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PEER TUTORING WITH XCHART UTILIZATION: ENHANCING STUDENTS' PROBLEM-SOLVING SKILLS AND SELF-DIRECTED LEARNING

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ABSTRAK

Penelitian ini mengeksplorasi pengaruh penggunaan XChart dan penerapan peer tutoring terhadap kemampuan pemecahan masalah dan kemandirian belajar siswa pada pendidikan matematika. Metode penelitian yang digunakan adalah desain penelitian eksperimen dengan kelompok kontrol. Hasil penelitian menunjukkan adanya peningkatan yang signifikan pada kemampuan pemecahan masalah dan kemandirian belajar siswa pada kelompok eksperimen dibandingkan dengan kelompok kontrol. Penelitian ini menyimpulkan bahwa penggunaan XChart dan penerapan peer tutoring dapat meningkatkan kemampuan pemecahan masalah dan kemandirian belajar siswa pada pendidikan matematika. Implikasi penelitian ini mendukung penggunaan kombinasi tersebut dalam pembelajaran matematika siswa.

ABSTRACT

This study explores the effect of using XChart and applying peer tutoring to problem-solving abilities and student learning independence in mathematics education. The research method used is an experimental research design with a control group. The study results showed a significant increase in the problem-solving abilities and students' learning independence in the experimental group compared to the control group. This study concludes that using XChart and applying peer tutoring can improve problem-solving abilities and student learning independence in mathematics education. This research's implications support using this combination in students' mathematics learning.

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INTRODUCTION

Mathematics education is essential to educating the nation's life, as explained in the 1945 Constitution. The learning process is an essential factor in human resource quality. It is critical to improve student learning freedom in the context of mathematics learning. Technology, such as mathematics software and mobile applications, provides new avenues for enhancing student learning independence. Previous studies have demonstrated that technology can help students learn to solve mathematical problems and explore concepts independently (Batubara, 2020). Mathematical problem-solving abilities are crucial for students because they teach them how to solve issues correctly using information, skills, and understanding. Using XChart to improve problem-solving skills is one approach.

XChart is a popular charting application for quickly creating graphs and data visualizations. XChart has emerged as a leading choice for software developers and data analysts over the last decade. XChart is well-known for its robust features, comprehensive documentation, and active community support. With XChart, users may construct numerous charts, including line, bar, pie, and area charts, and personalize their appearance and integrate them with multiple platforms (Pyzdek, 2021).

Several relevant research in mathematics instruction have been undertaken utilizing XChart and peer tutors. However, research has yet to investigate the combination of these two characteristics precisely. Utilizing XChart helps detect measurement mistakes (Maleki et al., 2023). Discovered that utilizing XChart unknown process parameters based on average process length. Although prior studies have made significant contributions, research has yet to mainly investigate the combination of the usage of XChart and the application of peer tutoring in increasing problem-solving abilities and student learning independence in mathematics education (Hu et al., 2023). As a result, this study is unique because it focuses on merging these two aspects, which can provide more thorough knowledge and more effective strategies for boosting kids' mathematics learning.

This study fills a significant research gap by emphasizing the unique integration between using XChart as a visualization tool and applying peer guidance in improving problem-solving skills and student learning independence in mathematics education. Previous research has explored using XChart in the context of learning mathematics and peer guidance. However, no research combines the two holistically in the context of mathematics education. The main innovation in this study is the emphasis on using XChart as a visualization tool supported by peer guidance. This approach has the potential to have a significant impact on improving students' problem-solving skills and their ability to learn independently. Given the complexity of today's educational demands, this research can contribute to creating innovative and practical approaches to mathematics that prepare students with strong problem-solving skills and the ability to manage their learning. This is an important endeavor to fill existing research gaps and promote a deeper understanding of how visualization technologies and social interactions between students can shape a more successful mathematics education in the future.

