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THE EFFECT OF EXPERIENTIAL LEARNING AND DIRECTED INSTRUCTIONS ASSISTED BY AUGMENTED REALITY ON STUDENTS' SELF-REGULATED LEARNING

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ABSTRACT

In the last decade, augmented reality has been one type of virtual reality technology. AR can be applied to mobile learning, improving efficiency and effectiveness in education, even for learning mathematics. The study aims to analyze and describe comprehensively the effect of experiential learning and direct instruction assisted by augmented reality on the acquisition and improvement of students' mathematical reasoning abilities. This research uses quantitative methods with a quasi-experimental, one-group pretest-posttest design and a pretest-posttest control group design. The sample in this study consisted of 50 students in the eighth grade at one of the secondary schools in Bandung, Indonesia. The instrument in this study is a set of mathematical reasoning ability tests. The results of this study concluded that 1) Based on the standard of the deviation, the descriptive spread of scores for achieving mathematical reasoning abilities of students learning with experiential learning assisted by augmented reality (more widespread); 2) Cohen's d value on the output paired samples effect sizes was 14.003 with a point estimate of (large) so the value of the effects sizes obtained shows that the implementation of experiential learning assisted augmented reality has a major effect on the acquisition of mathematical reasoning abilities; 3) The mean achievement of mathematical reasoning abilities of students studying with experiential learning assisted by augmented reality was 60.38 relatively lower than the mean achieving mathematics reasoning abilities of students who studied with directed instructions assisted by augmented reality, 70.33; 4) The effect size value shown by the value is -3.50, and this value is less than 0.2, so based on Cohen's d criterion, then the effect of experiential learning assisted by augmented reality on the acquisition of mathematical reasoning abilities students are in the small category. The findings combine experiential learning and directed instructions assisted by augmented reality, influencing students' reasoning ability mathematically.

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1. INTRODUCTION

The ability of mathematical reasoning can be transferred to any subject, and the impact of developing it will give children a more comprehensive ability to deal with a variety of problems (Schoenfeld & Sloane, 2016). This ability forms an essential element of readiness and developing thinking that children will need in school and outside school. The ability of reasoning enhances a person's metacognition (Ma et al., 2019). This allows students to monitor and evaluate their own thinking so that they have more autonomy over their learning and more awareness of what abilities are used. The ability to reason helps the child see things from a different perspective. The ability of mathematical reasoning supports creativity, supports children in making connections and approaches problems holistically.

Mathematical punctuation is one of the four capabilities in addition to understanding, smoothness, and problem solving (Douek, 1999). Winning is closely related to understanding and smoothness. Understanding covers the ability of students in terms of remembering different mathematical concepts and rules, and smoothness describes the students' ability when applying the same rules and concepts to solve problems and find appropriate solutions (Steen, 1999; Stein et al., 1996). To find the right solution students need to make an estimate, while to make a prediction, it is necessary to recall the student's personal experience. By applying knowledge and understanding, students can learn what succeeds and, more importantly, learn what fails (Rosita & Sukestiyarno, 2021). This experience is important to provide valuable experience that contributes to the student's reasoning when trying to solve problems or other challenges later on.

Students who have the ability to reason mathematically can develop mathematical concepts to solve a variety of problems. Based on the results of the mathematical reasoning ability of Abdullah et al. (2022) obtained information that the student's reasoning capacity is still low, during the problem-solving process of the student using the test of the formula or can be said the student does not use the mathematical reasoning ability. This is supported by the results of Hasanah et al. (2019) which showed that students with high mathematical ability can be said to have good mathematics reasoning ability because they converge four mathematics reasoning indicators. Meanwhile, students with low mathematically abilities still have deficiencies in the reasoning process, because they cannot converge the four indicators of mathematics reasoning where the aim of the research is to describe the mathematics reasoning abilities of students in solving mathematics problems.

