 is less than the t-table value of 1.997, the null hypothesis is accepted and the alternative hypothesis is rejected. The interpretation is that vocational students' skills in land surveying are similar between experiment and control classes. Therefore, the initial skill levels in land surveying of students in both the experimental and control classes are equivalent.

Once the two classes were deemed equivalent, the experiment was conducted in one class, while the other served as a control to compare and evaluate the learning success in the experimental class. Additionally, the descriptive analysis indicates that the lowest average pre-test scores are in indicators 7, 4, and 3. The lowest score, 30.29 out of 100, is for indicator 7, which involves transferring total station coordinate data. This is followed by indicator 4, operating the total station, with a score of 30.86, and the third lowest is indicator 3, explaining the parts of a total station, with a score of 32.57. These three lowest skill areas among students are a focus for improvement during the experiment.

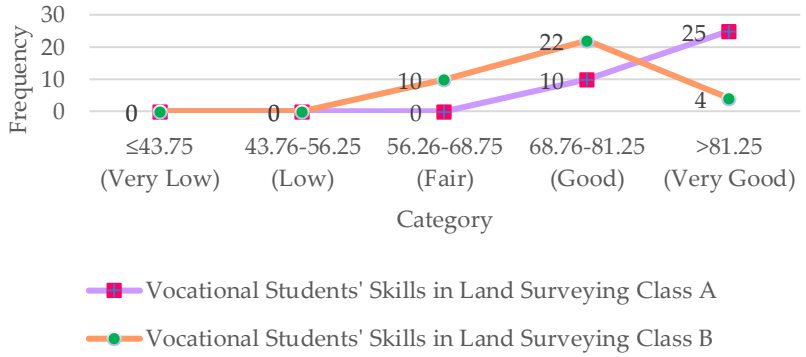
Improving Vocational School Students' Skills in Land Surveying Through Team-Based Projects Using Augmented Reality

This experiment was carried out at Sukoharjo State Vocational School, Indonesia. The initial assessment was a pre-test conducted at the start of the course, followed by a post-test administered after a semester of learning. The post-test results revealed that the average score for vocational students' skills in land surveying was 85.36 for the experimental class (class A) and 72.22 for the control class (class B) on a scale of 100. It falls into the Very Good category, with class A scoring above 81.25, and the Good category for class B, with scores ranging from 68.76 to 81.25. Based on the post-test skills of vocational school students, the average score is shown in Graph 2.



Graph 2. Average Score of Vocational School Students' Skills in Land Surveying (Post-Test)

Graph 2 illustrates that the post-test score for class A, the experimental group, is 85.36, and for class B, the control group, is 72.22 out of 100, indicating an improvement in scores. For class A, the score increased by 31.79 points, rising from a pre-test mean of 53.57 to a post-test mean of 85.36 on a scale of 100. Additionally, class B showed a smaller increase, rising by 18.33 points from a pre-test score of 53.89 to a post-test score of 72.22 on a scale of 100. Graph 3 presents the frequency distribution of the post-test scores from 71 students participating in the study.



Graph 3. Frequency Distribution of Vocational School Students' Skills in Land Surveying (Post-Test)

After the experiment, it was observed that the level of vocational students' skills in land surveying had changed in each class, showing a different distribution from the initial conditions. The frequency distribution of post-test scores for surveying competence in classes A and B, after a semester of experimentation, generally shows improvement. Table 2 provides a summary of the pre-test and post-test results.

Table 2. Summary of Vocational School Students' Skills Descriptive Statistics on Land Surveying

Vocational School Students' Skills in Land Surveying	Class A	Class B
Pre-Test average score	53.57	53.89
Post-Test average scores	85.36	72.22
Increase in average score	31.79	18.33

Similarly, to identify a significant difference between the experimental class (class A) and the control class (class B) using the independent samples t-test, the data's normality and homogeneity of variance were assessed as prerequisites. Based on the Shapiro-Wilk test, the post-test significance value for class A is 0.110 and for class B is 0.467. Since both values are greater than 0.05, the post-test data for classes A and B are normally distributed, as shown in Table 3. Therefore, the assumptions of normality for using the independent samples t-test have been met.