In mathematics education, the issue is a need for problem-solving capacity and student learning freedom (Asih & Ramdhani, 2019). This is evidenced by a lack of conceptual comprehension, difficulties implementing problem-solving procedures, and limitations in dealing with unexpected mathematical circumstances. Previous research has shown weaknesses in problem-solving skills and student learning independence (Reski et al., 2019). The research hypothesis is the combined effect of using XChart as a visualization tool and peer guidance on students' problem-solving abilities and independent learning in mathematics education.

To address this issue, use XChart as a visualization tool that aids problem-solving and incorporates peer tutors in providing student feedback and help. This strategy will empower students to build problem-solving abilities and gain learning independence. The study investigated the combined effect of using XChart as a visualization tool and peer guidance on students' problem-solving abilities and independent learning in mathematics education. This research will likely contribute to developing practical and creative mathematics learning techniques by providing a more thorough understanding of the potential of these two aspects.

METHODOLOGY

Research design

The following stages were included in the research design: 1) Designation of two high school classes as the experimental and control groups. 2) The pre-test stage assesses students' problem-solving ability and learning independence before the intervention. 3) The experimental group received intervention via XChart and peer tutors, while the control group continued to learn as usual. 4) A post-test is administered following the session to assess students' problem-solving ability and learning independence. 5) The acquired data will be examined statistically using different t-tests and descriptive analysis techniques.

The intervention period for the experimental group that will use XChart and peer tutors is planned to last two weeks. During this period, students in the experimental group will engage in in-depth mathematics learning that combines using XChart as a visualization tool with peer guidance. The duration of 2 weeks was chosen to allow sufficient time for students to adapt to this new learning technique and measure its long-term impact on improving their problem-solving skills and independent learning in the context of mathematics education.

Types of research

The research method employed is quasi-experimental quantitative research. Quantitative research is a planned, systematic, and closely controlled experiment in functional and factorial designs. This is consistent with (Nugroho, 2018), who stated that quantitative research methods are utilized to determine the effect of various treatments on an item. This study's research design is Quasi-Experimental, a form of quantitative research design. The Nonequievalent Pretest-Posttest Control Group Design is the quasi-experimental form used.

The quasi-experimental design, in particular the "Nonequivalent Pretest-Posttest Control Group Design," is particularly suitable for this study because it allows comparisons between the experimental group (which received intervention with XChart and peer tutoring) and the control group (without intervention). By collecting data before and after the intervention from both groups, this design allows a robust assessment of the impact of the intervention on problem-solving skills and learning independence. This design is essential because we can identify the changes caused by the intervention while also controlling for outside factors that could influence the outcome. This allows for a robust evaluation of the effectiveness of using XChart and peer tutoring in enhancing students' problem-solving skills and independent learning.

Research subject

SMPN 3 Cilegon City was selected as the research location based on several factors. First, this school is considered representative of many secondary schools in the surrounding area in terms of curriculum structure and student characteristics. Second, this school provides the necessary permits and cooperation to conduct research. Class VII students are selected because they are in the early secondary education stage, which is essential in developing problem-solving and independent learning. Random class selection ensured that the experimental and control groups had similar initial characteristics. Class VII (H) was used as the control group with 32 students (18 girls and 14 boys), while class VII (I) was used as the experimental group with 32 students (16 girls and 16 boys). The random class selection process helped avoid bias and ensured that the study results could be more generally applied to VII-grade students at other secondary schools. This ensures an accurate evaluation of the impact of the interventions tested in the research.

The experimental group in this study learned utilizing XChart learning material, whereas the control group received traditional instruction. Both the control and experimental groups were given a pre-test before learning and a post-test after learning was finished. Preliminary examinations assess students' ability to solve mathematical problems, and post-tests demonstrate students' independent learning after learning. Normalized gain (N-gain) improves pupils' mathematical problem-solving ability.

Research Data Collection Techniques

In this study, exams and questionnaires were utilized to collect data. Tests are given to students to determine their initial and final ability. The distributed exam is a problem-solving ability test consisting of 5 essay-style questions. The survey was designed to assess the efficiency of XChart media in supporting student learning independence. The questionnaire contained 20 items of favorable and unfavorable opinions.

