https://newjournal.lppmunindra.ac.id/index.php/jkpm/index
ISSN 2477-2682 (Electronic)
ISSN 2477-2348 (Print)

Jkpm
Jurnal Kajian
Pendidikan Matematika

Original Research

Development of Online Game 'Discount Dash' on Social Arithmetic Material Using *Scratch* Application

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INFO ARTICLES

Article History:

Received: 15-05-2026
Revised: 08-06-2026
Approved: 08-06-2026
Publish Online: 21-06-2026

Key Words:

Scratch; Social Arithmetic; MDLC; Interactive Media.

Abstract: Social arithmetic, specifically the concept of discounts, is an important topic for junior high school students, yet learning outcomes remain consistently low. This research aims to develop "Discount Dash", a *Scratch*-based interactive learning medium, utilizing the MDLC development model (concept, design, material collection, assembly, testing, and distribution) user acceptance testing involving 13 pre-service mathematics teachers at a university in Bandung. The evaluation instrument consists of expert validation, questionnaires, interviews, and documentation, which includes visuals, programming, content, and usability. The results showed the media was very feasible, achieving a score of 95.7% from the expert validation, 97.7% from the open-ended questionnaire, and 96.5% from the closed-ended questionnaire, proving that "Discount Dash" has a feasibility and can be used as an alternative interactive learning medium to support the teaching of social arithmetic in junior high schools, increase student engagement, and help teachers present mathematical concepts that are relevant to daily life. Future recommendations include improving aesthetics with dynamic animations, expanding content to include profit and loss, taxes, and interest, and implementing tools in Class VII classrooms using quasi-experimental pretest-posttest designs to measure their empirical effectiveness.

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How to Cite (APA 6th Style): Fakhriani, R., & Sudihartinih, E. (2026). Development of Online Game 'Discount Dash' on Social Arithmetic Material Using *Scratch* Application. *JKPM* (*Jurnal Kajian Pendidikan Matematika*), 11(2): 205-218. https://doi.org/10.30998/jkpm.v11i2.3605

Competing Interests Disclosures: The authors declare that they have no significant competing financial, professional, or personal interests that might have influenced the performance or presentation of the work described in this manuscript.

INTRODUCTION

The integration of technology in the mathematics curriculum is a fundamental need to facilitate the understanding of abstract concepts into concrete representations (Medina et al., 2024). According to Szabo, studying mathematics is very important because it fosters logical and clear thinking, facilitates everyday problem-solving, fosters creativity, highlights the relationships and similarities between experiences, and fosters awareness of cultural developments (Szabo et al., 2020). Some of the fundamental concepts necessary to understand and solve mathematical problems are included in the basics of mathematics. According to Hidayat & Iksan, mathematical concepts that are not well understood by students can have an impact on learning outcomes (Hidayat & Iksan, 2015). Mathematics is positioned as a foundation in the development of logical reasoning, where the material of social arithmetic plays a crucial role due to its direct relevance to daily economic activities(Nurseto Tejo, 2012). Mastery of the concepts of profit, loss, discount, and single interest is considered an indicator of financial literacy that students must have at the primary and secondary education levels (Khoirunnisaa & Rahmayani, 2020).

Facts on the ground show that social arithmetic is often considered difficult by students due to a learning approach that is still procedural and centered on memorizing formulas without contextual understanding (Mulyani Sri et al., 2020). Difficulties in interpreting story problems into mathematical models lead to low learning outcomes and student motivation (Riska, 2025). In addition, the availability of interactive learning media that can simulate economic transactions dynamically is still very limited, so the learning process tends to be monotonous (Khafifah & Rahayu, 2025).

The use of visual programming-based learning media, such as *Scratch*, is offered as a solution to overcome these cognitive barriers. *Scratch* allows the visualization of concepts through logical blocks of code, so that students become not only consumers of information but also shapers of mathematical logic (Risnawati et al., 2018). The use of this interactive media is known to increase active engagement and strengthen memory retention through game-based simulations or animations (Pratama & Setyaningrum, 2018). The integration of *Scratch* in mathematics learning is believed to be able to create an exploratory learning environment (Fitriani & Yahfizham, 2024).