Table 3. Summary of Experimental and Control Class Normality Test (Post-Test)

	Group	Shapiro-Wilk	Conclusion
		Sig.	
Vocational school students skills in land surveying	Class A Post Test	0.110	Normal
	Class B Post Test	0.467	Normal

Levene's test for homogeneity of variance indicated that since the Sig. value is greater than 0.05, the variance of the two groups is the same. Levene's test results showed a Sig. value of 0.956, which is greater than 0.05, indicating that the data variances for the post-test in classes A and B are homogeneous. Thus, homogeneity of variance is confirmed. Table 4 displays the post-test homogeneity of variance for the experimental and control classes.

Table 4. Summary of Experimental and Control Class Variance Homogeneity Test (Post-Test)

	Levene's Test for Equality of Variances	Conclusion
	Sig.	
Vocational school students skills in land surveying (Post-Test)	0.956	Homogeneous

The independent samples t-test was conducted to assess post-test differences between classes A and B. The analysis revealed a Sig. (2-tailed) value of 0.000, which is less than 0.05, indicating that the null hypothesis is rejected, and the alternative hypothesis is accepted. This suggests a significant difference in vocational students' land surveying skills between the experimental and control classes. This is further supported by the t-count value, which is greater than the t-table value: t-count = 8.649 > t-table = 1.997. Therefore, the skills in land surveying between the experimental and control classes are significantly different. Table 5 summarizes the results of the independent samples t-test.

Table 5. Summary of Independent Sample t-Test for Experimental and Control Classes (Post-Test)

	t-test for Equality of Means			Conclusion
	t	*df*	*Sig. (2-tailed)*	
Vocational school students skills in land surveying (Post-Test)	8,649	69	0,000	H_0 is rejected, and H_a is accepted

A normalized gain analysis was conducted to evaluate the improvement in vocational school students' land surveying skills from pre-test to post-test in the experimental and control classes. The interpretation criteria were $g < 0.3$ for low, $0.3 \leq g < 0.7$ for moderate, and $g \geq 0.7$ for high (Coletta & Steinert, 2020; Hake, 1998). Table 6 provides a summary of the normalized gain analysis.

Table 6. Summary of Normalized Gain Survey Competency Analysis Results (Pre-Test and Post-Test)

		N-Gain Score (g)			Conclusion
		Means	*Min*	*Max*	
Vocational school students skills in land surveying	Class A	0.6962	0.59	0.91	Moderate
	Class B	0.3861	0.29	0.48	Moderate

Table 6 shows the average g score for class A as 0.6962, placing it in the moderate category, indicating a 69.62% improvement in vocational students' skills after the experiment. This suggests that the team-based project learning model and augmented reality media for total stations effectively

enhance these skills. Class B's g score is 0.3861, also in the moderate category, indicating a 38.61% improvement in surveying competence.

Discussion

Descriptive analysis shows the initial findings as valuable information needed to improve vocational school students' skills in land surveying as an expected learning outcome. The main initial findings of the descriptive research were the three lowest indicators of vocational school students' skills in land surveying. The score is the weakest among all the scores achieved for further consideration, indicator 7, transferring total station coordinate data; indicator 4, operating the total station; and indicator 3, explaining the parts of a total station. This is in line with research on students (Setiawan et al., 2024). Information about student weaknesses will provide the proper initial guidance for a better learning experience.

