Using Total Station in Surveying Course for Increasing the Vocational Student Competence

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ABSTRACT
This research aims to increase the civil engineering education students' competence in surveying courses, especially in using modern surveying tools through implementing Digital Total Station. The method used is an experiment by surveying practice to determine the increase in student competence before and after attending courses. Data analysis was carried out descriptively, paired sample t-test and N-gain. Descriptive analysis shows that the average score of students' competence on the pre-test is 64.07, and the post-test is 84.54 on a scale of 100. Furthermore, based on the N-gain test, the average N-gain value is 0.5856, which is in the N-gain interval of $0.3 \leq g < 0.7$ medium categories, which means that student competency increased by 58.56% after attending a course for three months. Paired sample t-test analysis found a significant increase in competence with a significant correlation of 0.982 and Sig. 0.000 < 0.05 between the pre-test and post-test. In addition, the paired sample t-test shows t-count 87.995 > t-table 2.056 and the value of Sig. (2-tailed) 0.000 < 0.05 probability, meaning that there is an average difference between student competencies during the pre-test and post-test. Based on the analysis test, it can be concluded that surveying lectures using survey tools and Total Station mapping can significantly increase student competence.

Keywords: *Total Station, Surveying Competency, Vocational Student, Topographic Map.*

1. INTRODUCTION

Land surveying is a vital field that involves the measurement and mapping of the Earth's surface to determine land boundaries, topography, and spatial data for various purposes. To ensure students acquire a high level of competence in land surveying, the utilization of modern tools and technologies is crucial. One such instrument that has revolutionized the field is the Total Station, a sophisticated electronic device that combines electronic distance measurement (EDM) with a theodolite for precise measurements.

Enhancing student competence in land surveying, particularly in the utilization of Total Station instruments, requires an effective learning strategy that incorporates best practices from the field. The use of modern technologies and teaching methodologies can significantly contribute to students' understanding and proficiency in this important domain. It will outline a learning strategy supported by relevant references to guide educators in fostering student competence in land surveying using Total Station instruments [1]. It emphasizes the importance of interaction and collaboration among students. Students actively participate in discussions, problem-solving, and decision-making by working in small groups or pairs [2][3][4]. They share their knowledge, exchange ideas, and collectively construct meaning, which leads to a deeper understanding and retention of land surveying concepts.

Educational research continually seeks innovative strategies to enhance student learning and engagement. The team-based project learning strategy is an effective approach for enhancing student competence in land

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surveying, particularly in utilizing Total Station instruments [5]. This methodology revolves around collaborative projects where students work in teams to tackle real-world surveying challenges. By engaging in hands-on, practical projects that require teamwork, problem-solving, and application of knowledge, students develop a deeper understanding of land surveying principles and gain valuable skills [6].

Students can leverage their collective knowledge, skills, and perspectives to solve complex land surveying problems by working in teams. This collaborative environment not only mirrors real-world surveying projects but also promotes effective communication, cooperation, and teamwork, which are essential skills in the field [7][8][9].

Combining multiple effective approaches can lead to even greater educational outcomes. This study integrates team-based projects, cooperative learning, and the flipped classroom model as a comprehensive strategy for improving student competence in various subjects [10]. Specifically, it focuses on applying this combined approach in land surveying education using Total Station instruments. By leveraging the benefits of team collaboration, cooperative learning, and the flipped classroom, educators can create an enriched learning experience that fosters critical thinking, problem-solving, and deeper understanding [11].

Team-based projects: (1) Students are divided into teams and given a surveying project; (2) Each team plans and executes the project cooperatively using Total Station equipment; (3) Team members collaborate by assigning roles and responsibilities, and (4) Regular team meetings and progress updates are held to ensure coordination and communication.

Cooperative Learning: (1) Students participate in cooperative learning activities such as group discussions and problem-solving exercises within their teams; (2) Peer teaching and mentoring is encouraged, where students share their knowledge, skills, and experiences; (3) Students actively participate in group activities, fostering teamwork, collaboration, and effective communication; (4) Students receive constructive feedback and evaluation from peers to improve learning outcomes.

Flipped classrooms follow the following structure: (1) Students use an online learning platform to access instructional materials, such as video lectures and reading materials, related to surveying concepts and techniques; (2) Outside of class, students independently review the materials and gain a basic understanding of the topics; (3) In-class sessions concentrate on practical applications, hands-on exercises, and discussions related to the pre-learned content. (4) The instructor leads interactive sessions, answers questions, and helps students apply their learning to practical situations.

