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Representasi Matematis Siswa pada Resource-Based Learning Model berbantuan Google Classroom

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Abstrak

Matematika merupakan subjek yang kaya akan representasi, dari mulai tabel, diagram, simbol, fisik, hingga verbal. Dalam bermatematika, peserta didik dituntut menguasai semua jenis representasi tersebut. Untuk memfasilitasi pembelajaran yang memuat semua representasi tersebut, diperlukan berbagai bahan dan referensi yang terstruktur. Tujuan penelitian ini adalah untuk mengetahui seberapa besar peningkatan representasi matematis dari siswa yang memperoleh Model *Resource-based Learning* berbantuan *Google Classroom.* Metode penelitian yang digunakan adalah metode eksperimen semu. Sample penelitian ini adalah siswa kelas XI tahun pelajaran 2021/2022 di salah satu SMA di Bandung. Teknik pengambilan sampel yang digunakan adalah purposive sampling. Sampel penelitian dipilih berdasarkan kelas yang sudah tersedia dan dipastikan bahwa kedua kelas tersebut memiliki kemampuan awal yang setara. Salah satu kelas kemudian menjadi kelas eksperimen, sementara kelas yang lainnya adalah kelas kontrol. Instrumen penelitian ini adalah tes kemampuan representasi matematis. Berdasarkan hasil analisis data, peningkatan kemampuan representasi matematis siswa di kelas eksperimen lebih tinggi dibandingkan siswa di kelas kontrol. Didapatkan juga bahwa meskipun diberikan bantuan resource dalam Google Classroom, akan tetapi representasi verbal siswa masih kurang dan menjadi tipe representasi yang terendah selain representasi fisik.

Kata Kunci: *google classroom,* representasi matematis, *resource-based learning*

Students' Mathematical Representation in Resource-based Learning Model Assisted by Google Classroom

Abstract

Mathematics is a subject rich in representations, ranging from tables, diagrams, symbols, physical, to verbal. In the realm of mathematics, students are required to master all of these types of representations. To facilitate learning encompassing all of these representations, various structured materials and references are necessary. The objective of this research was to determine the extent of improvement in mathematical representation among students who received Model Resource-based Learning aided by Google Classroom. The research method employed was quasi-experimental. Sample of this study were students of grade XI in the academic year 2021/2022 at one high school in Bandung. Purposive sampling technique was used for sample selection. The research sample was selected based on available classes, ensuring that both classes had equivalent initial capabilities. One class then became the experimental group, while the other class served as the control group. The research instrument was a test of mathematical representation ability. Based on the data analysis, the improvement in mathematical representation ability among students in the experimental group was higher compared to students in the control group. It was also found that despite being provided with resources in Google Classroom, students' verbal representations were still lacking and remained the lowest type of representation besides physical representation.

Keywords*: google classroom; mathematical representation; resource-based learning*

INTRODUCTION

In recent years, there has been a tremendous surge in online learning resources (Haleem et al., 2022).Previously, access to educational materials was limited to textbooks, libraries, and other physically restricted sources. However, with technological advancements and increased internet access, people now have direct access to various online learning resources such as ResearchGate, Academia, Google Classroom, Khan Academy, Coursera, edX, and many more. Additionally, social media and video platforms like YouTube have also become popular means for sharing knowledge and skills (Listiani, Suwastini, & Dantes, 2021). The utilization of these learning resources varies widely, ranging from students seeking course materials, professionals aiming to enhance their skills, to children desiring interactive learning experiences (Zhou et al., 2020). In Resource-based learning, students' takes the responsibility of choosing resources, whether human or otherwise, that match their individual learning preferences, interests, and capabilities. There are also other resources like traditional reference books, online sources, interactive content, and innovative games may be allotted (Kononets et al., 2020). These resources, distributed into well-planned and authentic tasks, which in this research Google Classroom platform played the role in managing and distributing the resources. The platform would ease the students to search along variety of resource appropriate to their own preferences (Nidup, 2022). Type of resource provides students with opportunities to cultivate the skills and methodologies required to become independent learners and proficient information consumers (Kononets, 2015).

