

Students' Ability in Differentiating Linear and Non-Linear Functions Assisted by Photomath

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Abstrak

Penggunaan aplikasi berbasis kecerdasan buatan dalam pembelajaran matematika telah meningkat secara signifikan, termasuk juga penggunaan aplikasi Photomath, yang menyediakan solusi instan dan visualisasi grafis. Studi ini bertujuan untuk mendeskripsikan kemampuan pemahaman siswa dalam membedakan fungsi linear dan non-linear dengan bantuan aplikasi Photomath. Studi ini dengan menggunakan studi deskriptif yang melibatkan 20 siswa kelas VIII.1 di SMPN 2 Indralaya Utara. Data dikumpulkan melalui tes pemahaman tertulis dan dianalisis berdasarkan tiga indikator: translasi, interpretasi, dan ekstrapolasi. Hasil menunjukkan bahwa Photomath sangat mendukung kemampuan interpretasi siswa, khususnya dalam menginterpretasikan karakteristik grafis fungsi linear dan non-linear. Namun, keterbatasan diamati pada indikator translasi dan ekstrapolasi. Beberapa siswa mengalami kesulitan dalam menerjemahkan representasi grafis ke dalam gambar dan tabel manual, serta dalam melakukan sintesis berbagai karakteristik menjadi kesimpulan yang komprehensif. Temuan ini menunjukkan bahwa secara keseluruhan Photomath efektif mendukung visualisasi dan interpretasi awal, namun tidak secara otomatis mendorong kelancaran representasi atau penalaran tingkat tinggi. Oleh karena itu, penggunaan Photomath harus disertai dengan dukungan instruksional yang eksplisit untuk mendukung pemahaman konseptual yang lebih mendalam.

Kata kunci: Aplikasi Photomath; fungsi linear; fungsi non-linear; kemampuan pemahaman.

Abstract

The use of artificial intelligence-based application in mathematics learning has increased significantly, including the Photomath application, which provides instant solutions and graphical visualizations. This study aims to describe students' comprehension ability in distinguishing linear and non-linear functions assisted by the Photomath application. The study employed a descriptive study involving 20 students of class VIII.1 at SMP 2 Indralaya Utara. Data were collected through written comprehension test and analyzed based on three indicators: translation, interpretation, and extrapolation. The results indicate that Photomath strongly support students' interpretations abilities, particularly in identifying and interpreting graphical characteristic of linear and non-linear functions. However limitations were observed in the translation and extrapolation indicators. Several students experienced difficulties in translating graphical representations into manual drawings and tables, as well as in synthesizing multiple characteristics into comprehensive conclusions. These findings suggest that whole Photomath effectively supports visualization and initial interpretation, it does not automatically foster representational fluency or higher-order reasoning. Therefore, the use Photomath should be accompanied by explicit instructional scaffolding to support deeper conceptual understanding.

Keywords: photomath application; linear function; non-linear function; comprehension ability.

I. INTRODUCTION

The use of digital technology in education has increased significantly, particularly during the post-pandemic transition period. In mathematics learning, digital tools have been widely utilized to support instructional continuity, learning flexibility, and students' access to learning resources (Sari, 2022). More recently, the integration of artificial intelligence (AI)-based applications has become an important topic of discussion in mathematics education due to their potential to provide instant feedback, automated problem solving, and visual representations. However, the use of AI in mathematics learning also presents challenges related to students' conceptual understanding and the risk of learning dependence (Sinaga, 2024).

In the context of secondary education, the integration AI is often associated with the development of personalized learning experience, particularly in STEM objects. AI-based technologies allow students to receive adaptive feedback and visual support that may accommodate diverse learning needs (Subandi & Supardi, 2024). Nevertheless, several studies emphasize that the effectiveness of AI in mathematics learning depends not only on technological features, but also on how students engage cognitively with mathematical representations. Without appropriate instructional guidance, AI-based tools may encourage superficial understanding rather than deep conceptual learning (Sinaga, 2024; Subandi & Supardi, 2024).