Research findings, land survey, and coordinated data transfer should be paid more attention, confirmed by Zhou J., Xiao H., Jiang W., Bai W., and Liu G. (Zhou et al., 2020) in addition to transferring coordinate data accurately by measuring the angle and distance of the total station. This is important to ensure the safety of land surveying work when construction activities are carried out nearby. In line with Beshr A. A. A. and Abo Elnaga I. M. (Beshr & Abo Elnaga, 2011), operating and mastering the parts of a total station is essential for a surveyor. Especially project specifications, knowledge of the reliability and accuracy of survey equipment is inevitable. Skills in using a total station for several applications in geodetic engineering are fundamental to an accurate measurement process (Chella Kavitha et al., 2018).

Initial findings regarding more learning support through augmented reality in detailing learning materials for transferring total station coordinate data, operating and mastering parts of the total station are in line with previous research conducted by Restika A, Nirwana H, and Asriyadi (Restika et al., 2021) shows that augmented reality can provide a more interactive and exciting experience and in-depth understanding in studying total station equipment components, operations, and data transfer. Additionally, augmented reality supports students in land surveying. Surveyors can leverage AR in any measurement task, but doing so requires a fully developed 3D design model that can combine the existing conditions in their visual tools with simple device requirements (Davidavičienė et al., 2019; Mota et al., 2018; Velázquez & Méndez, 2018).

This paper significantly contributes to assessing the development of vocational students' skills in land surveying through augmented reality media and a team-based project model, ensuring equality between the experimental and control classes before starting the learning experiment. In addition, tests for normality and homogeneity of data variance were carried out using the Shapiro-Wilk test, and the results showed that both classes had a normal distribution. So, the conditions for using the independent sample t-test have been fulfilled. Meanwhile, the homogeneity of variance test using Levene's test was also fulfilled. The independent sample t-test was then analyzed to test the initial skills of vocational school students in land surveying, the difference between the experimental and control classes. The analysis results show that the Sig. (2-tailed) of 0.917, which is more than a probability of 0.05, meaning there is no significant difference in survey competency between the experimental and control classes before the class starts. This is also supported by the t-count value of 0.104 < t-table = 1.997, which means there is no significant difference in land surveying skills between the experimental and control classes. Both classes are equivalent. After the initial behavior of the entire class is declared the same, the total station augmented reality learning media and the team-based project learning model are available to be implemented.

The post-test assessment obtained an average score for the experimental class of 85.36 and the control class of 72.22 on a scale 100. It was included in the Very Good category (Class A) and the Good category (Class B). The increase was 31.79 points from the pre-test 53.57 and post-test 85.36 on a scale 100 for class A. Class A showed much better improvement than class B. Likewise, class B showed a vocational average score with the control class. Students' skills in land surveying, with a score of 18.33

from a pre-test score of 53.89 and 72.22 on a 100 scale post-test.

The normality and variance homogeneity of the post-test data were also assessed. The Shapiro-Wilk test showed a Sig. value of 0.110 for class A and 0.467 for class B. Since both values are greater than 0.05, it indicates that classes A and B have a normal distribution. The homogeneity of variance was assessed using Levene's test, which yielded a Sig. value of 0.956, greater than 0.05, indicating that the post-tests for classes A and B are consistent. Therefore, the prerequisites for the independent samples t-test were met. Additionally, the analysis revealed a Sig. (2-tailed) probability of 0.000, less than 0.05, suggesting a significant difference in land surveying skills between the experimental and control classes. Furthermore, the t-count value (8.649) exceeds the t-table value (1.997), indicating a significant difference in land surveying skills between the experimental and control classes. Therefore, the land surveying skills of vocational students in the two groups differ significantly.

Normalized gain analysis determines the increase in land surveying skills of vocational school students. The average g score for the skills of class A vocational school students in land surveying is $0.3 \leq 0.6962 < 0.7$, the Moderate category, which shows that the skills of class A vocational school students in land surveying have increased by 69.62% after treatment. Implementing a team-based project learning model and augmented reality for total stations. The class B land survey competency g score was $0.3 \leq 0.3861 \leq 0.7$ in the Moderate category, which means that the land survey skills of class B vocational school students increased by 38.61%. Class A experienced much better improvement than class B. The team-based project learning model and augmented reality media for total stations effectively improved vocational school students' land surveying skills.