Yaniawati et al. (2020) mentioned Resource-based learning has become a favored approach in education due to several advantages it offers. Firstly, it empowers students to cultivate independent learning skills by granting them control over selecting resources that align with their learning preferences, interests, and abilities. This autonomy fosters critical thinking, creativity, and self-reliance in learning. Additionally, the approach ensures the relevance of content by allowing access to up-to-date and pertinent resources, enabling students to relate the material to their personal experiences and contexts. Secondly, resource-based learning encompasses a wide array of resource types, including traditional textbooks, online articles, videos, and interactive mes. This diversity caters to various learning styles, allowing students to explore resources that best suit their preferences and needs. Moreover, the approach encourages collaboration and interaction among students and with teachers, facilitating the exchange of ideas and deepening understanding of the learning material (Fatimah et al., 2021; Sopian & Afriansyah, 2017).

Thirdly, resource-based learning stimulates creativity and innovation among students. By providing access to diverse resources, students have the opportunity to explore new ideas, develop creative thinking skills, and generate innovative solutions to problems. This fosters a dynamic learning environment where students are actively engaged in the learning process and encouraged to think critically and creatively. Lastly, resource-based learning aligns with the demands of 21st-century education, emphasizing skills such as problem-solving, critical thinking, communication, and collaboration. By offering relevant learning experiences, resource-based learning prepares students for success in a rapidly evolving world. In conclusion, resource-based learning offers a dynamic, student-centered approach to education, empowering students to reach their full learning potential (Kononets et al., 2020).

Among several advantages of the Resource-based Learning model, this research aimed to address the issue of mathematical representation in Indonesia, which according to several literatures such as Ristiani & Maryati (2022), Jumri & Murdiana (2022) and Utomo & Syarifah (2021), is still lacking. The indicator of mathematical representation with the lowest score in Ristiani & Maryati (2022) study was writing mathematical solution steps in words, with only a 24% achievement out of six subjects studied. Writing these steps is often sidelined by students because they are typically given limited time to solve problems. Furthermore, the assessment results tend to overly focus on problem-solving while overlooking the procedures they use. This constitutes an unhealthy assessment in mathematics learning, as mathematics emphasizes individual thinking processes.

In line with mathematical representation, which is also part of the dynamic and complex individual thinking process (Izzatin et al., 2020; Pedersen et al., 2021), mathematical representation is an important aspect of the mathematical problem-solving process. Thus, the emphasis in the instrument used in this research was not merely on students' final answers, but on how they generated effective representations to support the solution of the mathematical problems they encountered. Therefore, several issues in this research referred to specific indicators in mathematical representation.

The mathematical representation indicators used in this research referred to several theories, such as (Desai et al., 2021), who identified five types of representations: tables, graphs, formulations, verbal descriptions, and objects. Similarly, (Duval, 2006) also identified five types of representations: pictures, symbols, spoken language, real scripts, and manipulative models. Essentially, these five types of representations are not different. This research draws on the opinions of Pimm (1990) and Lesh et al. (1987) but with descriptions that are more appropriate for the present, as articulated by the National Council of Teachers of Mathematics (NCTM, 2020). These five types of representations are contextual, symbolic, visual, verbal, and physical.

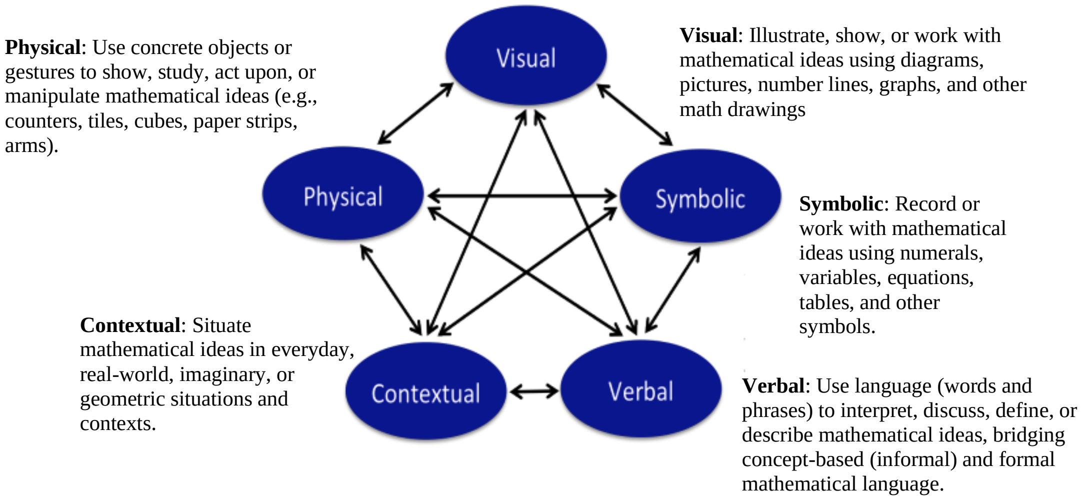


Figure 1. *Five types of Representation formulated by NCTM*
(Source: Standards for the Preparation of Secondary Mathematics Teachers, NCTM, 2014)