Several previous studies have explored the effectiveness of *Scratch* in education. Research by Eline and friends shows an increase in students' creative thinking skills through *Scratch* on geometry materials (Eline et al., 2021). In line with this, Lemote and friend confirmed that the use of *Scratch* is effective in reducing mathematical anxiety in algebraic material (Lamote et al., 2024). However, most previous research has focused more on the development of basic programming logic or geometry material (Eline et al., 2021). There is still a gap in the literature regarding *Scratch* applications specifically designed to simulate transactional logic in social arithmetic.

This research fills this gap by developing a learning medium that combines narrative elements of economic transactions with *Scratch* programming logic. The novelty lies in the design of interactions where students can manipulate the variables of price, profit percentage, and loss in real-time to see the immediate impact on the simulation output. In contrast to static media, this development emphasizes computational thinking algorithms combined with the systematic solving of social arithmetic problems (Fitriyadi & Wuryandani, 2021).

Based on the above discussion, this study aims to produce a valid, practical, and effective *Scratch*-based mathematics learning media product on social arithmetic. The novelty of this study lies in the development of a *Scratch*-based educational game that not only presents practice problems but also simulates buying and selling activities with a real-time discount system, allowing students to connect mathematical concepts with real-life situations. Additionally, this study integrates gamification elements (scores, lives, and challenges) with visual programming to support more interactive and meaningful social arithmetic learning (Yuliani & Saragih, 2015).

METHODS

The research method applied is Research and Development (R&D) with reference to the Multimedia Development Life Cycle (MDLC) model. This procedure was chosen because it provides a systematic stage in the development of interactive multimedia products to ensure the technical and pedagogical quality of the resulting media (Kumala et al., 2021).

The development of this online game was carried out through six main stages in accordance with the MDLC framework, namely: concept, design, development, material collection, assembly, and distribution. The development pipeline is shown in the following Figure 1.

Figure 1. MDLC Model Stages

The development stage of the learning media begins with the concept (conception), which includes the identification of learning objectives in social arithmetic materials, analysis of user characteristics and needs, and the formulation of game mechanics (gameplay) that will be applied in the application. Next, Design is carried out through the preparation of storyboards and flowcharts to map the narrative flow, programming logic structure, navigation, and visual layout in *Scratch*-based applications. The Development stage is carried out by creating an initial functional prototype to test basic algorithms, interaction systems, and game mechanics. After that, at the Material Collection stage, various digital assets are collected, such as images (sprites), backgrounds (backdrops), sound effects, and contextual question items that are in accordance with social arithmetic material. The assembly stage is done by integrating all materials and programming instructions into a single unified media in the *Scratch* work environment. The final stage is Distribution, which is uploading products to online platforms so that media can be accessed flexibly by users through a browser link.

The research involved students who were prospective mathematics teachers at one of the universities in the city of Bandung as the subject of the UAT test. Participants consisted of 11 women and 2 men. The involvement of prospective teacher students aims to obtain in-depth evaluative data, considering that the subject understands pedagogical mathematics concepts. The input collected is focused on three main aspects, namely the aesthetics of the display, the clarity of the sound output, and the accuracy of the mathematical concepts simulated in the online game.

Data were collected using non-test instruments in the form of validation sheets for material experts and media experts, as well as a User Acceptance Test (UAT) questionnaire with a Likert scale. The instrument indicators are compiled based on the quality standards of learning media as follows:

a. Material Validation: Measures the accuracy of concepts, depth of material, curriculum fit, and language quality (Koswara et al., 2021).

b. Media Validation: Assess aspects of navigation, interactivity, visual quality, and ease of operation (Amirudin & Setuju, 2018).
c. User Acceptance Test (UAT): Measures user perception of usefulness, ease of use, and overall satisfaction (Salloum et al., 2019).

