



DEVELOPMENT OF SCRATCH-BASED MEDIA TO IMPROVE STUDENTS' UNDERSTANDING OF COMPOSITE FUNCTIONS

Fadillah Nur Afina*, Ardhi Prabowo

Mathematics Education Study Program, Universitas Negeri Semarang, Jl. Raya Banaran, Semarang, Central Java, Indonesia
Corresponding author email: fadillah.nur.af@gmail.com

Abstract

Students generally still exhibit misconceptions when learning about composite functions. It is strongly suspected that this is because teaching aids are still dominated by conventional, text-based media and procedural explanations, meaning that pupils tend to focus on manipulating formulas. Through the 4D R&D model, a Scratch-based resource on composite functions has been developed that is valid in terms of both construct and content. The study involved two expert validators and 30 Year 11 pupils at State Senior Secondary School 12 in Semarang as research subjects in a limited trial. The research results show that the resource achieved a validation score of 86 per cent for the media aspect and 85 per cent for the content. The readability test results indicate that the design aspect fell into the 'very suitable' category with a score of 83 per cent; however, the animation, content and presentation aspects were classified as 'suitable' with scores of 72 per cent, 76 per cent and 80 per cent, respectively. The resource was effective in improving students' understanding, with an N-Gain score of 0,7. The Scratch-based learning resource developed was found to be suitable and can be used to support pupils' understanding of the concept of composite functions. This resource can be utilised by mathematics teachers as an alternative learning resource for composite functions and can be further developed through experimental research to test its effectiveness, as well as research examining its impact on other mathematical abilities and its comparison with those not using the resource.

Keywords: *Composition Function; Learning Media; R&D; Scratch*

Abstrak

Pembelajaran fungsi komposisi pada siswa umumnya masih menunjukkan hal-hal miskonsepsi. Dugaan kuat dikarenakan alat bantu pembelajaran masih didominasi oleh penggunaan media konvensional berbasis teks dan penjelasan prosedural, sehingga siswa cenderung berfokus pada manipulasi rumus. Melalui R&D model 4D, dihasilkan media berbasis *Scratch* pada materi fungsi komposisi yang valid secara konstruk maupun konten. Dengan 2 validator ahli dan 30 siswa kelas XI di SMA Negeri 12 Semarang sebagai subjek penelitian pada uji coba terbatas. Hasil penelitian menunjukkan bahwa media memperoleh skor validasi sebesar 86% pada aspek media dan 85% pada aspek materi. Hasil uji keterbacaan menunjukkan bahwa aspek desain berada pada kategori sangat layak dengan skor 83%, sedangkan aspek animasi, materi, dan tampilan berada pada kategori layak dengan skor 72%, 76%, dan 80%. Media efektif dalam meningkatkan pemahaman siswa dengan skor N-Gain sebesar 0,7. Media pembelajaran berbasis *Scratch* yang dikembangkan dinyatakan layak dan dapat digunakan untuk mendukung pemahaman konsep fungsi komposisi siswa. Media ini dapat dimanfaatkan oleh guru matematika sebagai alternatif media pembelajaran fungsi komposisi dan dapat dikembangkan lebih lanjut melalui penelitian eksperimen untuk menguji efektivitasnya, serta penelitian yang mengkaji pengaruhnya terhadap kemampuan matematis lainnya maupun perbandingannya dengan yang tidak menggunakan media.

Kata kunci: Fungsi Komposisi; Media Pembelajaran; R&D; Scratch

INTRODUCTION

Mathematical understanding is one of the essential abilities that students need to master's in mathematics learning (Damayanti & Anita, 2023). This is due to the abstract nature of mathematics and the systematic structure of its concepts, which require students to develop a deep understanding of concepts throughout the learning process (Cai et al., 2026; Taufik & Priwantoro, 2026). NCTM (2000)

states that the need for understanding and the ability to perform mathematical tasks in everyday life, particularly in the workplace, will continue to increase; therefore, conceptual understanding serves as a fundamental foundation in mathematics learning (Erawati et al., 2025). According to Cai et al. (2026), understanding is a dynamic and continuous process; thus, learning needs to be developed gradually, from basic concepts to more complex concepts (Emul et al., 2022). Therefore, understanding is necessary so that abstract mathematical problems can be manipulated, enabling students to solve problems not only procedurally but also through reasoning, communication, and the application of mathematical concepts in various contexts (Carter, 2024; Nurhangesti & Seruni, 2024).

The topic of composite functions is one of the abstract topics in mathematics. Therefore, solving problems related to this topic requires reasoning (Mahfuud & Pujiastuti, 2020). Putri et al. (2025) state that ideally, learning about composite functions should begin with establishing the basic concept of a function, namely, an element of the input set or domain that is mapped to produce an output or range element. Functions exist in everyday life and are not merely mathematical theories. Students need to develop a deep understanding that the concept of a composite function represents a chain process, namely, the sequential combination of two or more functions in which the output or range of the first function becomes the input or domain of the second function (Pramesti & Ferdianto, 2019). Therefore, the essential foundations that students must master are an understanding of the conditions for combining two functions and the ability to distinguish the domain, codomain, and range of a given function before proceeding to algebraic calculations.