Tests were used to collect data on mathematical problem-solving abilities. The test is a method of gathering data to measure or discover the outcomes of observations or research on a subject. The pretest-posttest method is applied. Before being used, the exam items were validated by an experienced validator and tested on class VIII students who were one level above them. The expert validator is a lecturer in mathematics education from Bina Bangsa University who declares that it is valid and that the test can be used. Subsequent exams on class VIII pupils included validity, reliability, item difficulty index, and discriminating power assessments. The validity test results were 0.88, indicating that the test instrument was valid; the reliability test results were 0.94 with very high criteria, indicating that the test instrument would produce relatively similar results for all subjects; the difficulty level test results indicated that there were one easy question, three moderate questions, and one complex item; and the discriminating power test results indicated that there were two moderate questions and three good questions, indicating that all questions could be used.

The questionnaire used to collect data on student learning independence in this study was developed carefully to avoid redundancy. This questionnaire is an essential instrument in measuring the impact of interventions on student learning independence. The following steps were taken to ensure the reliability and validity of the questionnaire: Question Development: The research team carefully developed the questions in the questionnaire. They detail the aspects of learning independence they want to measure, such as learning initiative, ability to manage time, and intrinsic motivation. Initial Testing: Before distribution to the primary sample, the questionnaire was tested on a small number of students with similar characteristics to the study sample to identify potential problems, such as questions that were ambiguous or difficult to understand. Content Validity: The questionnaire was validated by experts in psychometrics and education. They ensure that the questions reflect the relevant concept of independent learning. Reliability: After a specific duration, a re-test was administered to a subset of the student sample to gauge how consistent the questionnaire responses remained. Sample Selection: Questionnaires were distributed to students in class VII (H) and VII (I) at SMPN 3 Kota Cilegon, who were selected as the research sample. Consistent with the research context, which identified the effect of the intervention on the experimental and control groups. With these steps, the questionnaire used in the study has sufficient reliability and validity to collect accurate data about student learning independence in the school.

Research Data Analysis Techniques

Careful validation and testing processes for test items and questionnaires are vital to ensure data collection instruments' credibility. The following provides further information on the criteria and processes used in the instrument's validation, reliability, and assessment: Content Validity: The research team developed the test items and questionnaire questions to cover essential aspects of students' independent learning and math problem-solving skills. Experts in the field check content validity to ensure that this instrument truly reflects the concept to be measured. Initial Testing: Prior to distribution to the primary sample, the test items and questionnaire questions were tested on a small number of students similar to the study sample. The goal is to identify potential problems, such as ambiguous or difficult-to-understand questions. Construction Validity: Construct validity is evaluated by looking at the extent to which the items in this instrument consistently measure the same concept. Factor analysis can be used to check the validity of constructs by looking at the pattern of relationships between items. Reliability: The measure of reliability is to ensure that this instrument produces consistent results. Re-testing was conducted on a sample of students after a certain period to measure reliability. Reliability coefficients such as Cronbach's alpha can be used to measure the reliability of this instrument. Statistical Analysis: Statistical analyses such as exploratory factor analysis or confirmatory factor analysis can be used to support the validity and construction of the instrument. Statistical tests can also measure how well the instrument measures the desired concept. These steps were undertaken to ensure that the exam items and questionnaire questions have strong validity, consistently measure the desired concept, and that the instrument is reliable in collecting data. Therefore, the credibility of the data collection instrument is enhanced, bolstering the reliability of the research results.