Understanding mathematical concepts, especially related in topics related to functions, requires student to work with

multiple representations, such as symbolic expressions, graphs, and tables. Previous studies have shown that students at the junior high school level often experience difficulties in developing conceptual understanding in mathematics, even when they are able to perform procedural calculations correctly (Saepuloh, Luritawaty, & Afriansyah, 2024; Putri & Nasution, 2023; Sasomo, 2023; Setiani, 2022). These difficulties become more apparent in topics involving relations and functions, where students commonly face learning obstacles in interpreting graphs, identifying relationships between variables, and translating information across representations (Rahmi & Yulianti, 2022). One of the causes is the lack of optimizing the use of learning media (Luh et al., 2023). research conducted by Maisya & Sabrina (2024) stated that the results of the post-test of the minimum competency assessment (AKM) numeracy during the 6th batch of lectures at SMP Negeri 2 Indralaya Utara were still relatively low, namely <50%. Based on known experience, the learning carried out did not use learning media.

Understanding mathematical concepts is a student's ability to master subject matter by understanding the meaning and relationship between ideas, and being able to apply them flexibly on problem-solving (Listiani & Rachmawati, 2022; Oktavianah & Nurfalah, 2023; Miatun & Ulfah, 2023). Mathematical conceptual understanding is not limited to obtaining correct answer, but involve students; ability to interpret, connect, and apply mathematical ideas meaningfully. Several students highlight that conceptual understanding includes the

ability to translate representations, interpret mathematical relationships, and draw conclusions based on given information (Sengkey et al., 2023). When students lack representational fluency, their understanding tends to remain fragmented, particularly when they are required to move beyond recognition toward reasoning and generalization.

One AI-based application that is widely used by students is Photomath. Photomath enables users to scan mathematical expressions and instantly generates step-by-step solutions accompanied by graphical visualizations. A systematic literature review indicates that the use of Photomath in mathematics learning offers both benefits and limitations. While the application can assist students in solving problems efficiently, its contribution to conceptual understanding varies depending on how it is integrated into instruction (Rifa'i & Yahfizham, 2024). This suggests that Photomath should be viewed as a supporting learning tool rather than a substitute for conceptual reasoning.

Previous studies on visual-based learning media also indicate that visualization can support students' mental processes in mathematics learning; however, meaningful conceptual understanding still requires instructional scaffolding to help students connect visual information with mathematical concepts (Meryansumayeka et al., 2018; Abdullah et al., 2024; Maulandani & Afriansyah, 2024). This perspective aligns with concerns that AI-generated visual outputs, although helpful, do not automatically foster higher-order comprehension.

Based on these considerations, there remains a research gap regarding how AI-based applications such as Photomath support students' comprehension ability at different levels, particularly in distinguishing linear and non-linear functions. Therefore, this study aims to describe students' comprehension ability in distinguishing linear and non-linear functions assisted by the Photomath application. Students' comprehension is analyzed based on three indicators: translation, interpretation, and extrapolation. By examining these indicators, this study seeks to reveal not only the aspects of learning that are most supported by Photomath, but also the learning obstacles that persist. The findings are expected to contribute to mathematics education by providing empirical insights into the pedagogical role of AI-based applications as tools for supporting conceptual understanding.

II. METHOD

This type of research is descriptive study approach that aims to describe the ability of distinguish between linear and non-linear functions assisted by Photomath app. This research took place at SMP Negeri 2 Indralaya Utara in the odd semester of the 2024/2025 academic year with a research time of 3 meetings, namely 2 learning sessions and 1 written test. The subjects of this study were 20 students of class VIII.1 SMP Negeri 2 Indralaya Utara. The procedure used through 3 stages, namely the preparation stage, the implementation stage, and the data analysis stage. Data collection techniques through written tests.

The research instrument is in the form of 3 essay questions. At the analysis stage, student answers are checked. Then the test score is calculated based on the formula below.

$$Value = \frac{Total\ score\ obtained}{Total\ maximum\ score} \times 100$$

Then determine the category of understanding ability in distinguishing linear and non-linear functions with the Photomath app. The following is the category of understanding ability in distinguishing linear and non-linear functions.

Table 1.
Assessment Categories

Intervals	Categories
$81 \leq score \leq 100$	Very Good
$61 \leq score \leq 80$	Good
$41 \leq score \leq 60$	Enough
$21 \leq score \leq 40$	Low
$0 \leq score \leq 20$	Very Low

III. RESULT AND DISCUSSION

This section presents the results of the descriptive analysis of students' comprehension ability in distinguishing linear and non-linear functions assisted by Photomath app. The analysis is based on students' responses to write test items and its organized according to comprehension indicators: translation, interpretation, and extrapolation. An overview of students' performance for each indikator is first presented to describe general trends, followed by a more detailed analysis using representative examples of students' work.