In line with the results of research conducted by Velázquez F. and Méndez G. (Velázquez & Méndez, 2018) the emergence of new technologies expands the way students access information and, in turn, changes the way they interact and the experiences they encounter. Augmented reality contributes to inclusive, fair, and quality education, as stated by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in Sustainable Development Goal (SDG) 4. Furthermore, augmented reality has the potential as a learning resource, as conveyed by the secondary education learning unit in the technology field. The same research by Ali D., Johari N., and Ahmad A. (Ali et al., 2023) investigating the effectiveness of using augmented reality showed that students in the experimental group showed significantly higher visualization skills than students in the control group after the teaching and learning process. Similar findings were also revealed by Wijayanto B., Luthfi Z., Suci F., Operma S., Pernando J., and Johnstone J. (Wijayanto et al., 2023) reported an increase in students' spatial abilities in the subjects of basics of mapping, remote sensing and geographic information systems in class X odd semester using augmented reality-based mobile learning methods.

Additionally, integrating team-based projects into learning has proven to be a solid approach to instilling technical and scientific skills and encouraging professional development. Picard C., Hardebolle C., Tormey R., and Schiffmann J. (Picard et al., 2022) revealed that team-based projects are invaluable for developing these skills and have been widely added to engineering curricula. As the philosophy of Islam, teamwork is fostered in all facets of human life including team-based projects, that should be developed throughout the students' learning experiences (Taqi-ud-Din Al-Hilali & Muhsin Khan, 2011; Vasinayanuwatana et al., 2021). Team-based projects enhance communication and interprofessional skills; they help students develop a wider range of professional abilities, with significant improvements noted, especially in explicitly taught subjects.

4. CONCLUSION

After implementing the team-based project learning model and using total station augmented reality learning media in the building information modeling and design program at Sukoharjo State Vocational School, vocational school students' skills in land surveying experienced a significant

increase. Surveying competency increased by 31.79 from 53.57 to 85.36. Meanwhile, the post-test results stated a significant difference in survey competency between the experimental and control classes with a t-count value of 8.649>t-table 1.997 and a Sig. value (2-tailed) 0.000<0.05. In addition, the independent sample t-test shows that the initial behavior of the two classes is the same with a t-count of 0.104 <t-table of 1.997 and a Sig. (2-tailed) probability 0.917>0.05. All analysis exams confirm that team-based projects and augmented reality for total stations significantly improve the land surveying skills of vocational students. Additionally, a normalized gain analysis shows a mean g score of 0.6962 for the experimental class's surveying competence. This shows that vocational school students' land surveying skills increased by 69.62% after the experiment. In conclusion, applying a team-based project model using augmented reality effectively improves vocational school students' land surveying skills. Future work will define a contextually better learning experience by paying more attention to the most low-level skills, namely transferring total station coordinate data, operating and describing total station parts, and providing more learning support through augmented reality in detailing learning materials and strengthening team-based projects by getting used to collaborative learning and conditioning to be responsible for each specific teamwork task.

REFERENCES

Aiken, L. R. (1980). Content validity and reliability of single items or questionnaires. *Educational and Psychological Measurement*, *40*(4), 955–959. https://doi.org/10.1177/001316448004000419

Aiken, L. R. (1985). Three coefficients for analyzing the reliability and validity of ratings. *Educational and Psychological Measurement*, *45*(1), 131–142. https://doi.org/10.1177/0013164485451012

Ali, D. F., Johari, N., & Ahmad, A. R. (2023). The effect of augmented reality mobile learning in microeconomic course. *International Journal of Evaluation and Research in Education*, *12*(2). https://doi.org/10.11591/ijere.v12i2.24943

Arena, F., Collotta, M., Pau, G., & Termine, F. (2022). An Overview of Augmented Reality. In *Computers* (Vol. 11, Issue 2). https://doi.org/10.3390/computers11020028

Azwar, S. (2018). *Reliability and validity, 4th edition* (4th ed). Pustaka Pelajar.

