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Integrating Digital-Based Differentiated Learning Media in a Single Platform to Enhance Students' Motivation and Understanding of Social Arithmetic Concepts

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Abstract
This developmental research aims to produce digital based differentiated learning media designed to enhance students' motivation and conceptual understanding of social arithmetic. The development procedure employs the design research model, consisting of three phases: preliminary research, prototyping phase, and assessment phase. The subjects of this study were 34 seventh grade students at SMP Negeri 3 Mengwi. Data collection techniques included observations, interviews, questionnaires, tests, and documentation. The validity was verified by experts in media and material and learning, resulting in an average score of 4.65, categorized as very valid. The practicality level, based on student score on response questionnaires of 4.6 categorized as very practical and teacher response questionnaires, score of 4.7 categorized as very practical. The effectiveness of the media was assessed through improvements in learning motivation and conceptual understanding. Analysis of the learning motivation questionnaires showed a pretest score of 3.6 and a posttest score of 4.4, with an N-Gain value of 0.52 (medium category). Meanwhile, conceptual understanding test results indicated a pretest score of 61.47 and a posttest score of 81.47, with an N-Gain value of 0.52 (medium category). Effectiveness was determined through a one-group pretest–posttest design, indicating moderate improvement in both motivation and conceptual understanding.

Keywords: artificial intelligence, multimodal approach, learning engagement, conceptual understanding, systematic literature review.

1. Introduction

Article 1 of the National Education System Law Number 20 of 2003 explains that education is a conscious and planned effort to create a learning atmosphere and process so that students actively develop their potential to possess spiritual and religious strength, self-control, personality, intelligence, noble character, and the skills needed by themselves, society, the

nation, and the state. Education is not only a way to enlighten the nation's life but also plays a crucial role in transforming a lagging country into a developed one (Aprima & Sari, 2022). One of the expected learning objectives is for students to achieve learning outcomes in accordance with predetermined criteria. One attempt to accomplish this educational objective is to comprehend how teachers and students learn. In line with Ki Hajar Dewantara's philosophy, the educational process must be student-centered, acknowledging the individuality and distinctive qualities of every child. Therefore, creating meaningful learning by meeting diverse learning needs is the primary responsibility of educators (Herwina, 2021).

Students are expected to be aligned with curriculum developments and educational objectives, but in reality, many students still experience difficulties in understanding the material due to differences in learning styles, cognitive abilities, and backgrounds. Although each individual has unique learning preferences, specifically in receiving, processing, and remembering the information provided (Maulidia et al., 2023), the learning process in schools still tends to be uniform. Initial identification results indicate that teachers face obstacles in implementing differentiated learning due to limited time, media, and resources, rapid digitalization, a lack of teacher training, and tools to systematically identify student learning preferences. This results in learning becoming less meaningful and unable to accommodate differences in cognitive needs and learning style characteristics of students (Fitriah & Widiyono, 2023).

The impact of the same learning process for all students is one of the factors driving low student learning motivation. Learning motivation, which is an internal driving force, is often considered low because students view mathematics as an abstract and difficult subject, full of formulas, and boring (Sihombing et al., 2022). Observations revealed that this low motivation is characterized by students' passive attitudes during the learning process, a tendency to cheat, and diverting behaviors such as playing with their phones during learning. This initial study revealed that mathematics remains a difficult subject for students to understand because students easily give up on difficult problems and easily complain or despair when working on problems.

This condition directly impacts students' weak conceptual understanding, which is the main foundation in mathematics learning. Conceptual understanding is a student's ability to interpret the meaning of presented information, apply definitions based on the information provided, and provide an overview of ideas accompanied by creative and innovative explanations (Haq & Raicudu, 2023). Students with good conceptual understanding should be able to meaningfully connect new knowledge with existing knowledge. However, in reality, students are often only able to solve problems procedurally without understanding the meaning behind these steps. In mathematics learning, errors often occur in how students connect concepts. Some students memorize formulas without understanding the meaning of the relationships within the material in mathematics. And they are mostly unable to redefine in their own words and distinguish between examples and non-examples of a concept.

In mathematics lessons, particularly in social arithmetic, discounts, profits, interest, and percentages are discussed. This material should be relevant to everyday life, but many students still struggle to understand concepts and translate everyday problems into mathematical models. They often interpret story problems, make mistakes in formula selection, and even make arithmetic errors, thus suboptimal conceptual understanding (Aiman, 2021; Nuraeni, 2020; Pradnyadari, 2021). Furthermore, low learning motivation, characterized by passivity and disinterest in material considered abstract, is a complex problem that must be addressed immediately.