While the study conducted by Lestari (2019) has two results, the first achievement of mathematical reasoning ability of high school students whose learning with problem solving approaches better than students who obtain conventional learning as well as the results of the second study showed improvement in mathematics reasoning abilities of High school students who use problem-solving approach better than pupils who use traditional learning and improved ability to mathematics reasoning belongs to moderate. In the last decade, augmented reality (AR) has been one type of virtual reality (VR) technology. AR can be applied in mobile learning that can improve efficiency and effectiveness in the field of education even for learning mathematics. This is in line with the results of research by Auliya and Munasiah (2019) that AR can be used in the learning process, attract student interest and help students understand three-dimensional geometry material. Ahmad and Junaini (2020) also suggested that this AR could be beneficial to researchers and educators, thus suggesting ideas for further research, in mathematics learning. Nindiasari et al. (2024) has research result that AR media is an effective way to help students become more adept at solving problems related to medium-category geometry ideas, combining STEAM education with ARM media can enhance students' capacity for addressing geometric concept problems.

Cahyono et al. (2020) applied AR Mobile Math Trails to eighth-grade students in Semarang and obtained the findings that AR on mobile applications greatly helped students as a tool that bridges the gap between real-world situations and mathematical concepts in problem-solving following the mathematics modeling cycle thus can contribute to higher abilities in mathematics modeling. The research results of Guntur et al. (2019) show that the challenge faced by teachers is to meet minimum standards of hardware and software, limited references from both human sources, online media and print media and to find foreign language learning resources and form a joint AR learning community. AR is a technology that combines real-world objects with virtual objects in real-time, allowing users to see and interact with virtual object that overlaps with real objects. AR technology utilizes devices such as smartphones, tablets, and smart glasses equipped with cameras, sensors, and specialized software to display virtual object in a real environment.

AR technology is constantly evolving and has huge potential to transform the way we interact with the world around us. In the use of AR in mathematical learning, it is important to consider the selection of appropriate AR applications and design learning activities that fit students' needs. For this idea, users can have immersive experiences created as bridges between physical and digital objects using, for example, cameras from smartphones. Similarly, research evidence suggests that AR can enhance student motivation in the learning process (Bujak et al., 2013; Liu & Chu, 2010), promoting optimal user experience status of Chang et al. (2016) thus contributing positively to the overall learning experience. Important work on the use of AR applications has also been made in mathematics. Bujak et al. (2013) has presented a framework for understanding AR learning from three perspectives. The first is the physical dimension that allows the manipulation of natural interactions and the creation of representations that are realized. The second is the cognitive dimension. It provides information about how the temporal spatial alignment of information through the AR experience can help the student's understanding of symbolism to enhance the understanding of abstract concepts. The third is the contextual dimension in which AR technology can create the possibility of collaborative learning around virtual content and in non-traditional environments.

Cascales-Martínez et al. (2017) has suggested several reasons for using AR technology with tables that can be more effective for teaching than traditional approaches. The same author also argues that such things are presented as artifacts that can offer new ways of interaction. The use of AR technology in the educational process through a didactic prototype can enhance the visualization abilities associated with learning mathematical content (Kurubacak & Altinpulluk, 2017). The experimental experience confirms that AR technologies in education improve the current motivation of students to learn and serves as a platform that improves their learning performance due to use of visual and real mathematics applications (Uyen et al., 2022). Integrating experiential learning (EL) and augmented reality (AR) can create a more interactive, visual, and engaging learning experience for students. Here are some ways to integrate EL and AR: 1) Project-based Learning Project based learning can be integrated with AR to provide a more immersive and interactive learning experience. Students can be given projects that require the use of AR to complete them, such as making simulations or AR games. This can help students learn in person and apply the concepts they learn more interactively; 2) Environment based learning Environmental based learning can be integrated with AR to create a more realistic and interactive learning environment. In environment-based learning, students can use AR to explore the environment and apply mathematical concepts more interactively; 3) Simulation based learning Simulation-based learning may be incorporated into AR to generate more realism and interaction in learning simulations. Students can use the AR to visualize simulations related to mathematics or science concepts, so that they can understand and apply them more effectively. Using EL and AR can help students learn more interactive and exciting, but also need to be combined with other learning methods to ensure students understand concepts well. The study aims to analyze and describe comprehensively the impact of experiential learning and direct instruction assisted by augmented reality on the acquisition and improvement of students' mathematical reasoning abilities.