The choice of parametric statistical tests, such as independent sample t-tests and one-way ANOVAs, is based on solid judgments regarding the suitability of the research question and the type of data collected in this study. Independent Sample t-test: The Independent sample t-test was used in this study because the research questions involved a comparison between two groups of students: the experimental group that received the intervention with XChart and peer tutors and the control group that did not. The main objective is to measure whether there is a significant difference in the final results of problem-solving ability between these two groups. The independent sample t-test is suitable for comparing the means of two different groups. One-way ANOVA: The use of one-way ANOVA also has a strong basis because this study includes more than two groups. In addition to the experimental and control groups, the possibility of other groups, such as a control group with a different type of intervention, must be considered. One-way ANOVA allowed us to examine statistically significant differences among three or more groups, if any, in terms of the measured variable, such as improvement in problem-solving ability. Likert Scale Test: Using the Likert scale test to analyze the results of a questionnaire about student learning independence can be justified because the Likert scale provides a good framework for measuring the level of agreement or disagreement with statements related to learning independence. It provides an in-depth understanding of students' views of independent learning, which is relevant to the research question. In addition, Likert scales generate ordinal data that can be converted into interval data, which allows further statistical analysis such as t-tests or ANOVA to compare results between groups.

The choice of parametric statistical tests and the use of a Likert scale for questionnaire analysis were based on suitability for the research objectives, the type of data collected, and the ability of the statistician to test hypotheses and draw firm conclusions based on the data collected. It ensures that the research findings are reliable and pertinent to the research questions.

This study's data analysis technique was a parametric statistical test, which began by assessing the outcomes of the normality and homogeneity tests. The Shapiro-Wilk test is used to determine normality. In contrast, the homogeneity test determines whether the data obtained statistically has the same variance or diversity of values. Because the pretest-posttest data is from a population with a normal distribution and homogeneous variance, a t-test is performed, particularly the independent sample T-test with equal variance assumed. The two-average similarity test seeks to determine whether the experimental class students' initial mathematical communication skill is the same as the control class students. The hypothesis test was then performed, which included a one-way ANOVA test to examine variance and the N-gain test to determine an increase in mathematical problem-solving ability. In addition, the outcomes of the student learning independence questionnaire were determined using a Likert scale test.

RESULTS

Pre-tests were administered to the control and experimental classes before treatment (learning with the XChart program for the experimental class and conventional learning for the control class). The tests in both classes are identical. Similarly, each class was given the same final test following the treatment. The results of the pre-test and post-test were then evaluated. The following are the test findings from this study:

Data Analysis Prerequisite Test Results

a) Normality Test Results

In this study, the normality test was performed to assess whether data distribution on instrument outcomes between the experimental and control classes was normally distributed before and after treatment. SPSS 21 was used to run this test. Using the Shapiro-Wilk test to determine the normality of the students' pre-test and post-test data, the following data results were obtained:

Table 1. Normality Test Results

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Control Class	.126	32	.200*	.953	32	.176
Experiment Class	.154	32	.053	.952	32	.167

Selection: The Shapiro-Wilk test was used to test the normality of the data distribution. The Shapiro-Wilk test checks whether the experimental and control groups' data have a normal distribution. Assumptions: The basic assumption is that the data comes from a normal distribution. Interpretation: The normality assumption is met if the p-value results from this test are more than a predetermined significance level (usually 0.05). That is, the data can have a normal distribution. If the p-value is less than 0.05, the normality assumption is unmet, and alternative analysis may be required.

Based on Table 1 output, it is known that the significance value (Sig) for all learning outcomes of the experimental class's pretest-posttest is 0.176, and the pretest-posttest of the control class is 0.167, with both in the Kolmogorov-Smirnov and Shapiro-Wilk tests > 0.05, indicating that the pretest-posttest experimental class and control declared normal distribution. A homogeneity test will be performed if the data from the pre-test and post-test results are regularly distributed.

b) Normality Test Results

The homogeneity test determines whether a data variety is derived from two or more sources. The findings of the homogeneity test are as follows:

Table 2. Homogeneity Test Results

Levene Statistic	df1	df2	Sig.
.376	1	62	.542

Based on Table 2, the significant value (Sig) is $0.542 > 0.05$, implying that the variance of the pretest-posttest data for the experimental and control classes is the same or homogeneous.