E-learning: (1) e-learning platforms are used to supplement classroom instruction with extra materials like interactive modules, simulations, and quizzes; (2) students have access to online forums or discussion boards to promote virtual collaboration and knowledge sharing; (3) online assessments and quizzes are administered to assess students' understanding and progress; and (4) the e-learning platform serves as a repository of resources, allowing students to search through a variety of online databases.

2. METHOD

As experiment research, all students in the fourth semester participate in this study, February-July 2023. The surveying competence was evaluated by an assessment rubric with eight indicators, as displayed in Table 1. The assessment was given at the first meeting to reveal students' initial competence. After the mid-semester of the student learning activity as the experiment, an evaluation was conducted on the students to know the enhancement of surveying competence.

Table 1. Assessment rubric with eight indicators.

Basic competence	Indicators
Surveying	1. Classifying the surveying tool 2. Defining the land survey theory using Total Station 3. Explaining the parts of Total Station 4. Operating the Total Station 5. Measuring and processing the open polygonal traverse data in land surveying 6. Measuring and processing the close polygonal traverse data in land surveying 7. Transferring the Total Station coordinate data 8. Drawing the surveying result

The instrument was examined using the content validity test with the raters' agreement index proposed by Aiken V. The four raters consist of lecturers and industrial practitioners. An index value of V $\geqslant$ 0.40 is considered valid as the assumption [12][13]. The validity test used the Aiken V raters agreement index to examine the assessment rubric. The raters include experts from industry and academicians.

The formula is described as equation (1).

$$V = \frac{\sum s}{n(c-1)}$$

$$V_{for\ 8\ items} = \frac{\sum s_{for\ 8\ items}}{n(c-1)} = \frac{10.63}{4(4-1)} = 0.89 \qquad (1)$$

V means the raters' agreement index, s means the raters' score minus the lowest score in the category used ($s = r - I_0$, with r = rater's score, and I_0 the lowest score in the category of scoring), n means the number of raters, c

means the number of scores to be selected by raters. The content validity is 0.89, which is higher than the value of the V index of 0.40. It means the assessment instruments are valid.

The Interclass Correlation Coefficient (ICC) formula is used for the instrument's reliability, and the ICC value of more than 0.75 is used for the reliable assumption (ICC value ⩾ 0.75) [14]. The formula defines as follows:

$$\frac{MS_{people} - MS_{residual}}{MS_{people} + (df_{people}\ x\ MS_{residual})}$$

$$r = \frac{0.92-0.031}{0.92+(3\ x\ 0.031)} = 0.877 \quad (2)$$

r refers to the coefficients of ICC, MS_{people} is mean square between people, $MS_{residual}$ refers to the mean square within people residual, and df_{people} is degree of freedom within people. The reliability test results of the surveying competence assessment rubric using the IBM SPSS showed that the ICC reliability coefficient value of 0.877 fulfills the requirement of the ICC reliability coefficient value ⩾ 0.75. It means that the surveying competence assessment rubric is reliable.

The study analysed the data by descriptive statistics, paired sample t-test, and N-gain. The descriptive statistics describe the surveying competence on the pre-test and post-test by displaying the mean, frequency distribution, and histogram. Students surveying competence data are categorized based on criteria: very good, good, fair, low, and very low [15].

The data then analysed by a paired sample t-test to determine whether statistically significant variations exist between initial and after-experiment competence. Two applications for paired sample t-tests exist: (1) by comparing the Sig. (2-tailed) with a probability of 0.05. If the value of Sig. (2-tailed) probability is less than 0.05, which means the Null Hypothesis (H0) is rejected, and the Alternative Hypothesis (Ha) is accepted, which means there is a significant difference in students surveying competence between the pre-test and post-test. The Alternative Hypothesis is rejected, and the Null Hypothesis is accepted if the value of Sig. (2-tailed) is greater than 0.05, implying no appreciable change in the students' surveying competence between the pre and post-test. (2) the critical value table of the t distribution contains the assumption that t-count > t-table with a 5% probability (1-tailed), rejecting the null hypothesis and accepting the alternative. The results indicate that surveying competence significantly improved between the pre- and post-test. The Shapiro Wilk test, part of the Analysis precondition test, is required to determine whether the data have a normal distribution before applying the paired sample t-test. When the value of Sig. exceeds the 5% stated alpha level, the assumption of a normal distribution is made [16].