Beshr, A. A. A., & Abo Elnaga, I. M. (2011). Investigating the accuracy of digital levels and reflectorless total stations for purposes of geodetic engineering. *Alexandria Engineering Journal*, *50*(4). https://doi.org/10.1016/j.aej.2011.12.004

Carbonell-Carrera, C., Saorin, J. L., Melian, D., & Cantero, J. de la T. (2017). 3D creative teaching-learning strategy in surveying engineering education. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(11). https://doi.org/10.12973/ejmste/78757

Carmigniani, J., Furht, B., Anisetti, M., Ceravolo, P., Damiani, E., & Ivkovic, M. (2011). Augmented reality technologies, systems and applications. *Multimedia Tools and Applications*, *51*(1). https://doi.org/10.1007/s11042-010-0660-6

Chella Kavitha, M. N., Viswanath, R., Kavibharathi, P., Aakash, K., & Balajimanikandan, M. (2018). A comparative study of conventional surveying techniques with total station and GPS. *International Journal of Civil Engineering and Technology*, *9*(1).

Coletta, V. P., & Steinert, J. J. (2020). Why normalized gain should continue to be used in analyzing preinstruction and postinstruction scores on concept inventories. *Physical Review Physics Education Research*, *16*(1). https://doi.org/10.1103/PhysRevPhysEducRes.16.010108

Davidavičienė, V., Raudeliūnienė, J., & Viršilaitė, R. (2019). User experience evaluation and creativity stimulation with augmented reality mobile applications. *Creativity Studies*, *12*(1). https://doi.org/10.3846/cs.2019.3576

Elmqaddem, N. (2019). Augmented Reality and Virtual Reality in education. Myth or reality? *International Journal of Emerging Technologies in Learning*, *14*(3). https://doi.org/10.3991/ijet.v14i03.9289

Fan, M., Antle, A. N., & Warren, J. L. (2020). Augmented Reality for Early Language Learning: A Systematic Review of Augmented Reality Application Design, Instructional Strategies, and Evaluation Outcomes. *Journal of Educational Computing Research*, *58*(6). https://doi.org/10.1177/0735633120927489

Gabriela, M., & Susana, M. (2021). Content Validity of a Questionnaire to Assess Parental Involvement in Education. *European Journal of Psychology and Educational Research*, *4*(2). https://doi.org/10.12973/ejper.4.2.83

Gudoniene, D., & Rutkauskiene, D. (2019). Virtual and augmented reality in education. *Baltic Journal of Modern Computing*, *7*(2). https://doi.org/10.22364/bjmc.2019.7.2.07

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1). https://doi.org/10.1119/1.18809

Ibáñez, M. B., & Delgado-Kloos, C. (2018). Augmented reality for STEM learning: A systematic review. *Computers and Education*, *123*. https://doi.org/10.1016/j.compedu.2018.05.002

Indahsari, L., & Sumirat, S. (2023). Implementasi Teknologi Augmented Reality dalam Pembelajaran Interaktif. *Cognoscere: Jurnal Komunikasi Dan Media Pendidikan*, *1*(1). https://doi.org/10.61292/cognoscere.v1i1.20

Kamińska, D., Zwoliński, G., Laska-Leśniewicz, A., Raposo, R., Vairinhos, M., Pereira, E., Urem, F., Ljubić Hinić, M., Haamer, R. E., & Anbarjafari, G. (2023). Augmented Reality: Current and New Trends in Education. In *Electronics (Switzerland)* (Vol. 12, Issue 16). https://doi.org/10.3390/electronics12163531