These problems were also identified in the preliminary research conducted in this study. Based on observations of learning on composite functions among Grade XI students at SMA Negeri 12 Semarang, conducted as an initial diagnostic test involving 30 students, it was found that students were not yet able to model and represent contextual word problems or connect the concepts with real-life situations.

The data consisted of three conceptual understanding items related to Indicator 1, one item related to Indicator 3, and two items related to Indicator 3, with a maximum score of 10 for each item. Each indicator was calculated based on the students' average scores on the items associated with that indicator. An indicator was considered achieved when the students' average score on the corresponding items was at least 7.

Table 1. Results of the Preliminary Research

Conceptual Understanding Indicator	Number of Students Meeting the Criterion	Percentage
Restating the concept	27	76%
Providing examples and non-examples	10	56%
Applying concepts in problem solving	13	48%

This can be seen from the students' responses to composite-function problems, which indicate that students experienced conceptual errors or misconceptions regarding composite functions. In problem (a), the function of transforming sheep wool into fabric was identified as an image because the sheep wool is first transformed into yarn, or function image, followed by function image, in which the yarn is transformed into fabric. These findings indicate that students' difficulties are not limited to algebraic manipulation and operations but also involve understanding the relationships and sequences among functions.

Clothing is produced through 3 stages: transforming wool into yarn following the function $d(x) = x - 2$, then transforming yarn into fabric following the function $k(x) = x^2$, and transforming fabric into clothes following the function $b(x) = 200x$, where x represents the amount of wool used. Determine the function for: a. Wool to fabric and b. Wool to clothes

☐	Diketahui: $d(x) = x - 2$	☐	Given: $d(x) = x - 2$
☐	$k(x) = x^2$	☐	$k(x) = x^2$
☐	$b(x) = 200x$	☐	$b(x) = 200x$
☐	Orang-orang Bulu domba menjadi kambing?	☐	Question: Which function is a linear function?
☐	Bulu domba menjadi babi?	☐	What is the function of the linear function?
☐	Dijawab: a. Bulu domba menjadi kambing = $d(k(x))$	☐	Answer: A function is linear if it has the form $d(k(x))$
☐	$= d(x^2)$	☐	$= d(x^2)$
☐	$= x^2 - 2$	☐	$= x^2 - 2$
☐	b. Bulu domba menjadi babi = $d(k(b(x)))$	☐	The linear function is b, because $b(k(x)) = d(k(x^2))$
☐	$= d(k(200x))$	☐	$= d(k(200x))$
☐	$= d(40.000x^2)$	☐	$= d(40000x^2)$
☐	$= 40.000x^2 - 2$	☐	$= 40000x^2 - 2$

Figure 2. Student's Answer

The findings from these observations are consistent with previous studies (Hesti & Erita, 2023; Ikram et al., 2021; Putri et al., 2025; Tampubolon et al., 2025), which indicate that the learning of composite functions tends to focus on formula manipulation or calculation procedures rather than on the sequence of functions being performed. Students have not yet been able to model and represent contextual word problems, such as connecting mathematical concepts with real-life situations. Chain transformations in composite function operations are difficult to establish without the support of visualization. The absence of evaluation to address factors related to inaccuracy in algebraic operations prevents students from achieving a deeper understanding of composite-function problems. Research conducted by Kolins et al. (2020) showed that students made errors in data use, language interpretation, and technical procedures. Conceptual errors were also found among low-achieving students when solving composite-function problems. Pramesti and Ferdianto (2019) found that 86.7% of students experienced difficulties in conceptual understanding, 73.3% in skills, and 60% in problem solving.

These conditions indicate the need for instructional media that can help students visualize the composite-function process gradually and interactively. The use of interactive tools and software can improve students' understanding of abstract mathematical concepts (Maghfiroh, 2024). Understanding can be more easily achieved through visualization (Carter, 2024), as there is a relationship between understanding and visualization in mathematical concepts (Tappenden, 2005, as cited in Carter, 2024). Visual representations can be used to clarify the relationship between the input, the process of the first function, the intermediate output, and the process of the subsequent function. This need is increasingly relevant because composite functions involve a chain process that is not always easy to understand when presented only through symbols and algebraic manipulation. Therefore, the developed media needs to provide visualization that connects abstract concepts with processes that can be observed by students.