The Results of the Two Averages of the Similarity Test

Based on the data obtained previously indicating that the data is normal and homogeneous, the two average similarity test uses the independent sample T-test test equal variance assumed with the following results:

Table 3. Independent Sample t-test results

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Hasil Tes	Equal variances assumed	.376	.542	4.205	62	.000	12.81250	3.04691	6.72182	18.90318
	Equal variances not assumed			4.205	59.299	.000	12.81250	3.04691	6.71629	18.90871

According to Table 3, the independent sample T-test equal variance assumed test output obtained a Sig (2-tailed) value of $0.000 < 0.05$, indicating a difference in average student learning outcomes between the pre-test and post-test experimental classes. Moreover, for pair 2 data, a Sig (2-tailed) value of $0.000 < 0.05$ was achieved, implying a difference in the average student learning outcomes between the control class pre-test and control class post-test. Moreover, it can be inferred that learning via the XChart application learning medium affects traditional learning.

One-Way Anova Test Results

Analysis of variance is used to make demographic inferences or to evaluate the effect hypothesis. This study's analysis of variance is a one-way analysis of variance, also known as one-way ANOVA. Assuming that the data is usually distributed, homogeneous, and independent. The following are the findings of the one-way ANOVA test calculation:

Table 4. One-Way Anova Test Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2626.563	1	2626.563	17.683	.000
Within Groups	9209.375	62	148.538		
Total	11835.938	63			

Selection: A one-way ANOVA test is used when there are three or more groups to be compared in terms of a particular variable, for example, the experimental group, the control group, and other groups (if any). Assumptions: The central assumption is that the group data is normally distributed and the group variance is homogeneous. Interpretation: The results of ANOVA produce F-statistic values and p-values. If the p-value is less than the specified significance level, then there is a significant difference between at least the two groups.

Based on the signification value (Sig) of $0.000 < 0.05$ in Table 4 of the one-way ANOVA test, it can be stated that the average student learning outcomes differ. This suggests that combining XChart application media with traditional media affects student learning results.

N-Gain Test Results

The N-Gain test determines how much learning mathematics has on enhancing students' mathematical communication skills when utilizing the XChart application media. SPSS 21 is used to calculate N-Gain, and the results are shown in the table below:

Table 5. N-Gain Test Results

	Mean	Minimum	Maximum
Control Class	67,9429	50	100
Experiment Class	56,0479	27,78	100

Selection: The N-Gain statistical test measures a student's ability or understanding improvement after following a particular intervention or treatment. It is suitable for educational research to measure changes in students' understanding or skills before and after intervention. In the research context, N-Gain measures improvement in math problem-solving skills. Assumption: The basic assumption in using N-Gain is that the initial data (pre-test) and the data after the intervention (post-test) are typically distributed. In addition, N-Gain assumes that the pre-test and post-test data are paired data, which means that each post-test data is closely related to the corresponding pre-test data. Using N-Gain can measure how much intervention has successfully increased students' understanding of mathematical problem-solving. The interpretation of the N-Gain results helps evaluate the effectiveness of the intervention and whether the observed changes are statistically significant.

According to Table 5, the results of the N-Gain Score Test computation show that the average value of the N-Gain Score for the experimental class (XChart application media) is 67.949 or 67.9%, which falls into the reasonably practical category, with an N-Gain Score of at least 50% and a maximum of 100%. Meanwhile, the N-Gain Score Test calculation results show that the average N-Gain Score for the Control class (conventional media) is 56.0479 or 56.0%, placing it in the reasonably practical category, with an N-Gain Score ranging from 27.78% to 100%.