Kazimierczak, N., Kazimierczak, W., Serafin, Z., Nowicki, P., Jankowski, T., Jankowska, A., & Janiszewska-Olszowska, J. (2024). Skeletal facial asymmetry: reliability of manual and artificial intelligence-driven analysis. *Dento Maxillo Facial Radiology*, *53*(1). https://doi.org/10.1093/dmfr/twad006

Khan, T., Johnston, K., & Ophoff, J. (2019). The Impact of an Augmented Reality Application on Learning Motivation of Students. *Advances in Human-Computer Interaction*, *2019*. https://doi.org/10.1155/2019/7208494

Morgan, G. A., Barrett, K. C., Leech, N. L., A., & Gloeckner, G. W. (2019). *IBM SPSS for Introductory Statistics: Use and Interpretation* (DI, Ed.; 6th Edition, pp. 1–266). Routledge. https://doi.org/https://doi.org/10.4324/9780429287657

Mota, J. M., Ruiz-Rube, I., Dodero, J. M., & Arnedillo-Sánchez, I. (2018). Augmented reality mobile app development for all. *Computers and Electrical Engineering*, *65*. https://doi.org/10.1016/j.compeleceng.2017.08.025

Mulyana, Y. A., Setiawan, I. R., & Lelah, L. (2020). Rancang Bangun Media Pembelajaran Augmented Reality Mengenal Alat Musik Degung. *Jurnal Teknik Informatika Dan Sistem Informasi*, *6*(2). https://doi.org/10.28932/jutisi.v6i2.2699

Picard, C., Hardebolle, C., Tormey, R., & Schiffmann, J. (2022). Which professional skills do students learn in engineering team-based projects? *European Journal of Engineering Education*, *47*(2). https://doi.org/10.1080/03043797.2021.1920890

Rauschnabel, P. A., Babin, B. J., tom Dieck, M. C., Krey, N., & Jung, T. (2022). What is augmented reality marketing? Its definition, complexity, and future. In *Journal of Business Research* (Vol. 142). https://doi.org/10.1016/j.jbusres.2021.12.084

Restika, A. P., Nirwana, H., & Asriyadi. (2021). Implementasi Augmented Reality Sebagai Media Pembelajaran untuk Pengenalan Komponen Total Station. *Prosiding Seminar Nasional Teknik Elektro Dan Informatika (SNTEI)*, 208–214. https://jurnal.poliupg.ac.id/index.php/sntei/article/view/2866/2518

Samala, A. D., & Amanda, M. (2023). Immersive Learning Experience Design (ILXD): Augmented Reality Mobile Application for Placing and Interacting with 3D Learning Objects in Engineering Education. *International Journal of Interactive Mobile Technologies*, *17*(5). https://doi.org/10.3991/ijim.v17i05.37067

Sari, I. P., Batubara, I. H., Hazidar, A. H., & Basri, M. (2022). Pengenalan Bangun Ruang Menggunakan Augmented Reality sebagai Media Pembelajaran. *Hello World Jurnal Ilmu Komputer*, *1*(4). https://doi.org/10.56211/helloworld.v1i4.142

Setiawan, A. H. (2022). Enhancing collaborative mindset by lebnded online learning platform in a civil engineering education course. *Journal of East Asian Studies*, *20*(3), 1–35. http://petit.lib.yamaguchi-u.ac.jp/28854/files/165507

Setiawan, A. H., & Takaoka, R. (2020). Designing PBL steps in vocational course based on students' readiness and teachers' discussion. In Mashoedah, I. Hidayatulloh, N. Hidayat, & I. W. Djatmiko (Eds.), *Journal of Physics: Conference Series*. IOP. https://doi.org/10.1088/1742-6596/1456/1/012045

Setiawan, A. H., Takaoka, R., Ge, Q.-W., Nakata, M., Trianingsih, L., Murtiono, E. S., Arfandi, A., & Mitsuhara, H. (2024). Using total station in surveying course for increasing the vocational student competence. In A. Kusumastuti, S. Anis, A. N. Hidayanto, S. Nurmasitah, A. Atika, A. B. Utomo, D. Apriyani, D. F. Fitriyana, A. Bahatmaka, R. Rachmawati, & A. N. NurulIhsani (Eds.), *5th Vocational Education International Conference (VEIC 2023)* (pp. 775–782). Atlantis.