One of the media currently widely used is *Scratch*, which is designed to facilitate users in creating games, animations, and applications. Learning using *Scratch* increases student engagement by making learning more interactive, thereby facilitating conceptual understanding and improving learning outcomes (Sabilla et al., 2025). *Scratch*-based instructional media are effective in improving students' understanding (Astuti & Astuti, 2025). Various studies have demonstrated that *Scratch* as an instructional medium has a positive impact on mathematical understanding. The use of *Scratch* in learning has also been shown to improve students' understanding of abstract mathematical topics (Ningrum & Novtiar, 2023; Septorini, 2025). Therefore, *Scratch* is considered suitable for implementation as an instructional medium.

Based on the literature review conducted, research on students' difficulties and learning obstacles in composite functions has been widely carried out, including studies identifying difficulties in

conceptual understanding, problem solving, and representation. On the other hand, *Scratch* has been utilized as an instructional medium to support mathematical conceptual understanding in several topics. However, research developing *Scratch*-based media specifically to address difficulties in students' conceptual understanding of composite functions at the senior high school level remains limited. Therefore, there is a need to develop media that integrates the results of students' difficulty diagnosis with visual and interactive representations of composite functions.

Based on these problems, this study aims to develop *Scratch*-based instructional media for composite functions designed based on the identified difficulties in students' conceptual understanding, as well as to determine the feasibility and readability of the developed media. The developed media is intended to help students understand composite functions through visualization of processes, input-output relationships, the sequence of functions, examples and non-examples, and interactive activities. Therefore, the development of *Scratch*-based instructional media for composite functions is important to undertake. This interactive media is intended for Grade 11 senior high school students who are learning composite functions to improve their understanding.

METHOD

This study employed the 4D development model developed by Thiagarajan et al. in 1974, consisting of *Define*, *Design*, *Development*, and *Disseminate*, which was adapted to the context of developing instructional media using *Scratch*. The *Define* stage was conducted to identify the objectives and limitations of developing the instructional media through five stages. *Front-End Analysis* was conducted to identify the low level of conceptual understanding of composite functions at SMA Negeri 12 Semarang. *Learner Analysis* was conducted to select the class as the research subject. *Task Analysis* involved identifying the main knowledge and skills that students needed to understand. *Concept Analysis* involved organizing the concepts of the material into a hierarchy and providing relevant examples related to composite functions. *Specifying Instructional Objectives* involved determining the objectives of the instructional media to be developed.

The *Design* stage involved developing a prototype of the instructional media, including the selection of media and format for presenting the material, as well as the development of a *flowchart* using the analogy of making donuts as a real-life context for composite functions. The *Development* stage involved modifying the media prototype, followed by revisions based on feedback and suggestions from experts, resulting in the final media product. Finally, in the *Disseminate* stage, the media was publicly distributed through the *Scratch* website so that it could be accessed by teachers, students, and general users.

Data collection techniques used to obtain accurate and valid data included questionnaires, expert validation sheets, and achievement tests. The assessment involved two validators: one mathematics education lecturer and one mathematics teacher. A trial and student response questionnaire were administered to 30 Grade 11 students from class XI F-6 at SMA Negeri 12 Semarang to determine the practicality and effectiveness of the developed media. Effectiveness in terms of conceptual understanding was assessed based on individual and classical mastery. Comments and suggestions from the validators were used to revise the media. The validation data were calculated using a Likert scale to determine the percentage of media feasibility using the following formula:

$$\% = \frac{\text{total score}}{\text{maximum score}} \times 100\%$$

The improvement in scores from the *pretest* and *posttest* was calculated using the *N-gain score*, with the categories presented in Table 2.

Table 2. N-Gain Categories

Nilai N-Gain	Interpretation
$g < 0,3$	Low/Less Effective
$0,3 < g \leq 0,7$	Moderate/Effective
$g < 0,7$	High/Highly Effective

The results obtained were categorized based on the criteria presented in Table 3.

Table 3. Media Categories

Percentage	Intepretation
81-100	Highly Feasible/Highly Practical
61-80	Feasible/Practical
41-60	Moderately Feasible/Moderately Practical
21-40	Less Feasible/Less Practical
0-20	Not Feasible/Not Practical

The conceptual understanding test instrument was developed based on a test blueprint containing the indicators and distribution of items, as presented in Table 4.

Table 4. Test Instrument

Conceptual Understanding Indicator	Item Numbers	Number of Items
Restating the concept	1, 2	4
Providing examples and non-examples	4	1
Applying concepts in problem solving	2, 3	5
Total		10

The development of this instructional media utilized the Scratch platform so that it could be easily accessed by users without requiring additional memory or storage space on electronic devices. The product can be accessed online through the Scratch website by searching for Composite Functions in Donuts.