Mathematical representation plays a crucial role in understanding and solving mathematical problems (Mullis et al., 2021). With the advancement of technology, platforms like Google Classroom have become valuable tools in education. Several indicators of mathematical representation can be effectively incorporated into Google Classroom, enhancing the learning experience and improving students' mathematical representation skills. By utilizing the appropriate teaching models alongside this technology, educators can significantly boost students' mathematical representation abilities.

One key indicator that can be effectively integrated into Google Classroom is visual representation. Visual representations can help students make sense of mathematical concepts and abstract relationships (Parame-Decin, 2023). Google Classroom provides various tools for creating and sharing visual representations, such as graphs, charts, and diagrams, enabling students to visualize mathematical ideas more clearly. Similarly, highlight the significance of symbolic representation in mathematics, stating that symbolic representations, such as equations and formulas, are essential for expressing mathematical relationships concisely (Boaler & Sengupta-Irving, 2016).

In essence, the effective utilization of Google Classroom, combined with appropriate instructional strategies, can significantly enhance students' mathematical representation abilities. By incorporating visual, symbolic, verbal, and contextual representations into this digital platform, educators can create a dynamic learning environment that fosters a deeper understanding of mathematical concepts. Integrating technology like Google Classroom into mathematics education is not just about using gadgets; it's about transforming the learning experience and empowering students to become proficient mathematical thinkers.

The use of ICT has long been emphasized in the Indonesian curriculum due to its ability to assist teachers in creating material, organizing class assignments quickly and easily, providing immediate feedback to students efficiently, and communicating with students without being limited by time (Hapsari & Pamungkas, 2019). Google Classroom is an online classroom by Google, which serves as a learning aid that can be utilized across all educational settings. It aims to provide solutions in learning for both students and teachers by offering online teaching materials and facilitating the submission of assignments and access to educational resources.

From the explanation above, it is clear that the Google Classroom application can be an effective learning medium, helping teachers and students communicate online or outside of class hours without time constraints. The study, therefore, aims to measure the improvement in students' mathematical representation abilities when using the Resource-based Learning Model assisted by Google Classroom. Additionally, the research examines the types and limitations of students' representations..

METHOD

This study is a quasi-experimental research with a non-equivalent control group design. The population for this research comprises all students at SMAN 16 Bandung. The sample of this study was purposively selected based on established student classes. Despite employing a non-equivalent control group design, the measurement focused on the gain in mathematical representation ability scores. Consequently, both classes in this study were ensured to have equivalent initial mathematics abilities. One class was designated as the experimental class, while the other served as the control class.

Sample students were initially administered a pretest to determine whether there were any differences in the initial abilities of students between the experimental and control groups. Subsequently, both classes were subjected to different treatments, Resource-based Learning model was employed in experimental class, meanwhile conventional teaching was employed in the control class. Meetings were conducted three times, equivalent to 6 instructional hours. Afterward, the sample underwent a final test (posttest) to assess the differences in their mathematical representation abilities.

The instruments used in this research were a mathematical representation test. Before being utilized as an instrument, the test of mathematical representation ability was first subjected to validity analysis using the Pearson product-moment correlation formula with raw scores, reliability analysis using the Cronbach's alpha formula, difficulty index, and discrimination index within the range of 0.00 – 1.00.