Normalized gain analysis, or N-gain, is to ascertain whether the trials conducted increased the surveying competence. The following is the formula for normalized gain analysis [17].

$$g = \frac{S_f - S_i}{100 - S_i} \quad (3)$$

g refers to the gain score, Sf is the post-test final score, and Si is the pre-test starting score. The criteria for the gain level between the pre-test and post-test scores used to interpret the normalized gain analysis computation are high, medium, and low.

3. RESULT

To ascertain how employing team-based projects, cooperative learning, and flipped classrooms using e-vocational platforms can improve the students' surveying competency. The pre-test assessment tool was used to monitor the beginning conditions to determine whether there had been an improvement in surveying competence in the following experiment. The average score on the surveying competence pre-test is 64.07 out of 100. It is in the intermediate group, as determined by Azwar's evaluation criteria, with a value range of 56.26-68.75. The post-test evaluation also revealed that, on a scale of 100, the average rating for students surveying competence is 84.54. With a range of values > 81.25, it met the assessment criteria and was put in the very high category. The average value for surveying competence based on pre and post-tests is shown in Figure 1.

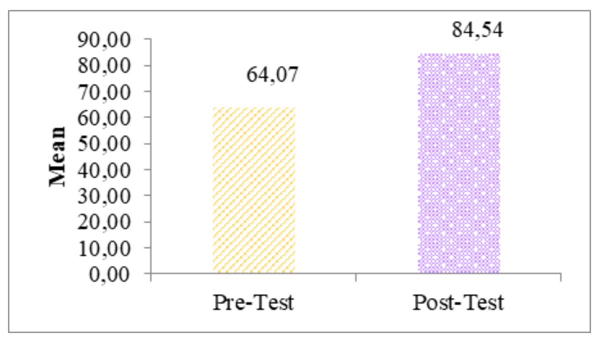

Figure 1 Surveying competence pre dan post-test.

The results of the descriptive analysis of the pre-test and post-test surveying competence are presented in Table 2 as follows.

Table 2. Descriptive analysis of students' surveying competence summary.

	Descriptive Statistics				
	N	**Min**	**Max**	**Mean**	**Std. Deviation**
Pre-Test	27	50	75	64,07	5,89
Post-Test		70	97.5	84,54	6,24
The mean value increase				20,46	

According to Table 2, the pre-test mean was 64.07, and the post-test mean was 84.54. The highest pre-test score was 75, and the post-test score was 97.5. The lowest score was 50 for the pre-test, and the post-test score was 70, with a 5.89 pre-test and a 6.24 post-test of standard deviation. Table 3 below lists further findings from the descriptive analysis of surveying competency indicators.

Table 3. The descriptive analysis of pre-test surveying competency indicators summary.

Num	Basic competence	Mean	Category
1	Classifying the surveying tool	80,74	High
2	Defining the land survey theory using Total Station	74,07	High
3	Explaining the parts of Total Station	48,15	Low
4	Operating the Total Station	45,19	Low
5	Measuring and processing the open polygonal traverse data in land surveying	72,59	High
6	Measuring and processing the close polygonal traverse data in land surveying	74,07	High
7	Transferring the Total Station coordinate data	49,63	Low
8	Drawing the surveying result	68,15	Medium

Prior to the experiment, students' initial surveying competence must be assessed. The students' deficiencies must be identified properly. Table 3 shows the indicators of student surveying proficiency with the lowest average score. With an average value of 45.19, the fourth indication, operating the total station, has the lowest average value. Indicators 3, Explaining the Parts of the Total Station, with an average value of 48.15, and 7, Transferring the Coordinate Data from the Total Station, with an average value of 49.63.

The pre-test and post-test data are also examined using the paired sample t-test to determine whether there is a significant difference. The paired sample t-test was examined to ascertain any variations between surveying proficiency before and after the experiment. To ensure the data is normally distributed using the Shapiro-Wilk test method, a preliminary analysis test is required before applying the paired sample t-test. When the value of Sig. exceeds the designated alpha level of 5%, the normal distribution assumption is demonstrated. Table 4 gives an overview of the data normality test.