The following Table 1. displays the indicators and questions for the closed and open questionnaires used in this study.

Table 1. Indicators, Questions, and Statements

Indicator	Questions	Statement
Display	What do you think of the overall look of the program?	In my opinion, the appearance of this program is unattractive and boring.
Programming	How easy is it to use this learning medium?	In my opinion, this program is easy to operate without any difficulties.
Material	Does this program help you in understanding social arithmetic material?	In my opinion, the presentation of social arithmetic material in this program is clear and systematic.
Language	What do you think of the use of language in this program? Is it clear and easy to understand?	I found the language used in the program to be easy to understand.
Audio	Is the sound in the program clear and unobtrusive?	In my opinion, the sound on this program is clear and unobtrusive.
Interest	What is your interest in learning social arithmetic using this program?	I think this program increased my interest in learning social arithmetic.
Benefits	Do you think this program is beneficial in the learning process? Explain.	I think this program helped me understand social arithmetic.

The closed questionnaire included responses in the form of statements with scores of 1, 2, 3, and 4 according to the criteria in Table 2. For negative statements, the score is reversed (Luthfiani et al., 2019). Analysis of closed questionnaire data was carried out using the Likert scale using Equation 1 (Najib et al., 2023). Quantitative data obtained from instrument scores were processed using percentage descriptive analysis techniques. The Formula (1) used to calculate the percentage of each aspect.

$$positive(\%) = \frac{total\ score}{highest\ score} \times 100\% \quad (1)$$

Description:
100% = Eligibility percentage.
$total\ score$ = The score obtained (the total answer of the respondents).
$highest\ score$ = Maximum expected score.

Table 2. Positive Statement Category

No.	Criteria	Score	
		Positive	Negative
1.	Strongly agree	4	1
2.	Agree	3	2
3.	Disagree	2	3
4.	Strongly Disagree	1	4

Open-ended questionnaire responses were processed by grouping answers into positive and negative categories to identify respondents' response patterns refers to Table 2. The findings from the

interviews were used to support and clarify the results of the questionnaire. The percentage calculation was carried out using Equation (2) (Agus et al., 2018).

$$Positive\ Statement(\%) = \frac{Total\ Score\ of\ Positive\ Statements}{Number\ of\ Respondents} \times 100\% \quad (2)$$

The percentage of positive statements is then classified according to the assessment category in Table 3., based on the criteria set (Pratama & Waskitoningtyas, 2020). The percentage value of a positive statement is expressed as p

Table 3. The Percentage of Positive Statements Category

Percentage (%)	Category
$p > 80$	Excellent
$60 < p \leq 80$	Good
$40 < p \leq 60$	Pretty Good
$20 < p \leq 40$	Not Good
$p \leq 20$	Very Bad

The results of the calculation are then converted into feasibility criteria to draw conclusions about the level of validity and practicality of the media. The media was categorized as feasible if it reached a percentage of at least 61% and is categorized as very feasible if it reaches a percentage above 80% (Indah et al., 2023).

The media was then validated by material and media experts, namely lecturers from one of the universities in Bandung. The media eligibility score is classified according to the assessment category in Table 4., based on the criteria that have been set (Pamungkas & Sudihartinih, 2021).

Table 4. Media Eligibility

Percentage (%)	Category
$p > 80$	Highly Worth It
$60 < p \leq 80$	Worthy
$40 < p \leq 60$	Quite Decent
$20 < p \leq 40$	Less Worthy
$p \leq 20$	Very Little Worthy

RESULTS

Mathematics learning media design process

The results of the development of mathematics learning media for social arithmetic topics that follow the MDLC stage are as follows. First, concept: this stage produces a program concept in the form of an interactive online game as a medium for learning social arithmetic. This application is designed for junior high school students to more easily understand basic concepts such as percentages, interest, discounts, and taxes in everyday life. However, this game only focuses on discounts so that students can apply them on a daily basis.