As an alternative solution to address these problems, differentiated learning supported by digital technology has become highly relevant. In order to help students achieve the best possible learning outcomes, differentiated learning involves tailoring instructional materials to their comprehension levels, learning styles, interests, and learning requirements (Handa, 2019; Purnawanto, 2023). This learning approach has been proven effective in improving learning outcomes and active student engagement in the classroom (Safarati & Zuhra, 2023; Yanti et al., 2022). Students' motivation and comprehension can be raised by implementing individualized instruction using the Visual, Auditory, and Kinesthetic (VAK) model (Made, 2022). However, to implement it optimally in the classroom learning process, supporting instruments in the form of interactive and varied learning media are needed (Rahmawati & Putra, 2022).

Therefore, according to the justification provided, the author is eager to adopt the title "Development of Digital-Based Differentiated Learning Media to Improve Motivation and Understanding of Social Arithmetic Concepts". The purpose of this study is to develop and obtain digital-based differentiated learning media to improve motivation and understanding of social arithmetic concepts that are appropriate for mathematics learning in grade VII. Although numerous studies have developed digital learning media, few have explicitly integrated differentiated learning principles that allow students to select learning media based on their individual learning characteristics, particularly in social arithmetic topics.

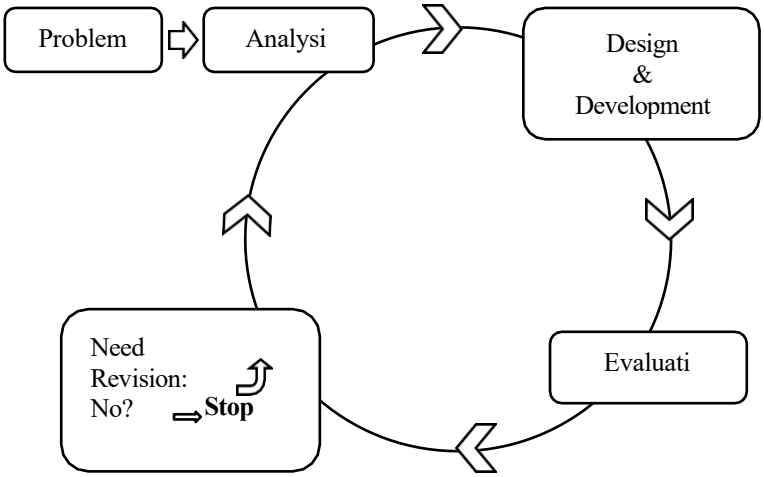
2. Methods

This research was conducted using a design research method. Design research is a research methodology that was developed by Plomp (2013) and is used to design, develop, and assess educational interventions, such as programs, strategies, teaching materials, products, and systems, with the goal of advancing knowledge about the characteristics of the interventions created and the process for creating and developing them (Plomp & Nieveen, 2013). The development procedure used the design research stages developed by Plomp, which consist of: preliminary research, prototyping phase, and assessment phase.

The subjects of this research trial were students in grade VII of SMP Negeri 3 Mengwi, with an average class size of 30 students. Meanwhile, the development subjects in this research were media experts as well as material and learning experts. The media experts selected were one lecturer in the Mathematics Department of Undiksha and one Informatics teacher at SMP Negeri 3 Mengwi. Meanwhile, the material and learning experts were one lecturer in the Mathematics Department at Universitas PGRI Mahadewa Indonesia and one Mathematics teacher at SMP Negeri 3 Mengwi. Although the sample size was limited, it was considered adequate for a preliminary effectiveness evaluation within a design research framework. Therefore, the effectiveness findings are contextual in nature and should be interpreted with limited generalizability beyond the study setting.

Tests, questionnaires, and interviews were employed to gather data in this study. Both qualitative and quantitative data analysis methods were used in the development of this educational resource. Quantitative data were obtained from expert, teacher, and student questionnaires, while qualitative data were derived from validators' comments and recommendations. The research instruments underwent content validity assessment by experts in media, material, and learning, and instrument reliability was examined using Cronbach's alpha coefficient to ensure consistency of measurement. As illustrated in Figure 1, the research flowchart follows Plomp's design research model, which incorporates a systematic instructional design process (Plomp & Nieveen, 2013).