Likert Scale Test Results

Following the outcomes of the problem-solving exams, the questionnaire test on student learning independence is required. This questionnaire test uses a Likert scale and the Microsoft Excel 2016 software, yielding the following results:

Table 6. Hasil Uji Skala Likert

Aspect	Skor		Criteria
	Maximal	Presents Rata-rata	
Self-confident	1600	65%	Strong
Initiative	1600	65%	Strong
Responsibility	1600	71%	Strong
Motivation	1600	71%	Strong

According to Table 6, the Likert Scale Test calculation results demonstrate that the four characteristics of student learning independence have a percentage value ranging from 65% to 75%. This percentage indicates that students in the control and experimental classes have great learning independence when using the peer tutor learning paradigm.

DISCUSSION

Similarities with Previous Research: Use of XChart: Findings regarding using XChart as a visualization tool that supports solving mathematical problems align with several previous studies that highlight the benefits of XChart in learning mathematics. Using XChart reinforces XChart's positive contribution to increasing students' understanding of mathematical concepts. Role of Peer Tutors: Findings about the positive effects of peer tutoring on increasing student learning independence align with previous research that has demonstrated the benefits of peer tutoring in mathematics education. The role of Peer Tutor confirms the importance of social interaction in learning mathematics.

Differences with Previous Research: Combined Use of XChart and Peer Tutors: One of the main differences is that research focuses on the combined use of XChart and peer tutors. Some previous studies considered only one of these elements separately. It showcases an innovative approach to integrating technology (XChart) with social interactions (peer tutors) for better results. Context and Population: Research results may also differ due to differences in the educational context, curriculum, or student population studied. Every educational environment has unique characteristics that can influence outcomes. Additional Variables: Some previous studies may have included additional variables in their analysis, such as students' initial skill levels or other control variables that could have influenced the results. Additional Variables can cause a difference in results.

Potential Reasons for Difference. Synergistic Effects: The combination of XChart and peer tutors may have a synergistic effect, where the two enhance each other's impact. Previous studies may not have identified this benefit because they only considered one element. School Context: School culture, teacher support, and technology infrastructure can influence outcomes. Differences in school context between research and previous research may be a reason for the difference in results. Technological Advances: Differences in the XChart technology or peer tutoring methods can affect results. Advances in technology and changes in the peer tutoring approach can lead to better results. By comparing results with past research, we better understand how the use of XChart and peer tutoring specifically contributes to context and provides insight into the potential of other factors influencing research results.

Significant findings are shown in this study about using XChart and using peer tutors to enhance problem-solving abilities (Table 5) and student learning independence in mathematics education (Table 6). Data analysis revealed that the experimental group, which got intervention with XChart and peer tutors, increased significantly more than the control group. The outcomes of this study back up prior research that found that using XChart and implementing peer tutoring in the setting of mathematics instruction was beneficial. Nasrullah et al. (2018) discovered in the International Journal of Emerging Technologies in Learning that using technology has a favorable impact on increasing students' abilities. These findings are consistent with the findings of this study, which revealed a considerable improvement in students' problem-solving ability following intervention with XChart.

The causes contributing to this study's excellent outcomes can be explained logically. Using XChart as a visualization tool allows students to organize and evaluate mathematical data more efficiently. XChart gives a clear visual depiction of data and mathematical concepts, which helps pupils understand the relationships between them. This is consistent with the findings investigating technology as a visual learning tool for solving mathematical problems (Angraini & Muhammad, 2023; Donnelly et al., 2020; Liburd & Jen, 2021; Kohen, 2019).

Furthermore, peer tutoring plays a crucial part in the study's findings. Peer tutors offer pupils social support and help when they face problem-solving obstacles. Peer tutors with math knowledge and comprehension can help students find problem-solving strategies, provide constructive feedback, and boost student confidence. This finding is consistent with the findings of Winatha et al. (2022), who discovered that peer tutoring effectively enhances students' competency abilities.

This study has several advantages. First, this study employs an experimental research design with a control group, allowing for direct comparisons between the experimental and control groups. This solid study design contributes to the research's internal validity. Furthermore, the study instruments utilized have been validated and evaluated in advance, ensuring their reliability and validity.