The results of the development of mathematics learning media for social arithmetic topics that follow the MDLC stage are as follows. First, concept: this stage produces a program concept in the form of an interactive online game as a medium for learning social arithmetic. This app is designed for Junior High School students to more easily understand basic concepts such as percentages, interest, discounts, and taxes in everyday life. But in this game, it only focuses on discounts so that students can apply them on a daily basis.

Second, design**:** at this stage, a material design was prepared that was in line with the Basic Competencies of the topic of social arithmetic, including the storyboard presented in Figure 2.,

complete with describing the sequence of scenes, user interactions, and storylines in the form of educational business games with elements of real mathematical challenges.

VISUAL	SKETSA	AUDIO
Dalam frame ini terdapat background layer dengan resolusi 480x360 *pixel*, teks judul, tombol "Start", dan 2 layer animasi.	Animasi Judul START	Fun Music

Figure 2. Initial Concept of Storyboard

Third, material collecting: this stage involves collecting social arithmetic teaching materials from school textbooks, official educational sites, and reliable reading resources on the internet. In addition, app assets such as animated images, thematic backgrounds (e.g., markets or banks), as well as background music audio and sound effects are collected from legal sources online, which are pulled from digital assets legally collected from platforms such as *Scratch*, *Canva*, *Pinterest*, and *YouTube* to enrich visual elements.

Fourth, assembly**:** the process of creating a game is carried out using the *Scratch* application according to the prepared storyboard design, including the integration of interactive elements such as quizzes, calculation simulations, and instant feedback.

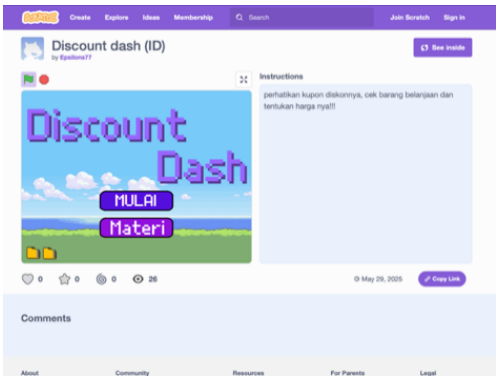
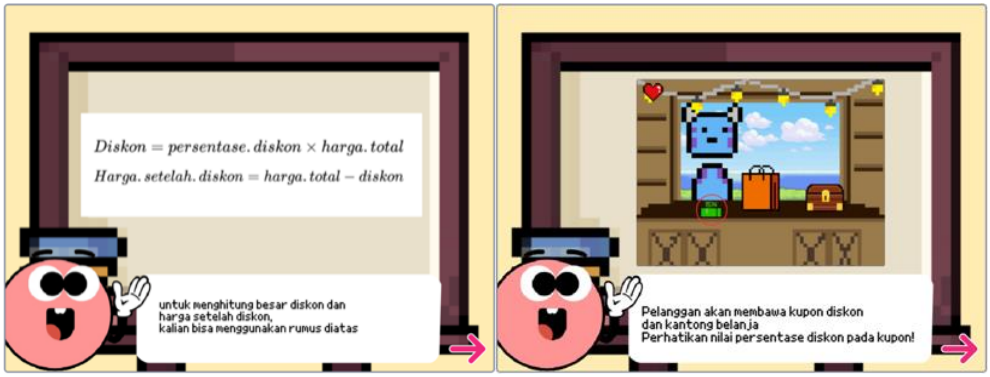


Figure 3. *Scratch* View

The initial look of the game is presented in Figure 3. To start the game, press the green button first, and the main display of the program will appear, displaying the title of the game Discount Dash and the topic of social arithmetic, accompanied by the two main buttons, including the Start button to start the game.

Figure 4. Initial Views

Material button in Figure 4. to see immediately the material on social arithmetic and see how the Discount Dash game is used with the view of Figure 5.(a) and Figure 5.(b) as follows.