Figure 1.
Systematic Cycle of Design Research (Plomp & Nieveen, 2013)



The design research process is cyclical. Analysis, design, evaluation, and revision activities are repeated until the right balance is achieved between the research objectives and their realization. This model was selected because it seeks to create a product that will be a digital-based differentiated learning medium that supports the needs of students' learning styles. For example, students who have a tendency toward visual learning styles can use e-comic learning materials; students who have a tendency toward auditory learning styles can use audio e-comic learning materials; and students who have a tendency toward kinesthetic learning styles can use scratch game learning materials. A number of steps are taken to create a legitimate, useful, and successful learning media product in order to improve motivation and comprehension of social arithmetic principles through the production of digital-based differentiated learning materials. This design research development process only employs one cycle.

The process of development starts with a preliminary phase, which involves analyzing needs, curriculum, identifying student learning styles, and developing infrastructure. This phase aims to gather information about existing problems, determine initial characteristics, and develop the design, as well as gather various information related to the product to be developed.

The prototyping phase begins with design planning, design optimization, formative evaluation, and the revision phase. This process involves creating digital-based differentiated learning media using Canva, AI, and SimpleBooklet applications to create e-comics and audio comics, as well as designing scratch game learning media according to the programming stages using the Scratch platform. In order to gather qualitative and quantitative data for product revision, the final prototype is validated by specialists and put through a few trials. Furthermore, in the assessment phase, a summative evaluation is conducted as the final series of stages, which includes field trials to measure reliability and effectiveness.

Developed learning media can be considered good if it meets the criteria of validity, practicality, and effectiveness. However, before the media is tested, the instruments used are first tested for validity to measure the desired achievement. The learning motivation questionnaire is analyzed to determine the validity and reliability of the instrument. Meanwhile, the conceptual understanding test is analyzed to determine validity, reliability, test the level of question difficulty, and test the discriminatory power of each question.

The validity of the subject matter and learning experts, as well as the validity of the media experts, are used to gauge the validity of learning media. The outcomes of each expert's instrument evaluation can be used to assess a learning medium's validity. Learning media is deemed suitable for use if the validation assessment results reach the sufficient category. The assessment and suggestions provided by the validators serve as a reference for researchers in revising and refining the developed media. The results of the improvements based on the experts' input are hereinafter referred to as prototype II.

Each differentiated learning tool created for this study was evaluated for practicality based on how well it worked in the classroom. Student and instructor response questionnaires were sent in order to gather information on the media's usefulness. If there were any notes or input from the responses, the researchers conducted further revisions to improve the media.

The outcomes, specifically the rise in students' motivation to learn and conceptual comprehension, demonstrate the efficacy of educational media. Data regarding student learning motivation, collected through questionnaires before and after treatment, were then analyzed descriptively to determine the category of student learning motivation levels and a gain test to determine the increase in the effectiveness of the treatment on learning motivation after learning compared to the initial conditions. In the meantime, a pre-test and post-test were used to gather data for the concept understanding test analysis. There were twenty multiple-choice questions on the test. The category of their learning achievement was then determined by descriptive analysis, and the N-Gain test was used to assess how much the treatment improved students' conceptual comprehension after learning in comparison to the beginning conditions.

3. Results and Discussion

This research successfully developed digital-based differentiated learning media for social arithmetic through the three systematic stages of the Plomp model**.** Beyond the development process, the discussion emphasizes how the differentiated design of the digital media contributed to improvements in students' learning motivation and conceptual understanding. The integration of varied learning pathways and interactive features enabled students to engage

with content that matched their learning characteristics, thereby supporting meaningful learning in social arithmetic.

3.1. Initial study stage

The preliminary research phase included fieldwork, curriculum analysis, literature review, and preliminary media design analysis. This phase yielded information through classroom observations and interviews with mathematics teachers. The preliminary study's findings showed that seventh-grade pupils at SMP Negeri 3 Mengwi had basic learning difficulties in social arithmetic. According to the survey, pupils' varied learning styles were not accommodated by the subpar and homogenous use of digital-based learning materials. This resulted in low learning motivation and a lack of in-depth understanding of student concepts. This was also influenced by the limited number of digital-based media that systematically integrate the principle of differentiation, whether through visual, audio, or kinesthetic media that can be independently selected. Therefore, differentiated digital-based learning media are needed that not only deliver material informatively but also provide flexibility for students to determine their learning styles, thereby increasing learning motivation and deepening students' conceptual understanding in a constructive and meaningful manner.