However, there are significant limitations to this study. First, this study was completed in a short period, namely three months. As a result, the long-term effects of this intervention cannot be adequately examined. Further research over a longer time is required to determine the long-term benefit of employing XChart and peer tutors in increasing students' problem-solving skills and autonomous learning.

Short Study Duration: One of the main limitations of this study is its relatively short duration. Longer-term research may provide a deeper understanding of the long-term impact of XChart and peer tutoring interventions. The results in a short time may not reflect the long-term effects that can occur. Sources of Bias: Although efforts have been made to minimize bias, this study has potential bias. An example is selection bias in the selection of students or control groups. In addition, the outcome measures of student learning independence questionnaires can be affected by response bias, in which students may give expected rather than actual responses. Generalization of Findings: Findings from this study are limited by the context and population used. These results may not directly apply to different mathematics education contexts or groups of students with different characteristics. Therefore, generalization of the findings needs to be done with caution. Uncontrolled Variables: Although efforts have been made to control for variables that affect the results, there may be unidentified or uncontrolled variables that can affect the results. Uncontrolled Variables include external factors such as environmental factors or previous learning experiences not included in the research. Technical Limitations: The existence of technical limitations, such as limitations in the number of students or the availability of XChart devices, may also affect the validity and generalizability of the results of this study. Limitations of the Questionnaire: Although the questionnaire was used to measure student learning independence, this questionnaire may not cover all aspects of learning independence properly. In addition, subjectivity in students' responses to the questionnaire is possible. Recognizing these limitations, the interpretation of the study's results should be approached with caution. Moreover, these limitations underscore the need for further research to address them and gain a more comprehensive understanding of the effectiveness of integrating XChart and peer tutoring in mathematics education.

The findings of this study suggest that using XChart and peer tutoring can be an effective alternative in increasing problem-solving skills and student learning independence in mathematics education. The findings of this study contribute significantly to creating creative and sustainable mathematics learning techniques.

Teachers and educators can use XCharts and peer tutoring to promote student involvement and knowledge of mathematical subjects.

The practical implications of this research significantly impact educators and educational institutions in improving their approaches to learning mathematics. Here are some steps that teachers and educational institutions can take. XChart integration: Teachers can leverage XChart as a powerful visualization tool in teaching mathematics. They can incorporate it into the course materials to assist students in comprehending more abstract concepts. XChart integration can include using graphs, diagrams, and other visual representations to facilitate student understanding. Utilization of Peer Tutors: Teachers can encourage social interaction in learning by adopting the practice of peer tutoring. They can enable students with a solid understanding to assist other students in solving problems or explaining concepts. Utilization of Peer Tutors improves the understanding of students who act as tutors and increases the learning independence of other students. Teacher Training: Educational institutions can train teachers using XChart and peer tutoring strategies. Teacher Training helps teachers understand how to integrate visual tools and social interaction into their curriculum.

Curriculum Development: Teachers and educational institutions can work together on developing a curriculum that integrates XChart and peer tutoring as essential components. Curriculum Development can involve creating specially designed learning materials to take advantage of visual technology and developing the skills of peer tutors. Empowerment of Students: In a broader context, applying XChart and peer tutoring helps develop students' problem-solving and self-learning skills. Teachers and educational institutions must empower students to participate in their learning and encourage critical thinking. Ongoing Evaluation: Teachers and educational institutions should regularly evaluate the effectiveness of using XChart and peer tutors in enhancing students' problem-solving and self-learning skills. Ongoing Evaluation allows for continuous adjustments and improvements.

It is important to remember that the effectiveness of implementing these strategies can vary depending on the context and characteristics of the students. Therefore, this approach must be adapted to the specific needs and characteristics of each class or educational institution. Integrating XChart and peer tutoring can change how mathematics education is applied, resulting in more effective and sustainable student learning.