RESULT AND DISCUSSION

The development of *Scratch*-based instructional media for composite functions was conducted using the 4D model, consisting of *Define*, *Design*, *Develop*, and *Disseminate*. At the *Define* stage, it was found that students still experienced misconceptions regarding composite functions. This was related to the abstract nature of composite functions, which requires students to understand the relationships and sequences among functions as one of the prerequisites. Consistent with previous studies (Kolins et al., 2020; Kusumaningrum et al., 2017; Pramesti & Ferdianto, 2019), which showed that students still experienced misconceptions in understanding composite functions, the preliminary study conducted in this research indicated that some students still confused the domain, codomain, and range of a function. These conceptual errors or misconceptions provided the basis for developing *Scratch*-based instructional media to visualize the sequence of composite functions interactively. Previous studies by Ivania (2025) and Yuliananto and Subali (2024) showed that the use of *Scratch* can support the understanding of abstract topics such as mathematics through interactive visualization. The complex and abstract nature of composite functions can lead students to experience misconceptions (Pramesti & Ferdianto, 2019).

The Define stage consisted of five stages: front-end analysis, learner analysis, task analysis, concept analysis, and specifying instructional objectives (Thiagarajan et al., 1974). In the front-end analysis stage, problems were identified in the learning of composite functions among Grade 11 students. Data were obtained through a seven-item test administered to 30 students from class XI F-6.

The results indicated that students' conceptual understanding of composite functions was still low. This was evident from conceptual errors in the test results, such as confusing the concepts of $(f \circ g)(x)$ and $(g \circ f)(x)$ and if composite-function operations involve multiplication between functions. The literature review also indicated that misconceptions regarding composite functions remain prevalent (Kolins et al., 2020; Kusumaningrum et al., 2017; Pramesti & Ferdianto, 2019).

In the learner analysis, the results indicated that senior high school or equivalent students were selected as the target users. In the task analysis, the main knowledge and skills that students needed to understand in order to use the interactive instructional media were identified. In the concept analysis, the concepts to be taught were identified and organized hierarchically, along with relevant examples related to composite functions. In specifying instructional objectives, the objectives of the developed instructional media were determined, namely, to enable students to understand the concept of composite functions and how to calculate them. The success indicator for the Define stage in this study was the identification of a gap between the ideal condition and the actual situation in the field, followed by the determination of a relevant solution. Based on the analysis, students were found to still experience misconceptions regarding composite functions. This finding established the urgency of developing Scratch-based media as an effort to improve students' conceptual understanding of composite functions.

The second stage was Design, which was marked by the development of a flowchart and storyboard as prototypes of the instructional media. The development process followed the prepared flowchart, accompanied by the selection of appropriate designs to make the media more engaging. The Design stage included criterion testing, selection of appropriate instructional media and games, determination of the learning presentation format, and simulation of the material using the designed media and games (Zamsiswaya et al., 2024). Scratch was selected as the instructional media platform because no Scratch-based instructional media for composite functions had previously been identified. In addition, the appropriate use of technology can optimize students' learning achievement (Shintia, 2022).

The concept of composite functions was represented through the process of making donuts. The donut-making process, in which frying is analogous to $g(x)$ and adding toppings is analogous to $f(x)$, was used to illustrate the concept. The sequence of these stages corresponds to the procedure for performing composite functions, in which the domain is subjected to one function and then followed by another function. Differences in the sequence of processes also affect the resulting donut. This is consistent with the non-commutative property of composite-function operations, $(f \circ g)(x) \neq (g \circ f)(x)$. If the donut-making process begins by adding the topping and is then followed by frying, the resulting product is a bomboloni donut, namely a donut with filling/flavor inside, or $(f \circ g)(x)$. If frying is performed first and followed by adding the topping, the final product is a donut with a flavored glaze on the outside, $(g \circ f)(x)$. The donut-making context is relevant to the conceptual understanding indicators of providing examples and non-examples and applying concepts in problem solving.

The media was then implemented using *Scratch* by incorporating animations, dialogues, simulations, and games. The visual elements were designed using Canva, while the interactions and animations were implemented through *Scratch*. The use of *Scratch* enables concepts to be presented visually and interactively, allowing students to observe the stages of the composite-function process more concretely. This is consistent with previous studies showing that *Scratch*-based media can support mathematics learning through visualization and interactivity (Ivania, 2025; Yulianto & Subali, 2024).

The prototype design was subsequently modified into the final draft. The development of the media was adjusted to the learning materials, objectives, and the flowchart and sequence that had been prepared. Canva was used to design the visual elements so that the appearance of the media would be

more engaging. The following are several views of the Scratch media that were developed, entitled "Composite Functions in Donuts."



Figure 4. Scratch Interface

The Development stage consisted of Expert Appraisal and Development Testing activities (Thiagarajan, 1974). At the Expert Appraisal stage, the media was validated by two validators. One validator was a mathematics teacher, while the other was a mathematics education lecturer. Media and material validation were conducted before the limited trial (Fauziah et al., 2023). The Expert Appraisal stage involved validators validating and providing revisions to the initial draft until the final draft was produced. The validators assessed the material based on the aspects of presentation, content, and language. The media was assessed based on Simplicity, Unity, Appearance, and Usability.