Table 2 summarizes students' average scores as an overview of their overall performance.

Table 2.

Average Student Comprehension Ability Score			
Intervals	Frequency	Percentage (%)	Categories
$81 \leq score \leq 100$	2	10%	Very Good
$61 \leq score \leq 80$	10	50%	Good
$41 \leq score \leq 60$	8	40%	Enough
$21 \leq score \leq 40$	0	0%	Low
$0 \leq score \leq 20$	0	0%	Very Low
amount	20	100%	
Average Value =		64,45	Good

In general, students' understanding ability is in the good category, but there is still a significant proportion of students with limited understanding.

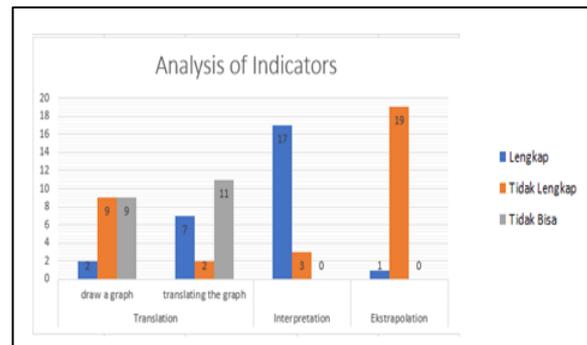


Figure 1. Indicators Analysis.

The image above is an analysis based on translation, interpretation, and extrapolation indicators. The translation indicator shows the most prominent weakness, marked by high score variation and low student ability in converting graphs to other representations. The following is a more in-depth analysis of each indikator.

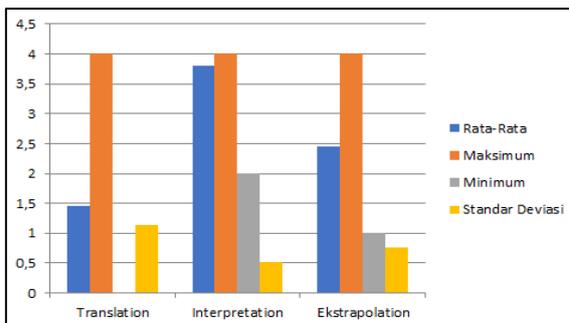


Figure 2. Analysis of Mean, Maximum, Minimum, and Standard Deviation.

Figure 2 illustrates clear differences in comprehension indicators. The translation indikator shows the weakest performance and the greatest variability, indicating that students experienced considerable difficulty in converting graphical information into other representations. In contrast, students demonstrated stronger and more consistent understanding in the interpretation indikator, suggesting that recognizing and identifying characteristics of linear and non-linear graphs was relatively easier for them.

Meanwhile, performance on the extrapolation indikator lies between translation and interpretation. Although some students were able to draw conclusion about differences between functions, their understanding was not yet fully developed. Overall, this pattern indicates that students benefited more from visual recognition supported by Photomath than from tasks requiring representationa transformation and inferential reasoning.

Representative student responses are presented to illustrate typical patterns of understanding and difficulty across indicators.

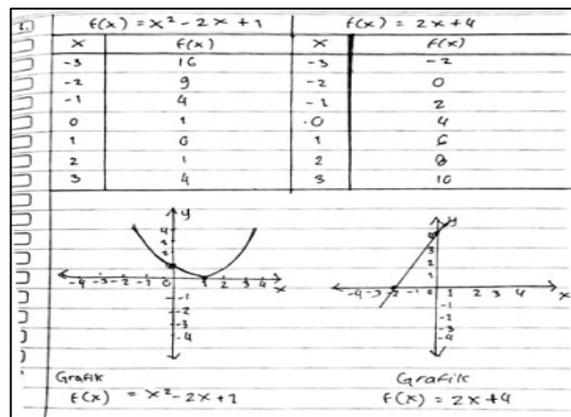


Figure 3. Student Answer M Number 1 Very Good Category.

Figure 3 presents the work of student M, who demonstrates achievement of the translation indikator with minor inaccuracies. The student successfully utilized the Photomath app to generate graphs of linear and non-linear functions and was able to transfer the graphical information into a table accurately. This indicates that the students could translate visual representations into numerical form effectively.