2. METHOD

2.1. Research Design

Based on the purpose, the methods in this research are quantitative with quasy experimental design. The experimental design used in this study is one group pretest-posttest design and pretest-posstest control group design to test the impact of the model implementation significantly (Gall et al., 2003). The control class is a model of directed instruction assisted by augmented learning (DI-AR) and the experimental class is experiential learning assisted by augmented reality (EL-AR).

2.2. Sample

Participants in this study were 8th grade students who were and are studying mathematics, root forms, and scientific notation. Study participants were selected for a number of specific reasons or purpossive sampling. Purposive sampling is a technique in research in which researchers deliberately select samples based on certain criteria that are relevant to the purposes of the research carried out (Creswell & Creswell, 2017). The research site is at one of the First Secondary Schools in Bandung City.

2.3. Research Instruments

Test instruments are structured on the basis of indicators of mathematical reasoning ability on matters of ranked numbers, number of root shapes, and scientific notation of students of 8th grade. The development of mathematical reasoning abilities test items includes aspects intuition, counterfactual thinking, critical thinking, backward induction, inductive reasoning, deductive thinking, and abductive inductions (Tall, 2014). As for the indicators of the students' ability to reason mathematically that can be observed (see Table 1).

Table 1. Indicators of mathematical reasoning ability

Aspects	Indicators
Intuition	Ability to reason in identifying mathematical patterns and relationships
Counterfactual Thinking	The ability of reasoning in connecting mathematical concepts
Critical Thinking	Ability to reason in critical and analytical thinking
Backward Induction	The ability of reasoning in solving mathematical problems creatively
Inductive Reasoning	The ability of reasoning in deduction and induction
Deductive Reasoning	Ability to reason in making generalizations
Abductive Induction	Ability to reason in communicating effectively

Based on Table 1, the researchers developed questions to measure students' ability to reason mathematically on matters of exponentiated numbers, number of root forms, and scientific notation. Selection of material based on this material will take place when the researcher applies for research permission or purposive. On the other hand, this material is selected for mathematical reasoning in linking basic concepts to matter. The issues developed in the form of questions of description with the number of questions as much as 15 items. The learning activity was observed and recorded in the learning observation sheet. The researchers recorded the observation on the learning activity sheet and collected data during the learning implementation process with the model in the experimental class.

The instruments in this study have been verified for validity and reliability. The empirical validity was analyzed using Pearson's product moment, which correlates the test results on self-regulated learning instruments that are correlated with the ability of mathematical reasoning in the day-to-day. Based on the validity test results, it can be concluded that the test instruments developed mathematics reasoning ability are valid and usable. While the instrument's reliability is verified internally by Cronbach alpha and turns out to be $0.855 > 0.60$ and its external reliability of 0.782 is greater than 0.7, it can be concluded that it is reliable to use.

2.4. Research Procedures

Research procedures on the impact of experiential learning with augmented reality on acquisition of mathematical ability students start with the preparation phase and formulation of the problem. This research begins with an in-depth understanding of the background of the problem, where the lack of student involvement and difficulties in understanding mathematical concepts are the focus of attention. The study aims to analyze and describe comprehensively the impact of experiential learning and direct instruction assisted by augmented reality on the acquisition and improvement of students' mathematical reasoning abilities. From here, the study formulates the research question, namely, 1) What is the description of the acquisition of mathematical reasoning abilities for students who receive experiential learning assisted by augmented reality?; 2) Does the implementation of experiential learning assisted by augmented reality (AR) have a significant effect on students' acquisition of mathematical reasoning ability?; 3) Is there a difference in the effect of the level of self-regulated learning on students' acquisition of mathematical reasoning ability; 4) Is there an interaction effect between learning and the level of self-regulated learning on students' acquisition of mathematical reasoning ability?.

The research hypotheses consist of: 1) Experiential learning assisted by augmented reality (EL-AR) has a significant effect on the acquisition of mathematical reasoning abilities of students; 2) There is a difference in the effect of the level of self-regulated learning of students on the acquiring of the abilities of the students in mathematics reasoning; 3) There are differences in the impact of experiential learning and directed instructions assisted by augmented reality on the improvement of students' mathematical reasoning abilities.