The validation results from Validators 1 and 2 regarding the material presented in the media showed scores of 15 and 20, respectively, out of a maximum score of 20 for the presentation aspect. This indicates that the sequence of concepts, systematic consistency of the presented material, examples, and images or videos included in the media were categorized as feasible. In the content aspect, Validator 1 gave a score of 27 out of 40, while Validator 2 gave a score of 39. Regarding the depth and completeness of the material and its ability to develop students' questioning skills, the media was considered sufficiently feasible. The accuracy of concepts, definitions, images, and the scope of composite-function material were categorized as feasible. The real-life examples used to present composite-function material were categorized as highly feasible.

For the language aspect, Validator 1 gave a score of 40 out of 45, while Validator 2 gave a score of 38 out of 45. The selection of sentences in terms of structure, statements, and sentence effectiveness was categorized as feasible. The media was categorized as highly feasible in terms of the selection of font type and size. The language used was also considered appropriate for students' ability levels and capable of motivating students.

Media validation was assessed based on the aspects of Simplicity, Unity, Appearance, and Usability. The Simplicity aspect received scores of 12 and 15 out of a maximum score of 15 from Validators 1 and 2, respectively. This aspect was categorized as feasible, as the animations used in the media were appropriate for the students' characteristics, the sentence selection was appropriate, and the media was easy to understand. In the Unity aspect, both validators gave a score of 13 out of 15. The use

of buttons/notations, usage instructions, and the size of animations, images, and text were considered appropriate and suitable, and were therefore categorized as feasible. The color selection and attractive animations were categorized as highly feasible.

The font selection was categorized as feasible under the Appearance aspect, with a score of 13 from Validator 1 and 12 from Validator 2, out of a maximum score of 15. For the Usability aspect, Validator 1 gave a score of 20, while Validator 2 gave a score of 22, out of a maximum score of 25. In detail, the program ran smoothly and could be used independently by users, which was categorized as highly feasible. The Usability aspect was categorized as feasible in terms of the ease of using the media, its ability to be used independently or as a teaching aid, and its ability to prevent users from becoming bored while using it.

The description above indicates that the material presented in the media was categorized as feasible. The results of the media validation showed that the media was categorized as highly feasible. This indicates that the instructional media can be used with minor revisions. The following figure presents several views of the media before and after revision.

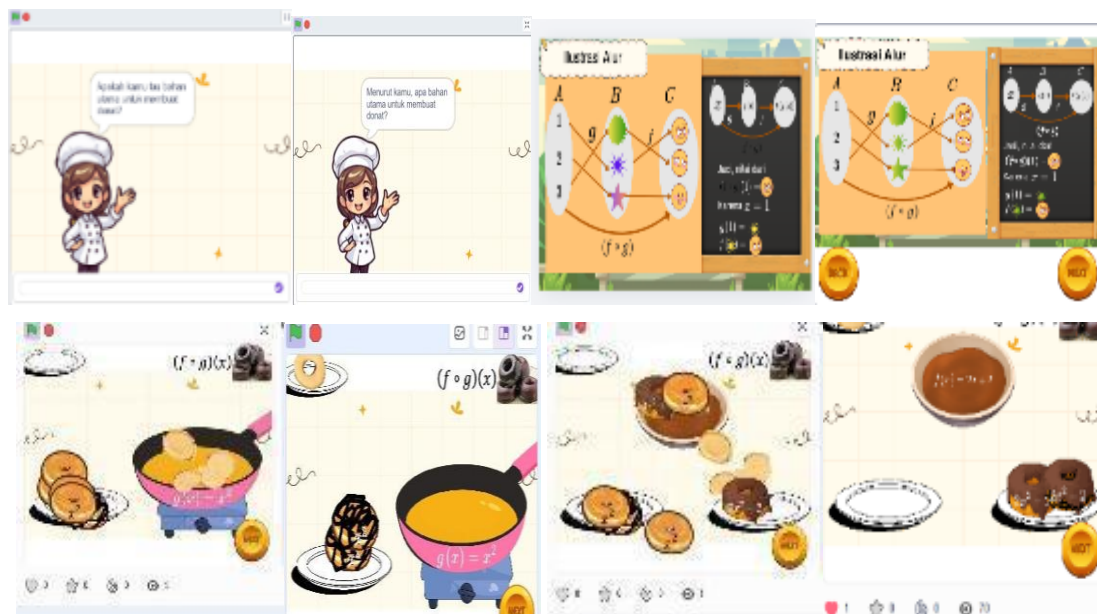


Figure 5. *Scratch* Interface Before and After Revision

The validator provided comments regarding the speed of dialogue changes in the media and suggested slowing down the dialogue and clarifying the intended meaning of the dialogue presented in the media. The validation results showed that the media was feasible for use with minor revisions, with a material validation percentage of 85% and a media validation percentage of 86%. Therefore, the media could proceed to a limited trial involving Grade 11 F-6 students at SMA Negeri 12 Semarang. Subsequently, during the *Development Testing* stage, a readability test was conducted with 30 students in the same class during the implementation of the *treatment*. The readability test results showed that the design aspect was categorized as highly practical, with a score of 83%, while the animation, material, and appearance aspects were categorized as practical, with scores of 72%, 76%, and 80%, respectively. These results are consistent with the validators' feedback regarding the revisions required for the media.