(a) (b)

Figure 5. (a) Material; (b) How to Play

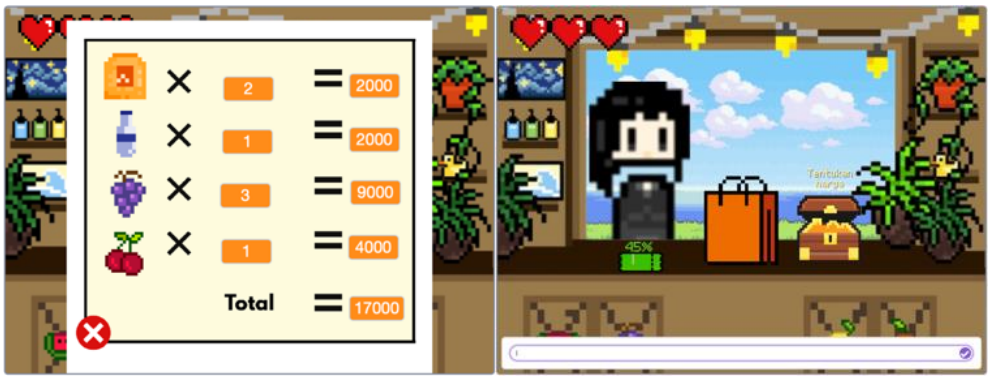
Then, to the left of the Figure 6. folder icon, to see the identity information of the course, compiler, and learning outcomes of this game, such as the ability to calculate discounts, taxes, and interest in a real context.

Figure 6. Group Members

Start Button in Figure 4., the function is to start the game when clicked, the program will switch to the first scene where the player will appear as if he is trading and selling food, the following Figure 7. appears to appear.

Figure 7. Display is in Business

When the animation enters, you will be given a discount ticket that provides information on the amount of discount that must be calculated. Then, opening the orange bag by clicking will bring up Figure 8.(a) and Figure 8.(b).



(a) (b)

Figure 8. (a) Purchased Items; (b) Determining The Answer

After the animated character buys an item, a calculation of the purchase amount that must be deducted by the animated character's discount appears. Next, participants click on the treasure icon, so that an answer box that must be filled in appears. If the answer is incorrect, the life (marked with the heart icon in the upper right corner) will be gradually reduced. If life runs out, the business is closed, or the game is over.

Figure 9. Game Over

The game is over, and the display appears as shown in Figure 9. This learning medium is suitable for playing with friends through competition mode to achieve the highest score.

Fifth, testing: the testing phase is repeated after development is complete, by checking each component of the program to ensure its functionality. This is called alpha testing (alpha test), which is carried out by a team of developers, including multimedia experts, to detect bugs and optimize the user experience.

Sixth, distribution**:** the final program is stored on *Google Drive* and the *Scratch* web platform through a registration/login process that can be accessed with a https://scratch.mit.edu/projects/1182234906 link, making it easy to access and share with students and teachers. The result of the development of the Discount Dash game on the topic of social arithmetic using *Scratch* is as follows.

Responses of media subject matter experts and prospective teacher students to social arithmetic learning media

The development of *Scratch*-based learning media has been carried out according to the MDLC stages. Validation tests by material experts and media experts to ensure media feasibility, followed by the distribution of open and closed questionnaires to measure student responses to Discount Dash learning media. Student responses from the open and closed questionnaires are shown in

Table 5. and Table 6., and questionnaires from subject matter experts and media experts are presented in Table 4.

Table 5. Results of Validation Tests of Material Experts and Media Experts

Indicator	Percentage	Category
Display	83%	Highly Worth It
Programming	100%	Highly Worth It
Material	87%	Highly Worth It
Language	100%	Highly Worth It
Audio	100%	Highly Worth It
Interest	100%	Highly Worth It
Benefits	100%	Highly Worth It
Average	95,7%	Highly Worth It

Based on Table 5., the results of the validation test of material experts and media experts on *Scratch*-assisted Discount Dash learning media on social arithmetic material show that all indicators obtained a very feasible category with an average of 95.7%.