The first step is to design a research experiment using the method pretest-posttest control group design. Two groups of students were randomly selected: the experimental group that would receive experiential learning assisted by augmented reality, and the control group which would receive directed instructions assisted by augmented reality. Furthermore, the research conducted the identification of research variables, with independent variables in the application of experiential learning assisted by augmented reality, and dependent variable in the acquisition and improvement of students' ability to reason mathematically. The research instruments used are mathematical reasoning tests that have been tested for validity and reliability.

The data collection process begins with the provision of pretests to both groups to measure the students' initial mathematical reasoning abilities. After that, interventions are carried out on the experimental group by applying the method of experiential learning assisted by augmented reality, while the control group still receives conventional learning. The data collected is then analyzed using statistical tests, to determine whether the difference between the results between the experimental group and the control group is significant. Thus, this research not only contributes to academic knowledge but also provides practical guidance to improve the quality of mathematics learning in schools using augmented reality technology.

2.5. Data Analysis

In this study quantitative data is analyzed results of mathematical reasoning ability tests that are grouped based on the learning model in the experimental class (experiential learning assisted by augmented reality). Hypothetical research questions were answered using parametric statistics. SPSS version 29 software is used to help analyze this research. To measure gains using data pretest and posttest mathematical reasoning abilities as well as to measure improvements using normalized gain (N-Gain) (Hake, 1998). The N-Gain formula and the N-Gain category are described in Table 2.

$$\text{N\_Gain (g)} = \frac{\text{posttest score} - \text{pretest score}}{\text{maximal score} - \text{pretest score}}$$

Table 2. N-Gain categories

Normalized Gain Score (N-Gain)	Interpretation
$g \geq 0.70$	High
$0.30 \leq g < 0.70$	Moderate
$g < 0.30$	Low

Effect size is a statistical measure used to show the size of an effect or relationship in research and is often used to assess the practical significance of research results (Ellis, 2010). Category effect sizes are 1) small, $0.2 \leq d < 0.5$; 2) moderate, $0.5 \leq d < 0.8$; and 3) large, $d \geq 0.8$.

3. RESULT AND DISCUSSION

3.1. Results

In this research has control group (Directed Instruction assisted by Augmented Reality) and experiment group (Experiential Learning assisted by Augmented Reality), then it has output analysis score pretest, posttest, and n-gain mathematical reasoning abilities, such as (see Table 3).

Table 3. Descriptive statistical output overview of acquisition of mathematical reasoning abilities of EL-AR and DI-AR

			Statistic	Std. Error
Posttest_DI_AR	Mean		70.33	3.883
	95% Confidence Interval for Mean	Lower Bound	62.23	
		Upper Bound	78.43	
	5% Trimmed Mean		71.12	
	Median		70.00	
	Variance		316.633	
	Std. Deviation		17.794	
	Minimum		33	
	Maximum		93	
	Range		60	
	Interquartile Range		29	
	Skewness		-0.436	0.501
	Kurtosis		-0.844	0.972
Posttest_EL_AR	Mean		60.38	4.488
	95% Confidence Interval for Mean	Lower Bound	51.02	
		Upper Bound	69.74	
	5% Trimmed Mean		60.41	
	Median		57.00	
	Variance		423.048	
	Std. Deviation		20.568	
	Minimum		20	
	Maximum		100	
	Range		80	
	Interquartile Range		35	
	Skewness		0.135	0.501
	Kurtosis		-0.667	0.972

Based on the SPSS output in Table 3, the following criteria were obtained:

1) Based on descriptive averages on a scale of 0-100, the average gain in mathematical reasoning abilities for students who study with experiential learning assisted by augmented reality (EL-AR) is 60.38, which is relatively lower than the average gain in mathematical reasoning abilities. Students who studied with directed instructions assisted by augmented reality (DI-AR) were 70.33.
2) The standard deviation or standard deviation of scores for the acquisition of mathematical reasoning abilities of students who study with experiential learning assisted by augmented reality (EL-AR) and directed instruction assisted by augmented reality (DI-AR) is 20.568 and 17.794, respectively. Based on the standard deviation value or standard deviation, descriptively, the distribution of scores for the acquisition of mathematical reasoning abilities of students who studied with experiential learning assisted by augmented reality (EL-AR) was 20.568 more spread out than the scores of mathematical reasoning abilities of students who studied with directed instructions assisted by augmented reality (DI-AR).