The revised media was distributed through the [Scratch website](https://scratch.mit.edu/projects/132952261/) under the name "Composite Functions in Donuts" or through the link <https://scratch.mit.edu/projects/132952261/>. The distribution

was conducted to facilitate the implementation of the trial with Grade 11 students at SMA Negeri 12 Semarang in the 2026/2027 academic year. A total of 30 students participated in the readability and effectiveness tests. The results of the readability test are summarized in the following table.

Table 5. Results of the Media Readability Test

Aspect	Average Score Obtained	Maximum Score	Percentage	Interpretation
Design	128	155	83%	Highly Practical
Animation	111.5	155	72%	Practical
Material	118	155	76%	Practical
Appearance	125	155	80%	Practical

Based on Table 5, the developed media received positive responses from the students who used it. Based on these results, the media was considered practical for use in mathematics learning.

The final stage, namely *Disseminate*, involved testing the media in only one predetermined class. Based on the research results described previously, the students' average pretest score was 58, with only 9 out of 30 students achieving scores above the minimum mastery criterion (KKM), corresponding to 29%. In the following meeting, a *treatment* was provided in the form of instruction on composite functions using the developed *Scratch* media and student worksheets (LKPD) containing composite-function problems. After the posttest was administered on the final day, the students' average posttest score was 90, with 2 students failing to achieve the KKM, resulting in a mastery percentage of 93%. Thus, individual mastery was achieved.

Classical mastery was assessed by comparing the *posttest* and *pretest* scores. A significance test was conducted using the *Non-parametric Wilcoxon Signed-Ranks Test*. The result was $sig = 0,00 < 0,005$, indicating a difference between the *pretest* and *posttest* scores. Based on the difference between the mean *pretest* and *posttest* scores, there was an increase of 30 points. The N-Gain score was 0.7, which was categorized as high. These results indicate that the improvement in students' understanding was in the high category.

The following table presents a comparison of the results of the *pretest* and *posttest* administered to Grade 11 F-6 students at SMA Negeri 12 Semarang before and after the use of the media.

Table 6. Average Results

No.	Indicator	Pretest	Posttest
1.	Restating a Concept	76%	84%
2.	Providing Examples and Non-Examples	56%	76%
3.	Applying Concepts in Problem Solving	47%	96%

The indicator of restating a concept was interpreted as effective in both the *pretest* and *posttest*. Meanwhile, the indicators of providing examples and non-examples and applying concepts in problem solving were interpreted as moderately effective in the *pretest* and effective in the *posttest*. The *pretest* items related to functions as prerequisite material for composite functions obtained an average score of 61, with 9 students achieving the KKM. In the *posttest* items related to composite functions, the average score was 90, with 28 students achieving the KKM.

These findings indicate that *Scratch* media can improve students' understanding of abstract mathematical topics such as composite functions. This is consistent with the research conducted by Yulianto and Subali (2024) on the abstract topic of Newton's laws in physics, research on fractions in junior high school mathematics (Septorini, 2025), and Maghfiroh (2024), which stated that understanding of abstract concepts can be improved through the use of interactive tools and software.

Other studies conducted by Sabilla et al. (2025) and Astuti (2025) also demonstrated effective improvements using *Scratch*.

CONCLUSION

Based on the development and research results, it can be concluded that the *Scratch*-based instructional media is feasible for use and can effectively improve students' conceptual understanding of composite functions. The validation results showed that the developed instructional media was categorized as highly feasible, with a material validation score of 85% and a media validation score of 86%. In addition, a readability test involving 30 Grade 11 students at SMA Negeri 12 Semarang confirmed the feasibility of the media in terms of design (83%), animation (72%), material (76%), and appearance (80%). Improvement was indicated by the individual mastery rate, which increased from 29% in the pretest to 93% in the posttest, with an N-Gain score of 0.7.

The *Scratch* media helped students understand the abstract concept of composite functions by making it more concrete and easier to understand through interactive visualization using the doughnut-making process. The frying stage was represented as a function $g(x)$ while the topping stage was represented as function $f(x)$. Donuts produced through different sequences of processes affect the form of the composite function and the resulting doughnut. Thus, the interactive *Scratch* media is feasible and effective as an instructional innovation for reducing students' misconceptions regarding composite functions. This media can be utilized by mathematics teachers as an alternative instructional medium for teaching composite functions and can be further developed through experimental research to examine its effectiveness, as well as through studies investigating its effects on other mathematical abilities or comparing learning outcomes with and without the use of the media.