Analysis of student characteristics shows that seventh-grade students have diverse socio-cultural backgrounds and are at a transitional stage of cognitive development from concrete operations to formal operations. Furthermore, students have not had experience learning mathematics using digital-based differentiated learning media. Students' learning motivation and understanding of mathematical concepts are classified as moderate to low, as reflected in student learning outcomes that have not yet achieved classical mastery. Initial data shows that student learning mastery has only reached 61.76%, still below the classical mastery standard of 75%. As an initial step for improvement, student learning styles were identified. The most prevalent responses for each student were used to classify the learning styles based on their responses to the learning style questionnaire, as shown in Table 1 below.

Table 1.
Recapitulation Results of Student Learning Styles

Learning Styles	Many Students
Visual	13
Auditory	13
Kinesthetic	8
Total Students	34

Students have a variety of learning style tendencies, according to the learning style analysis results. Specifically, 13 students have a visual learning style, 13 have an auditory learning style, and 8 have a kinesthetic learning style. In interpreting these results, it is important to acknowledge that learning styles are classified here as a practical tool for instructional differentiation rather than as fixed cognitive traits. While the theoretical rigidity of learning styles is debated, identifying these preferences helps educators diversify their teaching methods to better engage students.

These findings indicate the need for learning media that can accommodate the differences in student learning styles. The school has resources like a computer lab, internet access, LCD

screens in every classroom, and smartphone ownership for every student in order to facilitate the implementation of the learning process using digital-based differentiated learning media. These conditions indicate that the school environment is conducive to the development and implementation of digital learning media.

The curriculum analysis results indicate that the social arithmetic material in the Independent Curriculum for grade VII covers determining unit and total values, profit and loss, discounts and taxes, simple interest, and gross, net, and tare. These learning outcomes require a strong conceptual understanding and relevance to everyday life, necessitating contextual learning media.

A survey of the literature reveals that a lot of work has gone into creating digital learning materials, such as interactive multimedia, instructional games, and e-comics. Nevertheless, the majority of research has not explicitly incorporated a differentiated learning strategy that permits students to select media based on their preferred methods of learning. The requirement for the creation of digital-based differentiated learning materials that incorporate audio e-comics, visual e-comics, and scratch games into a single digital platform was identified based on the findings of this preliminary study. This information served as the foundation for the creation of media prototypes in the subsequent phase.

3.2. Development stage

The prototyping phase is a cycle between design planning, design optimization, formative evaluation, and the revision phase, all included in the development phase. Building a learning media design using the findings from the preceding analytical phase is the first step in this stage. Students with a propensity for visual learning styles can use e-comics, students with a propensity for auditory learning styles can use audio e-comics, and students with a propensity for kinesthetic learning styles can use scratch games. Differentiated learning media are made integrated with the help of Google Sites software which serves as the main portal on a single page that can be accessed by students, so that students can choose media that suits their learning style needs. This portal combines all media components in a single interface that can be accessed via a link or QR code, thus enabling flexible learning.

Figure 2.
Main Portal for Digital-Based Differentiated Learning Media

Each media has a number of characteristics specifically designed to support students' learning process in social arithmetic material. These media are arranged based on different student learning styles, each representing the characteristics of learning styles. Visual e-comic learning media is developed with an attractive graphic display, designed using Canva as a layout design, as well as character creation assisted by Pixton, then the final product is converted into a digital flipbook format using SimpleBooklet to provide a reading experience similar to a physical book that aims to help students more easily understand learning through visual representation. Meanwhile, audio e-comic learning media, visually adapted from e-comic designs that are converted to a horizontal orientation without text and given additional narration using AI voice-over and background sound effects, then uploaded to the Lumi platform to share H5P-based interactive features so as to provide a learning experience more suitable for students with auditory tendencies.

The Scratch game is designed as a medium that combines interactive materials and games, designed according to the programming stages using the Scratch platform. This medium consists of four levels, each with different challenges related to contextual social arithmetic material, allowing students to build conceptual understanding through exploratory activities and direct responses to learning stimuli. The media is structured based on a social arithmetic sub-material structure that includes topics such as unit value and total value, the concept of profit and loss, discounts and taxes, simple interest, and the concepts of gross, net, and tare. The material is structured according to a systematic conceptual flow so that students can build conceptual understanding gradually, starting from basic concepts to their application in contextual situations. Each type of media is also equipped with questions that allow students to directly determine their level of conceptual mastery. This learning media is designed to attract students' attention, so that the characters and stories presented in the learning media are related to the daily lives of junior high school students. So that the result of the development is prototype I. Next, the resulting prototype is submitted for further correction by experts in order to maximize the product and achieve the expected goals.