3) The skewness value of the mathematical reasoning ability test scores of students studying with experiential learning assisted by augmented reality (EL-AR) is 0.135, which means that the distribution of students' mathematical reasoning ability scores is positively skewed and tends to converge on low scores. Meanwhile, the skewness value of the mathematical reasoning ability test scores studied with directed instructions assisted by augmented reality (DI-AR) is -0.436, which means that in this distribution it converges on high scores.

From the hypothesis test results that suggested that experiential learning implementation with augmented reality (EL-AR) significantly influenced the acquisition of mathematical reasoning ability of students tested by comparing pretest scores and posttest scores. To test the hypothesis used the test paired samples t-test and the output is as follows (see Table 4).

Table 4. Output of paired samples statistics mathematical reasoning ability on EL-AR

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Posttest_EL_AR	59.42	26	20.574	4.035
	Pretest_EL_AR	28.77	26	16.398	3.216

From the SPSS output in Table 4 shows that after treatment, there was an increase in the average score from 28.77 (pretest) to 59.42 (posttest), with variability and accuracy of measurement indicated by the standard deviation and standard error of the average, respectively. The standard deviation for posttest scores on the EL-AR is 20.574, which means that students' posttest scores vary or spread around an average of 20.574, so that larger scores indicate wider variations among posttest scores. Meanwhile, the standard deviation for the pretest scores on the EL-AR is 16.398, which means that students' pretest scores vary or spread around an average of 16.39, so it can be said that the smaller scores compared to the posttest indicate that the variation between the pretest scores is narrower or more consistent. The average standard error for the posttest score on the EL-AR is 4.035, which means that the average posttest score resulting from the student sample is estimated to have an error or deviation of 4.035 from the actual average of the population. A smaller standard error indicates that the sample mean is a more accurate estimate of the population mean. The average standard error for the pretest score on the EL-AR is 3.216, which means that the average pretest score generated from the student sample is estimated to have an error or deviation of 3.216 from the actual average of the population. As with the posttest, smaller standard errors indicate more accurate estimates.

Table 5. Output paired samples correlations mathematical reasoning ability on EL-AR

		N	Correlation	Significance	
				One-Sided p	Two-Sided p
Pair 1	Posttest_EL_AR & Pretest_EL_AR	26	0.735	<0.001	<0.001

Based on Table 5, the significance value of the output paired samples correlations mathematical reasoning ability <0.001 and that significance value is less than 0.05 (α) indicates that there is a significant correlation between the pretest and the posttest score of the mathematical reasoning abilities of students studying with experiential learning assisted by the augmented reality (EL-AR) model with the correlation coefficient r=0.735 (in the highest category) so that $r^2 = (0.735)^2 = 54\%$ of the variation in posttest scores can be explained by variation within pretest scores.

Table 6. Output paired samples test mathematical reasoning ability on EL-AR

		Paired Differences					t	df	Significance	
		Mean	Std. Dev	Std. Error Mean	95% Confidence Interval of the Difference				One-Sided p	Two-Sided p
					Lower	Upper				
Pair 1	Posttest_EL_AR - Pretest_EL_AR	30.654	14.003	2.746	24.998	36.310	11.162	25	<0.001	<0.001

The significance value of the output paired samples test (see Table 6) is <0.001 and this value is less than 0.05 (α) so the research hypothesis (H_1) is accepted and it is concluded that the implementation of experiential learning assisted by augmented reality (EL-AR) has a significant effect on the acquisition of mathematical reasoning abilities of students.

Table 7. Output paired samples effect sizes mathematical reasoning ability on EL-AR

			Standardizer[a]	Point Estimate	95% Confidence Interval	
					Lower	Upper
Pair 1	Posttest_EL_AR - Pretest_EL_AR	Cohen's d	14.003	2.189	1.467	2.898
		Hedges' correction	14.441	2.123	1.423	2.810

a. The denominator used in estimating the effect sizes.
Cohen's d uses the sample standard deviation of the mean difference.
Hedges' correction uses the sample standard deviation of the mean difference, plus a correction factor.