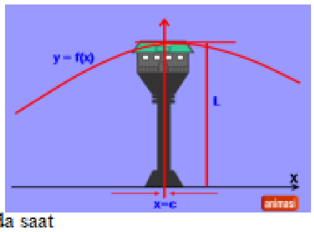
The collected data were then analyzed using both descriptive and inferential statistics. Descriptive statistics were employed to provide a general overview of the results obtained from both classes. Among the descriptive statistical measures used were the maximum value, minimum value, mean, standard deviation, and variance of the pretest and posttest data for each class. Meanwhile, inferential statistics in this research were used to draw conclusions and make decisions based on the analysis and hypotheses formulated. To compare the gain in students' mathematical representation scores, this study employed a test of mean difference (t-test or Mann-Whitney test) with a significance level of 5%. Before determining whether to use a t-test or Mann-Whitney test, a normality test of the data was conducted using the Shapiro-Wilk test. This was followed by the Levene's test to determine the homogeneity of the data. Statistical analysis in this research was carried out with the assistance of IBM SPSS 24.0 for Windows.

RESULTS

In summary, this research has been highly successful. The resource-based learning model, supported by Google Classroom, has effectively aided students in enhancing their representational skills. Although the approach was successful in fostering three types of representation, contextual; symbolic; and visual, only a small percentage of students (23.3% in the experimental group and 16.7% in the control group) were able to articulate a problem using verbal representations. Even though we have made efforts to familiarize students by providing worksheets designed to guide their answers towards appropriate representations, the desired outcomes have not been fully achieved. As illustrated in Figure 2, we have provided an example of how we direct students' responses to align with our expectations.

Situasi 1

Amatilah arah terbang dua ekor burung menuju Sangkar dari arah yang berbeda. Sangkar dari Arah yang berbeda. Jika jejak kedua burung terbang Tersebut identik dengan lintasan parabola $f(x) = -x^2 + 4x$. Jarak kedua ekor burung semakin dekat ke sangkar adalah 2 meter. Berapakah tinggi pada saat tinggi burung pada saat tiba dalam sangkar tersebut?



Problem statement

Penyelesaian :

Secara umum bentuk limit ditulis $\lim_{x \to a} f(x) = f(a)$

Jika $f(a) = k$, maka $\lim_{x \to a} f(x) = k$

Jika $f(a) = \frac{0}{k}$, maka $\lim_{x \to a} f(x) = 0$)

Jika $f(a) = \frac{k}{0}$, maka $\lim_{x \to a} f(x) = \infty$)

Translation:
Generally limit is written by $\lim_{x \to a} f(x) = f(a)$
If $f(a) = k$, maka $\lim_{x \to a} f(x) = k$
If $f(a) = \frac{0}{k}$, maka $\lim_{x \to a} f(x) = 0$
If $f(a) = \frac{k}{0}$, maka $\lim_{x \to a} f(x) = \infty$

Instructions to use symbolic representations

Diketahui :
Lintasan terbang burung =……
Jarak kedua ekor burung semakin dekat ke sangkar =
Ditanyakan :
Tinggi burung pada saat tiba dalam sangkar……
Jawab :

Translation:
Birds fly path in function is….
Distance between birds when they are closer to the birdhouse is….
Question:
Both birds arrives at the birdhouse on the height ….

Guiding and demonstrating verbal representations

$\lim_{x \to \dots} f(x) = \dots(\dots)^2 + 4(\dots)$

$= \dots + \dots$

$= \dots$

$L = \lim_{x \to \dots} f(x) = \dots$

Students were expected to follow the use of symbolic representations.

Kesimpulan :
Jadi, tinggi burung pada saat tiba dalam sangkar adalah.

Translation:
Therefore, both birds arrives at the birdhouse on the height ….

Students were expected to follow the use of verbal representations.

Figure 2. *Resource to guide Contextual, Symbolic, and Verbal Representations.*

A more detailed explanation of the research findings we obtained is presented as follows.

Students' Mathematical Representation

Research data includes pretest, posttest, gain index, and correlation data. Non-test result data includes the results of filling out the questionnaire. The quantitative data processing techniques used are the normality test, homogeneity test, mean difference test, and gain index. A brief description of the results of the mathematical representation ability test from the experimental class and the control class is presented in Table 1 below.