Setiawan, A. H., Takaoka, R., Tamrin, A., Roemintoyo, Murtiono, E. S., & Trianingsih, L. (2021). Contribution of collaborative skill toward construction drawing skill for developing vocational course. *Open Engineering*, *11*, 755–771. https://doi.org/10.1515/eng-2021-0073

Setiawan, A. H., Takaoka, R., & Trianingsih, L. (2020). Investigation of Vocational Students' Skills for Determining Learning Experiences on CAD Construction Drawing Course. *IEEE International Conference on Engineering, Technology and Education, TALE*.

Sugiyono. (2017). Metode Penelitian kuantitatif, kualitatif, dan R&D. In *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. CV. Alfabeta.

Syed, T. A., Siddiqui, M. S., Abdullah, H. B., Jan, S., Namoun, A., Alzahrani, A., Nadeem, A., & Alkhodre, A. B. (2023). In-Depth Review of Augmented Reality: Tracking Technologies, Development Tools, AR Displays, Collaborative AR, and Security Concerns. In *Sensors* (Vol. 23, Issue 1). https://doi.org/10.3390/s23010146

Taqi-ud-Din Al-Hilali, M., & Muhsin Khan, M. (2011). *Interpretation of the Meaning of The Noble Qur'an* (Revised). Darussalam. https://onlineislamicbook.com/noble-quran-medium-size-8-7-x-6-0-x-1-8-inch/

Tasrif, E., Mubai, A., Huda, A., & Rukun, K. (2020). Pemanfaatan media pembelajaran berbasis augmented reality menggunakan aplikasi Ar_Jarkom pada mata kuliah instalasi jaringan komputer. *Jurnal Konseling Dan Pendidikan*, *8*(3). https://doi.org/10.29210/153400

UNESCO-UNEVOC. (2013). World TVET database Indonesia. In *UNESCO-UNEVOC International Centre for TVET*. https://doi.org/10.4324/9781410610348

Vasinayanuwatana, T., Teo, T. W., & Ketsing, J. (2021). Shura-infused STEM professional learning community in an Islamic School in Thailand. *Cultural Studies of Science Education*, *16*(1), 109–139. https://doi.org/10.1007/s11422-020-09990-8

Velázquez, F. del C., & Méndez, G. M. (2018). Augmented reality and mobile devices: A binominal methodological resource for inclusive education (SDG 4). an example in secondary education. *Sustainability (Switzerland)*, *10*(10). https://doi.org/10.3390/su10103446

Wijayanto, B., Luthfi, Z. F., Suci, F. R. Z., Operma, S., Pernando, J., & Johnstone, J. M. (2023). Augmented Reality-Based Mobile Learning: Enhancing Student Spatial Intelligence. *Journal of Higher Education Theory and Practice*, *23*(9). https://doi.org/10.33423/jhetp.v23i9.6135

Yulianti, S., Premana, A., & Bachri, O. S. (2022). Penerapan Augmented Reality Sebagai Media Pembelajaran Materi Rumah Adat Indonesia Di Sekolah Dasar Kabupaten Brebes. *Jurnal Ilmiah Infokam*, *18*(2). https://doi.org/10.53845/infokam.v18i2.323

Zhou, J., Xiao, H., Jiang, W., Bai, W., & Liu, G. (2020). Automatic subway tunnel displacement monitoring using robotic total station. *Measurement: Journal of the International Measurement Confederation*, *151*. https://doi.org/10.1016/j.measurement.2019.107251