Cohen's value of d on Table 7, the output paired samples effect sizes was 14.003 with a point estimate of 2.189 > 0.80 (high) so this value of effects sizes shows that the implementation of experiential learning assisted by augmented reality (EL-AR) effects are in the high category against the acquisition of mathematical reasoning abilities of students.

To obtain analysis results regarding: 1) the differences in the effect of EL-AR and DI-AR learning on students' acquisition of mathematical reasoning abilities; and 2) the effect of the interaction between learning and the level of self-regulated learning on the acquisition of mathematical reasoning abilities. Then the research results were analyzed using SPSS software related to the general linear model (Two-Way ANOVA) with the following output (see Table 8).

Table 8. General linear model output (Two-Way ANOVA): Acquisition score mathematical reasoning ability class EL-AR and DI-AR

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	9667.639[a]	5	1933.528	8.907	<0.001	0.521
Intercept	200397.983	1	200397.983	923.175	<0.001	0.957
Learning	1072.807	1	1072.807	4.942	0.032	0.108
SRL_Level	6582.921	2	3291.461	15.163	<0.001	0.425
Learning * SRL_Level	1823.800	2	911.900	4.201	0.022	0.170
Error	8900.063	41	217.075			
Total	220406.000	47				
Corrected Total	18567.702	46				

a. R Squared = 0.521 (Adjusted R Squared = 0.462)

From the SPSS output in Table 8, namely the test of the between-subject effect, it turns out that the significance value is for:

1) Corrected model has a significance of <0.001, which means that the learning model used is acceptable.
2) Intercept, that the constants in this analysis can change without being influenced by the independent variables.
3) Learning is 0.032 and the value is smaller than 0.05 (α) so the hypothesis states that there is a difference in the effect of implementing experiential learning assisted by augmented reality (EL-AR) and directed instructions assisted by augmented reality (DI-AR) on the acquisition of mathematical reasoning abilities students are accepted and because the average value of mathematical reasoning ability of students who study with directed instructions assisted by augmented reality (DI-AR) is higher than the average value of mathematical reasoning ability of students who study with experiential learning assisted by augmented reality (EL-AR), it can be concluded that the effect of the implementation of directed instructions assisted by augmented reality (DI-AR) is higher than the effect of the implementation of experiential learning assisted by augmented reality (EL-AR) on students' acquisition of mathematical reasoning abilities.
4) The level of self-regulated learning (SRL) is <0.001, and this value is smaller than 0.05 (α), so H_0 is rejected and H_1 is accepted, so the hypothesis states that there is an effect of the level of self-regulated learning on the acquisition of mathematical reasoning abilities. This means that there are differences in the effect of the level of self-regulated learning on students' acquisition of mathematical reasoning abilities.
5) Learning*SRL level is 0.022, and this value is smaller than 0.05 (α), which means that H_0 is rejected and H_1 is accepted, which means that there is an interaction effect between learning and the level of self-regulated learning (SRL) on acquisition students' mathematical reasoning abilities.
6) The R squared value is 0.521, which means that around 52% of students' acquisition of mathematical reasoning abilities is influenced jointly by the model and students' level of self-regulated learning.

Table 9. Output post hoc test

(I) SRL_Level	(J) SRL_Level	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
High	Moderate	23.92*	5.295	<0.001	11.04	36.79
	Low	26.69*	5.209	<0.001	14.02	39.35
Moderate	High	-23.92*	5.295	<0.001	-36.79	-11.04
	Low	2.77	5.295	0.860	-10.11	15.65
Low	High	-26.69*	5.209	<0.001	-39.35	-14.02
	Moderate	-2.77	5.295	0.860	-15.65	10.11

Based on observed means.
The error term is Mean Square (Error) = 217.075.
*. The mean difference is significant at the 0.05 level.

In connection with post-hoc, it turns out in Table 9 that students who have high self-regulated learning have a higher effect than students who have moderate or low self-regulated learning on the acquisition of mathematical reasoning abilities. Students who have moderate self-regulated learning (SRL) have no different effect from students who have high and low SRL on the acquisition of mathematical reasoning abilities.