Table 1. *Descriptive Statistics Data on Pretest, Posttest Results and N-Gain for Experimental and Control Class*

		Control			Experiment		
		Pretest*	**Posttest***	**N-Gain****	**Pretest***	**Posttest***	**N-Gain****
Mathematical Representation	**N**	30	30	-	30	30	-
	Min	15	50	0.20	25	55	0.31
	Max	65	80	0.71	65	90	0.80
	Mean	44.23	68.83	0.43	45.47	72.83	0.50
	Std. Dev	13.04	9.16	0.14	11.49	9.80	0.14

*) Maximum Score: 100
**) Normalized gain index 0-1

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Based on the results of the statistical analysis, it was found that the pretest scores of the experimental and control classes were slightly different. During the pretest, the minimum, maximum, and average scores of the experimental class were consistently higher than those of the control class. The standard deviations of both classes were not significantly different. In the posttest, the minimum, maximum, and average scores for the experimental class remained higher than the scores of the control class. However, the difference in average scores between the experimental and control classes during the pretest was more substantial, with a larger standard deviation in the control class. Meanwhile, in terms of normalized gain (n-gain), the minimum n-gain in the experimental class was larger than that in the control class, with a higher average in the experimental class. Additionally, the experimental class also exhibited a smaller standard deviation compared to the control class. At a glance, based on this descriptive data which also visualized with Boxplots in Figure 3, it can be observed that the scores of students in the experimental class are higher compared to those in the control class. However, to validate these conclusions, a test of mean differences as outlined in the previous methodology section was employed.

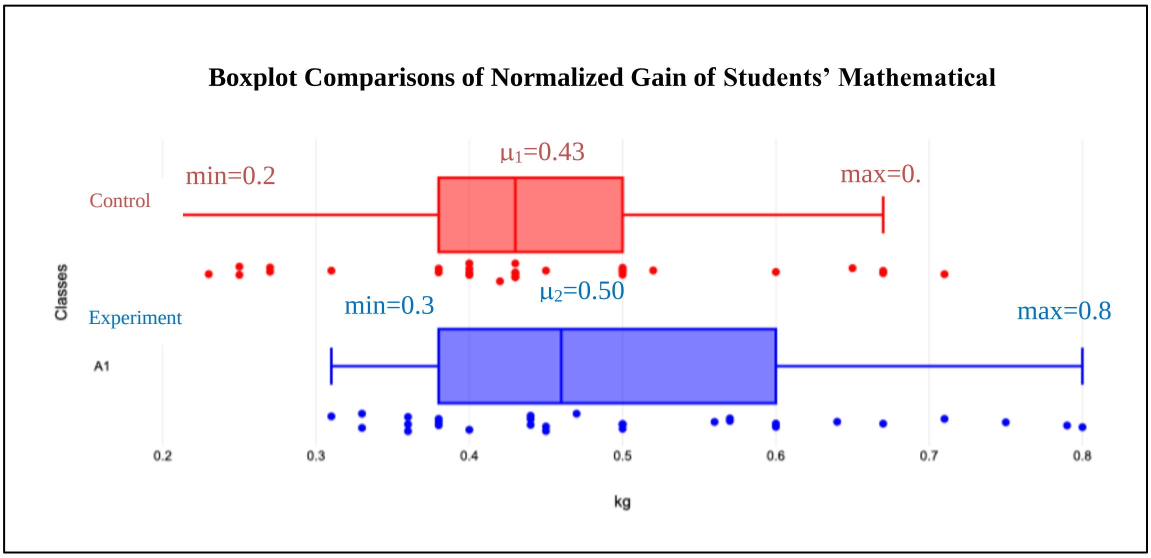


Figure 3. *Boxplot Comparisons of N-Gain of Students' Mathematical Representations*

Before conducting the test of mean differences, a normality test was first performed on the data of students' mathematical representation ability scores in both classes. This was done to determine the test formula to be applied. With a sample size of only 60, the normality test for the data was conducted using the Kolmogorov-Smirnov formula. The results of the normality test for the n-gain data of both classes are presented in Table 2 below.

Table 2. *N-Gain Normality Test Result of Both Classes*

	Kolmogorov-Smirnov[a]		
	Statistic	**df**	**Sig.**
Control	.141	30	.132
Experiment	.141	30	.131

As mentioned earlier, this research utilizes a significance level of 5%, allowing us to conclude that the n-gain data for both classes follows a normal distribution since the significance values are 0.132 and 0.131, both are greater than 0.05. Therefore, the type of mean difference test used is the t-test. The t-test results for the n-gain data for both classes are presented in Table 3 below.