REFERENCES

- Astuti, R. D., & Astuti, R. (2025). Efektivitas Media Game Berbasis Scratch Terhadap Hasil Belajar Biologi Di SMA Negeri 1 Polanharjo. *ORYZA: Jurnal Pendidikan Biologi*, 14(1), 88–94. <https://doi.org/https://doi.org/10.33627/oz.v14i1.3230> Vol.
- Cai, J., Ding, M., & Hwang, S. (2026). *Fostering students' mathematical understanding: Toward a theoretical framework*. <https://doi.org/10.1177/27527263261442721>
- Carter, J. (2024). Mathematical understanding – Common themes in philosophy and mathematics education. *Journal of Mathematical Behavior*, 76(November), 101202. <https://doi.org/10.1016/j.jmathb.2024.101202>
- Damayanti, Y., & Anita, I. W. (2023). Karakteristik Kemampuan Pemahaman Konsep Siswa kelas Viii Di Mts Az-Zahra Parongpong Berdasarkan gender. *JPMI (Jurnal Pembelajaran Matematika Inovatif)*, 6(5), 1831–1840. <https://doi.org/10.22460/jpmi.v6i5.18750>
- Emul, N., Gulkilik, H., & Aydan Kaplan, H. (2022). What Is Mathematical Understanding and How Is It Achieved? Preservice Middle School Mathematics Teachers' Views and Reflections in Their Teaching Practices. *Kastamonu Eğitim Dergisi*, 30(4), 843–855. <https://doi.org/10.24106/kefdergi.1195601>
- Erawati, D. Y., Riswari, L. A., & Amaliyah, F. (2025). EFEKTIVITAS MEDIA PEMBELAJARAN CIBATAR TERHADAP PEMAHAMAN KONSEP MATEMATIKA SISWA SEKOLAH DASAR. *JUPIKA: Jurnal Pendidikan Matematika Universitas Flores*, 8(1), 64–75. <https://doi.org/https://doi.org/10.37478/jupika.v8i1.5393>
- Fauziah, R. S. I., Martadiputra, B. A. P., & Nurjanah. (2023). DEVELOPMENT OF MATHEMATICS

INTERACTIVE MULTIMEDIA WITH SCRATCH TO ENHANCE STUDENT ' S MATHEMATICS UNDERSTANDING. *Prima: Jurnal Pendidikan Matematika*, 7(1), 124–134. <https://doi.org/https://doi.org/10.31000/prima.v7i1.7437>

Hesti, N., & Erita, S. (2023). Analisis kemampuan pemahaman konsep matematika Siswa dalam menyelesaikan soal pada fungsi komposisi dan invers. *Primatika. Jurnal Pendidikan Matematika*, 12(2), 127–138. <https://doi.org/https://doi.org/10.30872/primatika.v12i2.2785>

Ikram, M., Studi, P., Matematika, P., Palopo, U. C., & Selatan, S. (2021). Analisis kesalahan konstruksi siswa dalam menyelesaikan masalah fungsi invers. *Pedagogy: Jurnal Pendidikan Matematika*, 6(2), 102–116. <https://doi.org/https://doi.org/10.30605/pedagogy.v6i2.1619>

Ivania, N. F. (2025). PENGGUNAAN MEDIA SCRATCH UNTUK MENINGKATKAN HASIL BELAJAR SISWA SMP PADA MATERI ALJABAR. *JURNAL PEMBELAJARAN DAN MATEMATIKA SIGMA*, 11(2), 297–302. <https://doi.org/https://doi.org/10.36987/jpms.v11i2.8177>

Kolins, A. Y., Wahyuningsih, Safrudin, N., & Rusdin, M. E. (2020). Analisis Kesalahan Peserta Didik Dalam Menyelesaikan Soal Matematika Pada Fungsi Komposisi Dan Fungsi Invers. *Journal of Mathematics Education*, 6(2), 86–95. <https://doi.org/10.30595/alphamath.v6i2.7866>

Kusumaningrum, D., Napitupulu, B., & Tyas, D. K. F. N. (2017). Analisis Miskonsepsi Siswa di Kelas XI SMA Negeri 1 Jayapura pada Materi Fungsi Komposisi. *Jurnal Ilmiah Matematika Dan Pembelajarannya*, 2(1), 14–21. <https://ejournal.uncen.ac.id/index.php/JIMP/article/view/250/222>

Maghfiroh, A. N. (2024). Pengaruh penggunaan teknologi dalam pembelajaran matematika terhadap prestasi siswa. *Maliki Interdisciplinary Journal*, 2(11), 1247–1257. <https://urj.uin-malang.ac.id/index.php/mij/article/view/7725>

Mahfuud, D., & Pujiastuti, H. (2020). ANALISIS KEMAMPUAN SISWA MEMAHAMI SOAL CERITA PADA MATERI FUNGSI KOMPOSISI DAN FUNGSI INVERS. *Journal of Mathematics Education and Science*, 3(2), 51–54. <https://doi.org/https://doi.org/10.32665/james.v3i2.137>

National Council of Teachers of Mathematics (NCTM). (2000). *Principles and Standards for School Mathematics*. Reston, VA: NCTM.