Table 10. Output effect of interaction between learning and SRL level on the acquisition of mathematical reasoning abilities

(I) Interaction	(J) Interaction	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
High EL-AR	Moderate EL-AR	36.278*	7.159	<0.001	21.82	50.74
	Low EL-AR	26.333*	6.945	<0.001	12.31	40.36
	High DI-AR	-1.079	7.425	0.885	-16.07	13.92
	Moderate DI-AR	8.778	7.425	0.244	-6.22	23.77
	Low DI-AR	26.063*	7.425	0.001	11.07	41.06
Moderate EL-AR	High EL-AR	-36.278*	7.159	<0.001	-50.74	-21.82
	Low EL-AR	-9.944	7.159	0.172	-24.40	4.51
	High DI-AR	-37.357*	7.625	<0.001	-52.76	-21.96
	Moderate DI-AR	-27.500*	7.625	<0.001	-42.90	-12.10
	Low DI-AR	-10.214	7.625	0.188	-25.61	5.19
Low EL-AR	High EL-AR	-26.333*	6.945	<0.001	-40.36	-12.31
	Moderate EL-AR	9.944	7.159	0.172	-4.51	24.40
	High DI-AR	-27.413*	7.425	<0.001	-42.41	-12.42
	Moderate DI-AR	-17.556*	7.425	0.023	-32.55	-2.56
	Low DI-AR	-0.270	7.425	0.971	-15.26	14.73
High DI-AR	High EL-AR	1.079	7.425	0.885	-13.92	16.07
	Moderate EL-AR	37.357*	7.625	<0.001	21.96	52.76
	Low EL-AR	27.413*	7.425	<0.001	12.42	42.41
	Moderate DI-AR	9.857	7.875	0.218	-6.05	25.76
	Low DI-AR	27.143*	7.875	0.001	11.24	43.05
Moderate DI-AR	High EL-AR	-8.778	7.425	0.244	-23.77	6.22
	Moderate EL-AR	27.500*	7.625	<0.001	12.10	42.90
	Low EL-AR	17.556*	7.425	0.023	2.56	32.55
	High DI-AR	-9.857	7.875	0.218	-25.76	6.05
	Low DI-AR	17.286*	7.875	0.034	1.38	33.19
Low DI-AR	High EL-AR	-26.063*	7.425	0.001	-41.06	-11.07
	Moderate EL-AR	10.214	7.625	0.188	-5.19	25.61
	Low EL-AR	0.270	7.425	0.971	-14.73	15.26
	High DI-AR	-27.143*	7.875	0.001	-43.05	-11.24
	Moderate DI-AR	-17.286*	7.875	0.034	-33.19	-1.38

*. The mean difference is significant at the 0.05 level.

The existence of an interaction effect between learning and SRL level on students' acquisition of mathematical reasoning abilities is shown by the output in Table 10. For example, the average gain in mathematical reasoning abilities of students with a moderate SRL level and studying with EL-AR (moderate EL-AR) is lower than that of students with a high SRL level and studying with DI-AR (high DI-AR). Likewise, the average gain in mathematical reasoning abilities of students with a high SRL level and studying with EL-

AR (high EL-AR) is higher than that of students with a moderate SRL level and studying with EL-AR (moderate EL-AR); this interaction effect is called an ordinal interaction effect.

3.2. Discussion

The results of the analysis of the answers to research question number 1 showed that descriptively, the average value of mathematical reasoning ability of students who learned with directed instruction assisted by augmented reality (DI-AR) had a higher effect than experiential learning assisted by augmented reality (EL-AR) on the acquisition of students' mathematical reasoning abilities. This was because students were used to learning with directed instruction (DI), and this was in accordance with the opinion of Stockard et al. (2018) and Hattie (2023) that directed instruction (DI) has the following advantages: 1) effective for various groups of students, including students with special needs, those from low socio-economic backgrounds, and those with learning difficulties; 2) the clarity and structure of the direct instruction help to reduce the cognitive burden of students and facilitate better understanding.