Table 3. *The t-Test Result of N-Gain on The Experimental and Control Class.*

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
n-gain	Equal variances assumed	.525	.472	1.917	58	.060	.06867
	Equal variances not assumed			1.917	57.8	.060	.06867

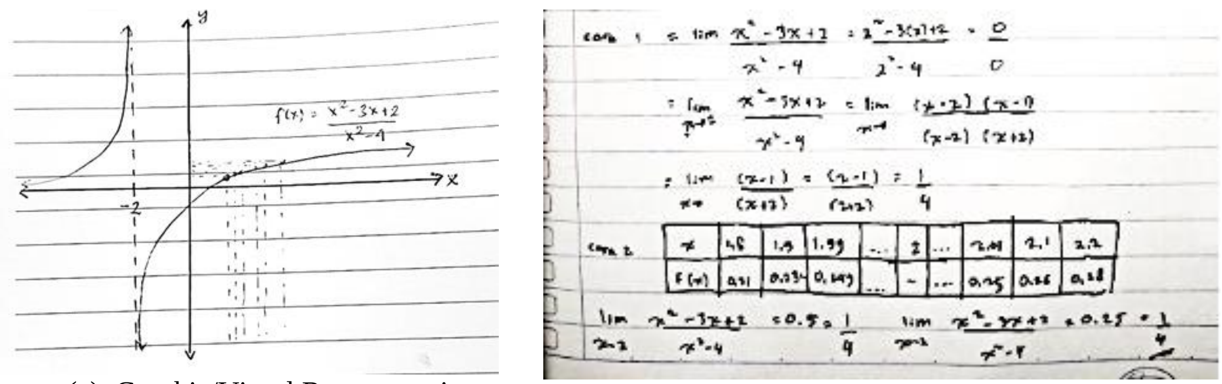
Based on the Levene's test, as displayed in Table 3, the significance value for the n-gain data is .472, which is greater than .05. This indicates that both classes have equal variance. Therefore, the first row result in Table 3 were the best way on figuring the results. Based on the table, the calculated t-value = 1.917. Meanwhile, as what have been stated before, .05 significance level used in this research and degrees of freedom (df) equal to 58, the t-distribution table value is 1.67155. Thus, based on the t-test, it can be concluded that students' gain, which was to measure improvement on mathematical representation in the experimental class, was higher than students' gain in the control class.

DISCUSSION

The use of Resource-based Learning in the study enabled students to independently select resources that they tended to understand. In this research, it was found that Resource-based Learning had a positive impact, as evidenced by higher n-gain scores for mathematical representation compared to students learning through conventional models. In terms of process, the experimental class provided more options for learning resources for participating students. The use of Google Classroom also facilitated access, allowing students from various locations to access educational materials without physical or distance barriers (Sudarsana et al., 2019). The media used as learning resources for the experimental class were shared within Google Classroom. This made it easier for students to directly access learning resources without having to search among many sources.

The use of Google Classroom in this study for the topic of Function Limits learning provided students with ease in accessing various resources that they could understand. Some students could easily grasp the formal definition of function limits, but others might have required additional visualization to form their perception and understanding (Nidup, 2022; Ramadhani et al., 2019; Sudarsana et al., 2019), thus necessitating visual media such as images or videos. Other media such as YouTube also provided assistance in examples and solutions to limit problems.

Approaches often used by students in understanding the concept of limits were tables and graphs for visualization. The use of tables in the concept of limits aligned with students' visual understanding that the limit of a function had a value if the left-hand limit and the right-hand limit approached the same value. This understanding could be well interpreted by students. As shown in Figure 4, which demonstrated that students were able to formulate real-world problems into the form of function limits to find their solutions.



(a) Graphic/Visual Representation

(b) Symbolic Representation

Figure 4. *Students' responses using various representations in Algebraic Function Limit problems*.

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In the provided Google Classroom, there were various representations readily accessible to assist students in their understanding. The graphical representation in Figure 4.a presented by the student was done with the aid of the GeoGebra module shared within Google Classroom. Various representations played a crucial role in mathematics learning as they aided both teachers and students in mastering key points of mathematical abstractions (Desai et al., 2021). As evident in Figure 4, students demonstrated an understanding of the main concepts of algebraic function limits. It was also noticeable that students were comfortable transitioning between different types of representations, from graphical to symbolic representation. Moreover, they were capable of providing answers to the problem effectively.