Overall, this study has cleared the path for creating more effective ways of mathematics learning. The result is that instructors and schools should consider using XChart and peer tutors to construct more engaging and successful mathematics learning. Future research can expand on this intervention by enrolling more individuals and prolonging the study period to examine the long-term impact of this intervention on increasing students' mathematics learning. Furthermore, the Likert scale test demonstrates that the peer tutor learning model affects student learning independence in control and experimental classes.

CONCLUSION

In summary, this research highlights the significant improvement in problem-solving abilities and student learning independence through using XChart and peer guidance in mathematics education. The results confirm that integrating visual technology with social interaction can substantially benefit learning. These findings provide a solid basis for educators to consider this innovative approach to promote more meaningful and successful mathematics learning.

This study achieved its primary objective in the introduction: to investigate the combined effect of using XChart as a visualization tool and peer guidance in improving students' problem-solving skills and independent learning in mathematics. This study addressed the research gap by providing empirical evidence that combining these elements produces significant results. These results confirm that this innovative approach has great potential to develop more effective methods of teaching mathematics that align with contemporary education's demands.

The first conclusion is that the findings of this study show that using XChart and peer tutoring favorably impacts increasing students' problem-solving abilities and independent learning in mathematics education, and using XChart as a visualization tool aids students in efficiently understanding and evaluating mathematical material. At the same time, peer tutoring provides excellent social support and helps with problem-solving issues.

Second, this research supports the findings of prior studies that support using XChart and peer tutors to increase mathematics learning. These findings provide a more complete understanding of the efficacy of combining these two components in the context of mathematics instruction. Using XChart and the implementation of peer tutoring in the context of this study dramatically improved students' problem-solving skills and autonomous learning.

Third, the research implication is that teachers and schools should consider using XChart and peer tutoring as an effective strategy in designing mathematics learning that is more interactive and focuses on problem-solving abilities and student learning independence. In the long run, this combination can contribute significantly to creating novel and sustainable mathematics learning techniques.

These findings suggest that using XChart with peer tutoring is a good alternative for enhancing maths learning. These findings give a solid foundation for instructors and educators to consider when building more meaningful and successful student learning experiences. Further investigation of the long-term impacts of this intervention and the development of more effective learning strategies to promote problem-solving abilities and student learning independence in mathematics education can be carried out in future research.

The practical implications of this research for educators and educational institutions are significant. Teachers can effectively integrate XChart and peer tutors by including visual elements in the course material and encouraging student-to-student collaboration. This strategy enables the development of problem-solving skills and independent learning by encouraging students to participate in their learning actively.

In addition, educational institutions can train teachers on using visual technology and the peer tutoring approach. In this way, mathematics education can become more interactive, support critical thinking, and be relevant to the needs of students in a broader educational context.

The practical implications of these findings in mathematics education are invaluable. Educators can integrate XChart into lessons to present math concepts and motivate discussion visually. Peer guidance can be applied through student collaboration, promoting joint problem-solving. The guide for educators involves training in visual technologies and collaboration-based learning. In this way, the classroom can become an environment in which students develop problem-solving skills and self-directed learning naturally, resulting in a profound and relevant understanding of the context of mathematics.

These findings have substantial practical implications in mathematics education. Guidance for educators is critical. They can start by understanding the potential of XChart as a powerful visualization tool. It should be integrated organically into the curriculum, helping students understand complex mathematical concepts. Then, engage in peer mentoring to encourage collaboration and communication between students. XChart can be achieved through group projects or discussion sessions. The results will promote problem-solving skills and independent learning in a natural classroom environment, helping students become more competent and confident math learners.

This research provides an in-depth look at integrating XChart and peer guidance to enhance problem-solving and independent learning abilities in mathematics education. These findings confirm that innovations in teaching methodologies have great potential to enhance learning. This research is essential for a more effective and relevant mathematics education. However, this is also a starting point. In the future, further research and innovative exploration is needed to develop this approach. We encourage researchers and educators to continue exploring, testing, and building on these findings. In doing so, we can jointly contribute to the evolution of effective mathematics learning techniques, benefit students, and support the growth of mathematics education.

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