Ningrum, N. P. A., & Novtiar, C. (2023). PENGARUH PENGGUNAAN MEDIA PEMBELAJARAN MATERI BERBANTUAN SCRATCH TERHADAP KEMAMPUAN PEMAHAMAN MATEMATIS SISWA SMP. *JPMI (Jurnal Pembelajaran Matematika Inovatif)*, 6(5), 1941–1950. <https://doi.org/10.22460/jpmi.v6i5.20751>

Nurhangesti, M., & Seruni. (2024). Faktor-Faktor Pemahaman Konsep Matematika: Kajian Literatur. *Jurnal Media Akademik (JMA)*, 2(12), 3031–5220. <https://doi.org/https://doi.org/10.62281/v2i12.1381>

Pramesti, P., & Ferdianto, F. (2021). Analisis Kesulitan Siswa Belajar Matematika pada Materi Fungsi Komposisi dan Fungsi Invers Kelas X SMA Negeri 1 Rajagaluh. *Jurnal Pendidikan Matematika Dan Sains*, 7(2), 74–79. <https://doi.org/10.21831/jpms.v7i2.25243>

Putri, F. A., Azizah, N., Bahriaturrohman, Purnamasari, S., & Hernaeny, U. (2025). Pengenalan Fungsi Komposisi dan Fungsi Invers dalam Matematika SMA. *JURIHUM: Jurnal Inovasi Dan Humaniora*, 3(3), 460–466. <https://jurnalmahasiswa.com/index.php/Jurihum/article/view/3560>

Sabilla, A. M., Sakir, M., & Firdaus. (2025). PENGEMBANGAN MEDIA PEMBELAJARAN INTERAKTIF BERBASIS GAME BASED LEARNING DENGAN SCRATCH PADA

MATERI HUKUM NEWTON UNTUK MENINGKATKAN PEMAHAMAN KONSEP SISWA.
OPTIKA: Jurnal Pendidikan Fisika, 9(1), 140–154. <https://ejournal.uniflor.ac.id/index.php/optika/article/view/5774/3135>

- Septorini, A. (2025). PERMATA-S (Pembelajaran Pecahan Matematika dengan Scratch): Pengembangan Media Ajar Berbasis Scratch MIT untuk Meningkatkan Pemahaman Konsep Pecahan Siswa Kelas IV Sekolah Dasar. *JGSD: Jurnal Guru Sekolah Dasar*, 2(1), 1–12. <https://doi.org/10.70277/jgsd.v2i1.1>
- Tampubolon, A., Hutagalung, C. F., Br, S. N., Studi, P., Matematika, P., Alam, P., Medan, U. N., & Pendahuluan, A. (2025). Analisis kemampuan berpikir komputasional matematis siswa sma pada materi fungsi. *Pedagogy: Jurnal Pendidikan Matematika*, 10, 2432–2450. <https://doi.org/10.30605/pedagogy.v10i4.7713>
- Taufik, M., & Priwanto, S. W. (2026). MATHEMATICS LEARNING DIFFICULTIES IN NUMBER TOPICS : AN ANALYSIS BASED ON THE LEARNING STYLES OF JUNIOR HIGH SCHOOL. *JUPIKA: Jurnal Pendidikan Matematika Universitas Flores Volume*, 9, 152–164. <https://doi.org/https://doi.org/10.37478/jupika.v9i1.8278>
- Thiagarajan, Sivasailam, & Other. (1974). Instructional Development for Training Teachers of Exceptional Children: A Sourcebook. *Journal of School Psychology*, 14(1), 75. [https://doi.org/10.1016/0022-4405\(76\)90066-2](https://doi.org/10.1016/0022-4405(76)90066-2)
- Yulianto, A., & Subali, B. (2024). Pengembangan Media Pembelajaran Berbasis Scratch Materi Momentum, Impuls, dan. *Unnes Physics Education Journal*, 13(1), 103–106. <https://doi.org/https://doi.org/10.15294/upej.v13i1.8637>
- Zamsiswaya, Sawaluddin, & Sihombing, B. (2024). Model Pengembangan 4D (Define , Design , Develop, dan Disseminate) dalam Pembelajaran Pendidikan Islam. *Journal of Islamic Education El Madani*, 4(1), 11–19. <https://doi.org/10.55438/jiee.v4i1.135>