After the expert validation stage, the survey was administered to 13 participants. The results of the open and closed questionnaires from the Discount Dash learning media survey are presented in Table 6. and Table 7. Respondents' assessment of *Scratch*-based interactive multimedia on social arithmetic materials received a positive response.

Table 6. Open Survey Results

Indicator	Percentage	Category
Display	94%	Excellent
Programming	98%	Excellent
Material	100%	Excellent
Language	100%	Excellent
Audio	100%	Excellent
Interest	92%	Excellent
Benefits	100%	Excellent
Average	97,7%	Excellent

Student responses to *Scratch*-based applications on social arithmetic materials as an educational game, Discount Dash, based on the open questionnaire in Table 6., showed very positive responses. All indicators in the category are very good with an average of 97.7%, so this medium is feasible and potentially effective for learning.

Table 7. Results of The Closed Questionnaire

Indicator	Percentage	Category
Display	92%	Excellent
Programming	100%	Excellent
Material	92%	Excellent
Language	100%	Excellent
Audio	100%	Excellent
Interest	92%	Excellent
Benefits	100%	Excellent
Average	96,5%	Excellent

From Table 6., and Table 7., it can be seen that participants in the form of prospective mathematics teacher students as a whole gave a positive response, with the average percentage per indicator reaching 97.7% and 96.5% in the category of being very good for the online games developed. They consider this game to be fun, interesting, cool, good, easy to use, concept-based, easy to understand, clear and precise language, fun, entertaining, uplifting, useful, and increases interest thanks to attractive visuals. These findings are in line with previous research that stated that

well-designed games received a positive response (Sudihartinih et al., 2021). The following are the results of interviews I conducted as interviewers, P1 and L1 as participants, and documented in Figures 12 and 13. The following are the results of interviews I conducted as interviewers, P1 and L1 as participants, and documented in Figure 10.(a) and Figure 10.(b).

(a) (b)

Figure 10. Interview Documentation: (a) P1; (b) L1

The high percentage level in terms of programming and ease of use indicates that Discount Dash media has a user-friendly interface. This proves that *Scratch* can be used to create learning media that is easily accessible to novice users. This finding is in line with the results of research by Sudihartinih et al. (2021) which found that *Scratch*-based learning media received a positive response from users because it has easy-to-use features and can increase their involvement in the learning process (Sudihartinih et al., 2021). The high scores on the interest and usefulness aspects showed that the gamification elements in Discount Dash, such as the points system, challenges, and direct feedback, were effective in increasing students' motivation to learn. These findings reinforce the game-based learning theory that game-based learning can increase students' emotional and cognitive engagement, thereby making the learning process more meaningful. High scores on the material aspect show that the presentation of discount concepts through simulations of everyday transactions helps users understand the relationship between mathematical concepts and real-life contexts. Thus, this media has the potential to help students understand social arithmetic material which has often been considered difficult and abstract.

In order to validate the responses to the open-ended questions, the researcher conducted interviews with two participants. The results of the interviews between the researcher (P) and the participants (coded Q1 and Q2) are presented in Table 8., with full documentation seen in Figure 10.(a), and Figure 10.(b).

Table 8. Interview Results

Questions	They Respond	Answer
What do you think about the overall look of the program?	Q1	So, after playing earlier, this is for 7th graders, yes, I think it's quite exciting, the story is rich in the game with many characters, fun and colorful colors, and the instructions are easy to understand.
	Q2	It's interesting, but because the concept is too boxy, it's too dizzying, but for the idea, it's funny.
How easy is it to use this learning medium?	Q1	Not confused at all, quite easy to understand, because the instructions are clear, the discounts are already listed, the prices and the total are all in total, so it is quite helpful.
	Q2	Easy, clear, just press the shopping box, exciting.
Does this program help you in understanding social arithmetic material?	Q1	Honestly, it was very helpful, especially 7th grade junior high school students, so math wasn't a scary scourge, but they became aware that math was important, especially for everyday life.