Based on the various types of representations proposed by Desai et al., (2021), Mainali (2021), NCTM (2020) the resources provided in this study clearly demonstrated their effectiveness in supporting the learning of algebraic function limits. This effectiveness is evident from the significant improvement in students' representational abilities, as reflected in their n-gain scores. Furthermore, a closer analysis revealed that certain types of representations were particularly strong and were more frequently utilized by students when solving problems related to algebraic function limits. These types of representations and their usage by students are illustrated in Figure 5 below.

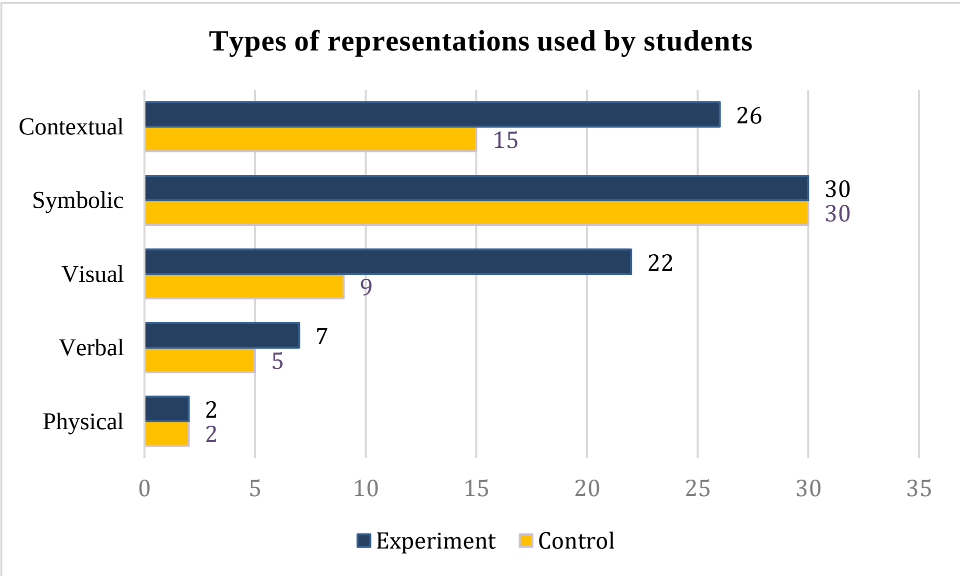


Figure 5. *Utilization of representation types by students in algebraic function limit problems*.

The use of representation types in the experimental class was more varied compared to those in the control class. Students in the experimental class also tended to have better abilities than those in the control class in interpreting contextual problems. Interpreting contextual problems and their connection to mathematical representations was highly important. Mathematical representation was an essential element to help students understand concepts and connections between concepts; to communicate the mathematical approaches used; to make mathematical arguments; and to apply mathematical concepts in everyday life (Alifa et al., 2022; Lutfi & Dasari, 2023; Utomo & Syarifah, 2021).

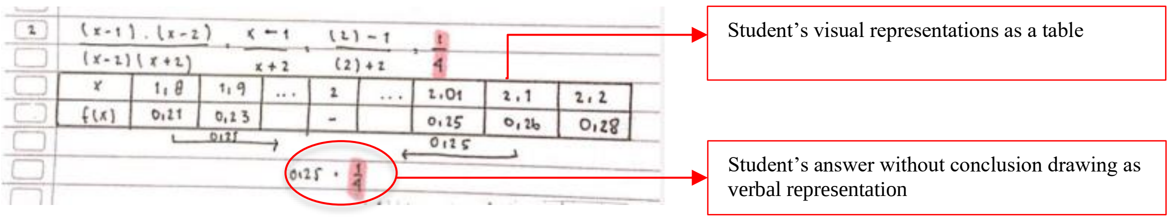
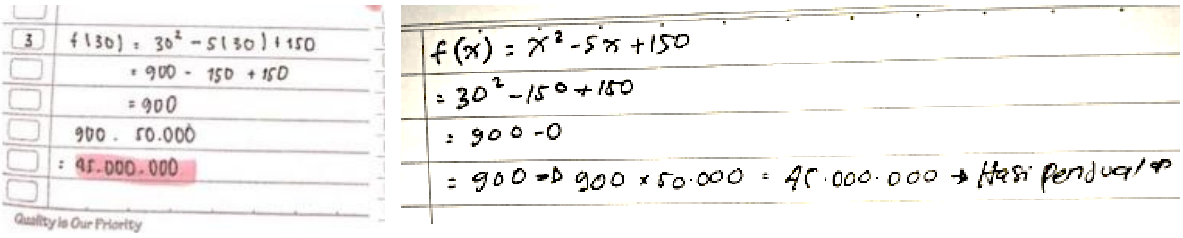