According to the results of the Shapiro-Wilk test, the pre-test, and post-test surveying competency data are normally distributed because the values of Sig. pre-test 0.406 and post-test 0.414 are both Sig. > 0.05. As a result, the paired sample t-test's prerequisites and assumptions of normality have been met. The paired sample t-test was run following the necessary analytical test to ensure normality, and the results were then examined to see if there were any changes between the pre and post-experiment surveying competency levels. The analysis's findings indicate that the Alternative Hypothesis is accepted and the Null Hypothesis is rejected when the value of Sig. (2-tailed) pre-test and post-test is 0.000 or less than probability 0.05, meaning there is a significant difference in surveying competency between the pre and post-test.

Table 4. Summary of data normality test.

Research topic	Group	Shapiro-Wilk		Conclusion
		df	Sig.	
Using total station in surveying course for increasing the vocational student competence	*Pre-Test*	27	0,406	Normal
	Post-Test	27	0,414	Normal

Therefore, the alternative hypothesis is accepted, and the null hypothesis is rejected because of t-count = 87.995 > t-table with $d_f = 26$ and 0.05. The conclusion is that the surveying competency between the pre-test and post-test differs significantly. As a result, the average pre-test and post-test surveying competence increased, with the average value increasing by 20.46 from 64.07 to 84.54, and the correlation value (r) between the pre-test and post-test surveying competencies was 0.982, with Sig. 0.000 is less than 0.05. Table 5 below summarizes the analysis of the paired sample t-test.

Table 5. Analysis of paired sample t-test summary.

Pair	Paired Samples Correlations		Paired Differences		Paired Samples Test	
	Correlation	Sig.	Mean	t	df	Sig. (2-tailed)
Pre-Test – Post-Test	0,982	0,000	-20,463	-87,995	26	0,000

Additionally, a normalized gain analysis was conducted with the interpretation of $g < 0.3$ low, $0.3 \leqslant g < 0.7$ medium, and $g \geqslant 0.7$ high to determine the increase in pre-test and post-test survey competence [17]. Table 6 gives a summary of the normalized gain analysis.

According to Table 6, the average g score for surveying competence is 0.5856 in the range of $0.3 \leqslant 0.5856 < 0.7$, which indicates that after a mid-semester learning process in the surveying course, the surveying competence increases by 58.56%. Therefore, combining team-based projects, cooperative learning, flipped classrooms, and e-vocational platforms in a total station surveying course is advantageous to increase student surveying competency. Based on the analytical tests' results, flipped classrooms using e-vocational platforms combined with team-based projects and cooperative learning can considerably increase surveying competency.

Table 6. Summary of normalized gain analysis (N-Gain).

Basic competence	N-Gain Score (g)			Conclusion
	Mean	Min.	Max.	
Surveying	0.5856	0.40	0.90	Medium

4. DISCUSSION

Assessing students' initial land surveying competence is crucial before conducting the experiment. Table 3 provides an overview of the indicators of surveying proficiency with the lowest average scores. Among these indicators, operating the total station (indicator 4) has the lowest average value of 45.19. Explaining the parts of the total station (indicator 3) and transferring the coordinate data from the total station (indicator 7) also scored relatively low, with average values of 48.15 and 49.63, respectively.

The findings from the pre-test assessment indicated that the average score on the surveying competence pre-test was 64.07 out of 100. According to Azwar's evaluation criteria, this score falls within the intermediate group, which ranges from 56.26 to 68.75. These results suggest that students had a moderate level of surveying competency before the intervention.

A post-test evaluation was conducted to assess the students surveying competence after implementing team-based projects, cooperative learning, and flipped classrooms using e-vocational platforms. The average rating for surveying competence in the post-test was 84.54 on a scale 100. This score exceeds the assessment criteria, which indicates a significant improvement in students' surveying competency. With a range of values greater than 81.25, the post-test score falls into the very high category according to Azwar's evaluation criteria.

To determine whether there is a significant difference between pre-test and post-test surveying competency, the paired sample t-test was conducted. Before applying the t-test, a preliminary analysis test was performed to ensure the data followed a normal distribution using the Shapiro-Wilk test method. If the calculated p-value (Sig.) is greater than the predetermined alpha level of 5%, it indicates that the normal distribution assumption is met. Table 4 presents the results of the data normality test.

Based on the Shapiro-Wilk test results, both the pre-test and post-test surveying competency data were found to be normally distributed, as indicated by Sig. values of 0.406 for the pre-test and 0.414 for the post-test, exceeding the significance level of 0.05. Therefore, the prerequisites and assumptions of normality for the paired sample t-test were satisfied. The t-test was then performed to examine whether there were any significant changes in surveying competency between the pre and post-experiment phases.