However, when redrawing the graphs manually, the students showed limited precision in representing the quadratic function. The drawing focused mainly on points where the graph intersected the x-axis, while intermediate points were overlooked. This suggests that although Photomath supported the student in recognizing graphical forms, careful attention to coordinate relationships was still lacking. Consequently, the student's performance met translation indikator but did not reach a fully accurate level.

In contrast, the following example illustrates the responses of a student in the sufficient category, highlighting typical difficulties encountered in the translation indikator.

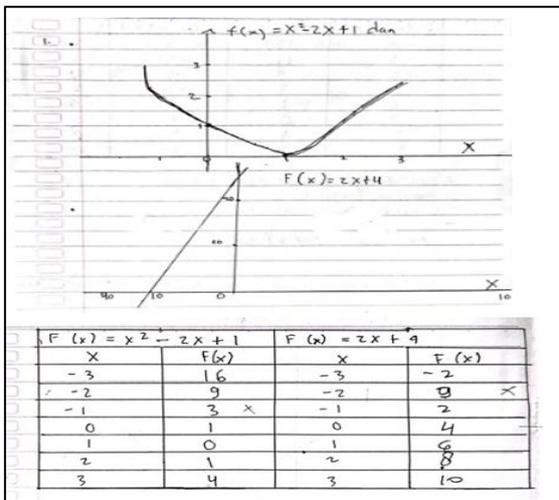


Figure 4. Student Answer S Number 1 Fair Category.

The image above shows the response of student S, who is categorized in the sufficient group. Student S used Photomath app to generate graphs of the linear and non-linear (quadratic) functions. After the graphs were displayed, the student attempted to redraw both graphs manually on Cartesian plane and then translate the graphical information into a table.

Although student S was able to use Photomath to obtain the graphical representations, difficulties emerged when translating these representations into manual drawings. The student did not accurately consider the relationship between the x- and y-coordinates when plotting points, resulting in errors in reconstructed graphs. Similar difficulties were observed when converting the graphical information into a table, as several values did not correspond to graphs shown.

These findings indicate that student S was unable to meet the translation indicator, as the student struggled to accurately transform graphical representations into both manual graphs

and tabular forms. Consequently, student S obtained a score 0 for this indicator.

Consistent with this study's findings, earlier research has identified significant challenges for students working with Cartesian coordinates and graph representations. Bahrin et al. (2021) reported that many students hold misconceptions about coordinate concepts, resulting in procedural errors when drawing and interpreting graphs, while recent descriptive studies affirm that student struggle with determining and plotting (x, y) points in Cartesian (Naifah et al., 2023). These difficulties reflect a broader pattern in mathematics education where students' visualization and representational skills remain problematic without explicit scaffolding.

The next indicator analyzed is interpretation, which reflects students' ability to interpret the graphical characteristic generated by Photomath app. The following example represents a student who successfully achieved the interpretation indicator.

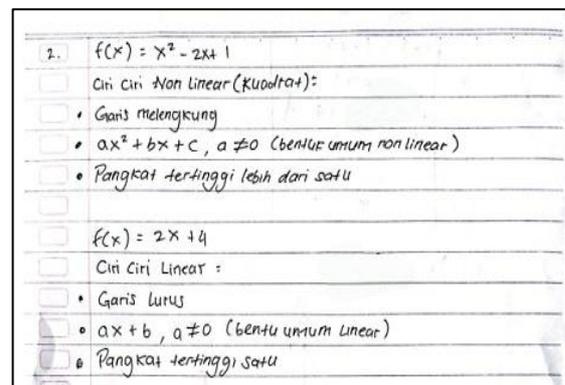


Figure 5. Student Answer M Number 2 Category Very Good.

Figure 5 is the answer of student M for the interpretation indicator. Student M demonstrates a complete achievement of interpretation indicator by accurately

identifying both linear and non-linear graphs. The student is able to recognize key characteristics of each function, including graph shape, general form, and the degree of the highest power. Specifically, the student distinguishes linear functions by their first-degree form and straight-line graphs, while identifying non-linear (quadratic) functions by their second-degree form and curved graphs. These responses indicate a well-developed ability to interpret graphical representations of functions.