Figure 6. *The student's response indicates that he/she did not provide the expected verbal representation*

Despite its success in three types of representation: contextual, symbolic, and visual; only a few students (23.3% in the experimental class and 16.7% in the control class) were able to provide verbal representations of a problem. Those students who did not offer verbal representations were not incapable of problem-solving or understanding the problem; rather, they seemed untrained in doing so. Further research is needed on this issue, as the resources distributed in Google Classroom always include a verbal representation process, at least at the end during the conclusion.

The provided resources effectively directed the problem-solving process with various possible representations without unnecessarily hindering the problem-solving process. However, students were overly focused on algebraic processes and calculations, as demanded by the minimum curriculum requirements, disregarding the representation process in problem-solving. The example provided in the previous Figure 2 illustrates one of the given resources.

Figure 7 were the students' responses to a similar problem as depicted in Figure 6. It is worth noting that the problem in Figure 6 was the content of one of the resources distributed in Google Classroom, while the response in Figure 7 below was the answer to a mathematical representation test with a similar question.



(a) (b)

Figure 7. *Student's response that indicates that he/she did not provide the expected verbal representation although appropriate resources have been provided*.

Even the best provided answer only had limited and somewhat unclear explanations, as illustrated in Figure 8 below.

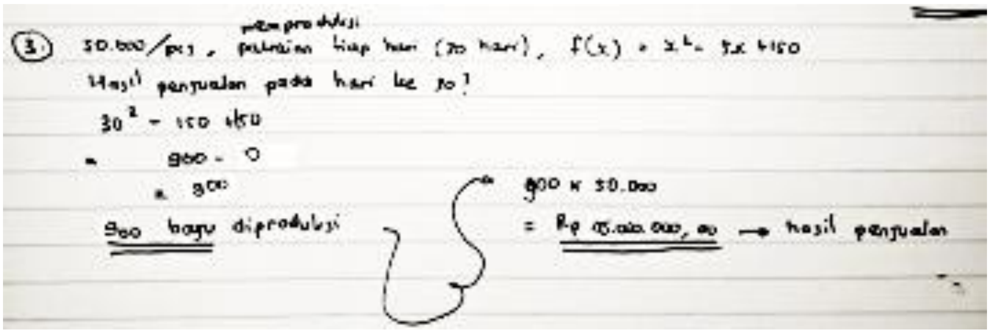


Figure 8. *Best student's response with some scanty explanations that were not very clear*.

Based on Figure 8, it is evident that the student provided a symbolic representation by mathematically modeling the problem. The student's solution is indeed correct. However, the presentation of the results and the reintegration of the answer into the real-world context appear to be lacking, as the explanation given is very brief and unclear. This indicates a deficiency in the student's symbolic representation skills, despite the implementation of the resource-based learning model. Concerning physical representations, the score for this type of representation was the lowest in this study. However, this could be understood, as no resources were provided for this indicator. This was due to the limitations of time and space provided for this research. Certainly, this could be a point of consideration in future research

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CONCLUSION

The research findings outlined above compared the enhancement of students' representational abilities between the experimental and control groups. Testing the results through a mean difference test (t-test) concluded that the students' improvement, which aimed to measure mathematical representation in the experimental group, exceeded that of the control group. A more detailed analysis of the students' work indicated that the variety of representation types in the experimental group surpassed those in the control group. Physical and verbal representations identified as less mastered or not displayed by the students. For those who did not provide verbal representations, they failed to demonstrate proficiency in problem-solving or comprehending the problem; rather, they appeared untrained in doing so. Meanwhile, it is imperative to acknowledge that the utilization of physical representations posed a limitation in this study. Time constraints, the availability of teaching aids, and infrastructure presented challenges in providing appropriate physical representations, especially in the form of measurement during assessments. Such factors could serve as crucial considerations for future research endeavors.

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