The analysis results indicate that the Alternative Hypothesis is accepted, and the Null Hypothesis is rejected, as the p-value (Sig.) for both the pre-test and post-test is 0.000, less than the significance level of 0.05. This finding suggests a significant difference in surveying competency between the pre and post-test phases. Furthermore, the alternative hypothesis is accepted, and the null hypothesis is rejected, as t-count (87.995) is greater than the critical t-table value with the degrees of freedom (d_f) of 26 and a significance level of 0.05. Therefore, it can be concluded that there is a significant difference in surveying competency between the pre-test and post-test.

In addition to the analysis conducted earlier, a normalized gain analysis was performed to assess the increase in surveying competence between the pre-test and post-test phases. According to Table 6, the average g score for surveying competence is 0.5856, falling within the range of $0.3 \leq 0.5856 < 0.7$. This indicates that after the mid-semester learning process in the surveying course, there is a medium increase in surveying competence by 58.56%. The normalized gain analysis further supports the effectiveness of combining team-based projects, cooperative learning, flipped classrooms, and e-vocational platforms in enhancing students' surveying competency.

The results of the analytical tests consistently demonstrate that the integration of flipped classrooms using e-vocational platforms with team-based projects and cooperative learning significantly improves surveying competency. The combination of these strategies creates a conducive learning environment where students actively engage in collaborative activities, apply their knowledge practically, and access instructional materials through e-vocational platforms. This multifaceted approach facilitates a deeper understanding of surveying concepts, enhances critical thinking skills, and improves problem-solving abilities.

The substantial increase in the post-test scores suggests that the combined use of team-based projects, cooperative learning, and flipped classrooms using e-vocational platforms positively impacted students' surveying competence. This intervention allowed students to actively engage in collaborative activities, apply their knowledge in practical projects, and access instructional materials through e-vocational platforms.

These strategies likely facilitated a deeper understanding of surveying concepts, enhanced critical thinking skills, and improved problem-solving abilities.

Using team-based projects allowed students to work collaboratively, fostering effective communication, cooperation, and teamwork skills. This collaborative environment mirrors real-world surveying projects, allowing students to develop practical skills applicable in professional settings. Cooperative learning activities further supported students' engagement and interaction, promoting peer learning, knowledge sharing, and clarification of concepts [18].[19] The flipped classroom approach allowed students to engage with instructional materials outside of class, enabling more interactive and application-focused in-class sessions.

The findings of this study highlight the potential of integrating team-based projects, cooperative learning, and flipped classrooms using e-vocational platforms to enhance students' surveying competency.

5. CONCLUSION AND FUTURE RESEARCH

The statistical analysis confirms that there is a significant improvement in surveying competency between the pre and post-test phases. The average surveying competence increased. These findings support the effectiveness of the employed team-based projects, cooperative learning, and flipped classroom approach in enhancing students' surveying competence. It improving students' understanding of surveying concepts, critical thinking skills, and problem-solving abilities. These findings support the implementation of these strategies in surveying education to enhance students' competence and prepare them for professional practice.

Combining team-based projects, cooperative learning, flipped classrooms, and e-vocational platforms in the total station surveying course significantly increases student surveying competency. The analytical tests consistently support the effectiveness of these strategies, emphasizing their role in enhancing students' understanding, skills, and overall performance in the field of land surveying.

The future work is increasing student surveying competence with special priority in indicator 4, operating the total station; indicator 3. explaining the parts of the total station; and Indicator 7, transferring the coordinate data from the total station by developing a learning strategy to support the three indicators through integrating e-vocational learning platform.

AUTHORS' CONTRIBUTIONS

Abdul Haris Setiawan[1*]: Conceptualization, methodology, data collection, and writing of the original draft.

Ryo Takaoka[2]: Supervision, interpretation, and critical review of the manuscript.
Qi-Wei Ge[2]: Supervision, interpretation, and critical review of the manuscript.
Mitsuru Nakata[2]: Supervision, interpretation, and critical review of the manuscript.

Lilis Trianingsih[1]: Data analysis, interpretation, Literature review, editing, and final approval of the manuscript.

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Anas Arfandi[3]: Supervision, interpretation, and critical review of the manuscript.

Hiroyuki Mitsuhara[4]: Supervision, interpretation, and critical review of the manuscript.

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