Questions	They Respond	Answer
	Q2	It helps because the concept is more attractive, and also because it is not too difficult to convert a price that is not too big.
What do you think of the use of language in this program?	Q1	It's so easy to understand, but once you read the instructions, you will be able to understand it.
Is it clear and easy to understand?	Q2	Interested, interesting, so not monotonous in learning, as a result, you can discuss with friends, especially games that can be played together.
Is the sound in the program clear and unobtrusive?	Q1	Obviously, it's interesting, because it looks interesting, so it's easy for us to understand. Here, about the discount, the character also changes, so don't get bored.
	Q2	Yes, the sound is a cool effect, like getting points, it sounds like 'ding', makes you want to keep playing.
What is your interest in learning social arithmetic using this program?	Q1	It's really interesting because the appearance is also interesting, so it's easy for us to understand. Here, about the discounts, the characters also change, so don't get bored.
	Q2	Interested, interesting, so not monotonous in learning, as a result, you are not bored, let alone able to discuss with friends, let alone play games that can be played together.
Do you think this program is beneficial in the learning process? Explain	Q1	It is useful, because in addition to understanding the material, we can know how to directly demonstrate, not only the theories, but also apply them directly.
	Q2	Interested, interesting, so not monotonous in learning because of not being bored, let alone being able to discuss with friends, let alone games that can be played together.

The results of this study show that the Discount Dash game developed based on *Scratch* managed to get a variety of positive responses from prospective mathematics teacher students. This proves that *Scratch* is a potentially effective platform for designing high-quality learning media, as supported by previous research that has also succeeded in developing similar media with positive responses from students (Pamungkas & Sudihartinih, 2021; Sudihartinih et al., 2021)

The use of the MDLC model in game development has proven to be potentially effective in producing valid, practical, and interesting learning media. Several supporting studies confirm that MDLC is capable of producing decent educational games (Syamsudin et al., 2022), practical in use, as well as potentially effective in improving student understanding, such as in *Scratch*-based social arithmetic games.

The findings of this study further strengthen various previous reports that games as a learning medium play a role as a tool to assist teachers in delivering material in the classroom (Lahan et al., 2019), allow students to learn independently about social arithmetic concepts such as discounts and taxes (Pratama & Setyaningrum, 2018), as well as making learning math fun and not boring (Sudihartinih et al., 2021).

The use of *Scratch* in particular has a positive impact on increasing students' interest in mathematics (Chaerunnisa et al., 2021), which ultimately helps improve learning outcomes (Annisa et al., 2021) and in-depth understanding of the material (Sudihartinih et al., 2021) Discount Dash has the potential to improve understanding by turning the abstract concept of discounts into interactive visual simulations that allow students to manipulate price variables in real-time, reduce cognitive load through visual programming, and strengthen retention via gamification (life, high score). Therefore,

interactive learning media such as Discount Dash can be tested to measure their effectiveness as a solution to overcome difficult social arithmetic learning problems for grade VII junior high school students.

CONCLUSION

The results of the study show that *Scratch*-based Discount Dash media on social arithmetic materials (discounts) has been successfully developed optimally through the MDLC model, which includes the concept, design, material collecting, assembly, testing, and distribution stages. The validation test of material and media experts showed that the category was very feasible (average 95.7%), while the participants' responses to the open (97.7%) and closed (96.5%) questionnaires obtained the category very well. This media is considered interesting, practical, supports the understanding of the concept of discounts, and has the potential to increase the learning motivation of junior high school students. Thus, Discount Dash is worth using as a social arithmetic learning supplement. The next research development suggestion is to improve visual aesthetics with dynamic animation and varied themes, and expand the material to profit-loss, tax, and single interest, then conduct an empirical effectiveness test, a pre-post test group design in grade VII of junior high school.

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