In the answer to research question number 2, the results of the analysis of the effect of experiential learning assisted by augmented reality (EL-AR) on the acquisition of students' mathematical reasoning abilities were obtained. Experiential learning assisted by augmented reality (AR) has a high effect on the acquisition of students' mathematical reasoning abilities. The effect size value is 14.003 with a point estimate of 2.189 > 0.80 (high category), so it shows that experiential learning assisted by augmented reality (EL-AR) has a high category effect on the acquisition of students' mathematical reasoning abilities. This is based on the advantages of experiential learning (Marsick & Watkins, 2001; Watkins & Marsick, 1992), namely: 1) improving retention and comprehension of the material because it involves students directly in experiences relevant to the content of the lesson. Through hands-on experience, students have the opportunity to build a deeper understanding and strengthen the connection between theory and practice; and 2) build student engagement because it engages students in tangible and meaningful activities that help increase students' intrinsic motivation and promote student-centered learning.

The results of the analysis of research answer number 3 obtained information that the effect of the implementation of directed instruction assisted by augmented reality (DI-AR) was higher than the effect of the implementation of experiential learning assisted by augmented reality (EL-AR) on the acquisition of students' mathematical reasoning abilities. This is due to the advantages of directed instruction (DI) and the weaknesses of experiential learning (EL). The advantages of directed instruction (DI), according to Stockard et al. (2018), are: 1) The teacher provides quick and timely feedback and corrections during learning so as to help students correct student mistakes immediately and ensure a deeper understanding of the material being taught; and 2) it is effective for a wide range of student groups, including students with special needs, students from low socio-economic backgrounds, and students with learning difficulties, and helps reduce achievement gaps among these groups. Disadvantages of experiential learning (EL), according to Fry et al. (2008): 1) requires longer time and more resources compared to traditional teaching methods; and 2) not all students may have the same experience or benefit from experiential learning; factors such as differences in students' abilities, interests, and backgrounds can affect learning outcomes.

The results of the analysis of the answers to research question number 4 obtained information that there was an interaction effect between learning and the level of self-regulated learning (SRL) on the acquisition of students' mathematical reasoning abilities. The average acquisition of mathematical reasoning abilities of students with a moderate level of self-regulated learning (SRL) and learning with EL-AR (Moderate EL-AR) was lower than that of students with a high level of SRL and learning with DI-AR (High DI-AR), which was in accordance with research of Hattie (2008). It was found that the Directed Instructions (DI) model is a well-structured learning that provides better results, especially for students with high SRL levels. Likewise, the average acquisition of mathematical reasoning abilities by students with a high level of self-regulated learning (SRL) and learning with EL-AR (High EL-AR) is higher than that of students with a moderate level of self-regulated learning (SRL) and learning with EL-AR (Moderate EL-AR); this interaction effect is called the ordinal interaction effect. This is in accordance with the research of Pintrich (2004), which states that students with high self-regulated learning (SRL) tend to have better learning outcomes, including in the context of the use of educational technology such as augmented reality (AR).

4. CONCLUSION

Based on the research questions, research findings, and discussion described previously, the following research conclusions were obtained: First, the average gain in mathematical reasoning abilities of students who study with experiential learning assisted by augmented reality (EL-AR) is lower than the average gain in mathematical reasoning abilities of students who study with directed instruction assisted by augmented reality (DI-AR). Based on the standard deviation or standard deviation values, descriptively, the distribution of scores for the acquisition of mathematical reasoning abilities of students who study with experiential learning assisted by augmented reality (EL-AR) is more spread out than the scores for mathematical reasoning abilities with directed instructions assisted by augmented reality (DI-AR). Meanwhile, based on the skewness value of the mathematical reasoning ability test scores of students who study with experiential learning assisted by augmented reality (EL-AR), the distribution is positively skewed and tends to converge on low scores, while the mathematical reasoning ability test scores of those who study with directed instruction-assisted augmented reality (DI-AR) scored high. Second, the implementation of experiential learning assisted by augmented reality (EL-AR) has a high impact on the acquisition of students' mathematical reasoning abilities. Third, the effect of implementing directed instructions assisted by augmented reality (DI-AR) is higher than the effect of implementing experiential learning assisted by augmented reality (EL-AR) on the acquisition of students' mathematical reasoning abilities. Fourth, there is an interaction effect between learning and the level of self-regulated learning (SRL) on students' acquisition of mathematical reasoning abilities. In connection with post-hoc, it turns out that students who have high self-regulated learning have a higher effect than students who have moderate or low self-regulated learning on the acquisition of mathematical reasoning abilities.

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