Overall, students demonstrated a relatively uniform and strong performance on the interpretation indicator. Most students were able to correctly identify and explain the characteristics of linear and non-linear (quadratic) function graphs, including graph shape, general form, and the highest power of the variable. This consistency indicates that the interpretation indicator was well supported by the use of the Photomath app.

The graphical representations generated by Photomath appear to play a crucial role in helping student visually distinguish between straight-line and parabolic graphs, thereby facilitating conceptual recognition rather than procedural computation. As a result, even students with moderate overall achievement were able to interpret key graphical characteristics correctly. This finding suggests that Photomath is particularly effective in supporting students' conceptual understanding at the interpretation level through visual scaffolding.

The analysis now proceeds to the extrapolation indicator, which examines

students' ability to draw conclusions and generalize differences between linear and non-linear functions based on graphical information generated by the Photomath app. The following example represents a student in the sufficient category, illustrating partial achievement of the extrapolation indicator.

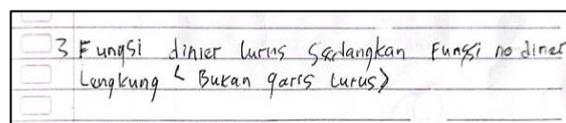


Figure 6. Student S's Answer Number 3 Fair Category

The image above presents the response of student S, who is categorized in the sufficient group. Student S was able to distinguish between linear and non-linear functions by making an inference based on the graphical representation. The student correctly identified the differences in graph the difference in graph shape between the two functions, indicating an initial ability to draw conclusions from the visual information provided.

However, the inference made by student S was limited in scope. Although the task required the student to mention three differences through inference, the response focused on one aspect, namely the graph shape, without extending the conclusion to other relevant characteristics. This indicates that student S demonstrated only partial achievement of the extrapolation indicator, as the ability to synthesize multiple characteristics into a comprehensive conclusion was not yet evident. This suggests that while the graphical output generated by Photomath supported initial inference, it did not sufficiently prompt deeper generalization.

Consequently, student S obtained score of 2 in this indicator.

Overall, students demonstrated weaker performance on the extrapolation indicator compared to the translation and interpretation indicators, their conclusions were often limited to a single characteristic, such as graph shape. This suggest that students experienced difficulties in synthesizing of information into a comprehensive generalization.

Although Photomath app effectively supports visualization and initial interpretation of graphs, it appears to provide limited scaffolding for higher-order reasoning required in extrapolation. Drawing broader conclusions and generalizing differences between linear and non-linear functions require reflective and integrative thinking processes that extend beyond automated graphical outputs. Therefore, explicit instructional guidance remains necessary to support students in developing extrapolative reasoning skills. This finding aligns with previous evidence indicating that AI-based tools in mathematics learning are most effective when accompanied by teacher guidance, as AI functions optimally as a supporting instrument for formative assessment rather than a stand-alone learning solution (Indaryanti et al., 2025).

IV. CONCLUSION

This study investigated students' comprehension ability in distinguishing linear and non-linear functions assisted by the Photomath app, focusing on three indicators: translation, interpretation, and extrapolation. The findings demonstrate that Photomath contributes differently

across these indicators, highlighting both its strengths and limitations as a learning support tool.

Photomath was found to be most effective in supporting students' interpretation abilities. The graphical visualization generated by the application enabled students to consistently identify key characteristics of linear and non-linear functions, such as graph shape, general form, the highest power of the variable. In contrast, student experienced greater difficulties in the translation and extrapolation indicators, particularly in converting graphical representations into manual forms and in drawing comprehensive conclusions based on multiple characteristics.

This study has several limitations. The research was conducted with a limited number of participants from a single class, which may restrict the generalizability of the findings. In addition, the analysis focused only on three indicators of comprehension and did not examine other aspects such as long-term conceptual retention or students' affective responses toward the use of AI-based applications like Photomath.

Despite these limitations, this study contributes to the field of mathematics education by providing empirical evidence on the differentiated role of AI-assisted application across levels of conceptual understanding. The findings imply that Photomath should be used as a complementary instructional tool rather than a stand-alone solution. Teachers are encouraged to provide explicit instructional scaffolding to help students connect digital graphical representations with manual

representations and to support higher-order reasoning. Future research is recommended to involve larger and more diverse samples and to explore instructional strategies that integrate AI-based application more effectively in mathematics learning.

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