This learning media has passed the validity test. Two media experts one lecturer from the Undiksha Mathematics Department and one informatics teacher at SMP Negeri 3 Mengwi, as well as two material and learning experts, one lecturer from the mathematics department at PGRI Mahadewa Indonesia University and one mathematics teacher from SMP Negeri 3 Mengwi, performed the validity test of the learning materials. The examination of learning media experts, material experts, and learning experts yielded an average score of 4.65 with a valid category. Additionally, changes were made in accordance with the experts' directions, and learning materials in the form of a workable prototype II were obtained. Table 2 below shows the general summary.

Table 2.
Recapitulation of Overall Evaluation Results

Eligibility	Average Score
Media Expert	4.7
Subject Matter and Learning Expert	4.6
Amount	9.3
Average	4.65

3.3. Evaluation stage

The evaluation phase (assessment phase) is the final series of stages, which includes field trials to measure the level of reliability and effectiveness. A brief trial was carried out to assess the usefulness of the created learning materials using student and instructor response questionnaires following the acquisition of a workable prototype II. To evaluate the usefulness of the learning materials, teachers and students filled out answer surveys. The overall score was transformed into a very good criterion since the teacher response questionnaire yielded a score of 4.7 and the student response questionnaire yielded a score of 4.6. Therefore, in this activity, the digital-based differentiated learning media's practicality was achieved in line with the indicators' expectations. The following Tables 3 and 4 are a recapitulation of the student and teacher response questionnaires.

Table 3.
Student Response Questionnaire Recapitulation

Number of Statements	15
Total Score	155.3
Average	4.6
Criteria	Very high

Table 4.
Recapitulation of Teacher Response Questionnaire

Number of Statements	15
Total Score	71
Average	4.7
Criteria	Very high

Next, an assessment of the effectiveness of digital-based differentiated learning media was conducted to improve students' learning motivation and understanding of social arithmetic concepts. This stage involved 34 students and was carried out after all students' learning styles were identified based on the results of the student learning style questionnaire distribution. Increasing student learning motivation was carried out by completing the motivation questionnaire before and after treatment. Descriptive analysis was carried out with pre-test scores in the range of $2.60 < Sr < 3.39$. While in the post-test there was an increase in the range of $3.20 \leq Sr < 50.00$. Meanwhile, the average N-Gain value calculated was 0.517 which is in the moderate category. These findings are consistent with previous studies reporting moderate N-Gain improvements through digital and differentiated learning approaches (Purba & Harahap, 2024). This indicates that the developed learning media is effective in improving student motivation in social arithmetic lessons. The following Tables 5 and 6 are a recapitulation of the learning motivation questionnaire and the average N-Gain results.

Table 5.
Summary of the Learning Motivation Questionnaire

Trials	Total Score	Average Score	Criteria
Pre-test	2414	3.6	Currently
Post-test	2924	4.4	Very high

Table 6.
Average N-Gain Result

	Pre-test	*Post-test*	*N-Gain*
Average	2414	2924	0.517241

Meanwhile, students' understanding of learning concepts was measured based on the results of the pre-test and post-test in the form of 20 multiple-choice questions. The test results were analyzed using descriptive analysis with pre-test scores in the range of $58.33 \leq Sr < 74.99$. While in the post-test there was an increase in the range of $Sr \geq 74.99$ this falls into the category of very good. In the meantime, the computed average N-Gain value was 0.519 which is in the moderate category. This shows that the developed learning media is effective in helping students understand social arithmetic material better. The following Tables 7 and 8 are a recapitulation of the conceptual understanding test scores and the average N-Gain results.

Table 7.
Conceptual Understanding Test Score Recapitulation

Trials	Total Score	Average Score	Criteria
Pre-test	2090	61.47	Good
Post-test	2770	81.47	Very good

Table 8.
Average N-Gain Result

	Pre-test	*Post-test*	*N-Gain*
Average	61.47	81.47	0.519083969

It is clear from the two tables above that the generated digital-based differentiated learning materials satisfy the requirements of validity, practicality, and efficiency, making them appropriate for use in the educational process.

Despite the positive results regarding the validity and effectiveness of the developed media, this study has several limitations. First, regarding the research design, the sample size was relatively small (34 students) without a control group, which limits the generalizability of the findings and makes it difficult to attribute improvements solely to the intervention. The study was also conducted over a short duration, leaving the long-term retention of student understanding unassessed. Second, regarding the practical implementation of the digital media, several challenges were identified during development and testing. Digital learning environments can be prone to distractions, where students may lose focus due to social media or entertainment sites. Technical barriers also pose a significant challenge; issues such as unstable internet connectivity, device compatibility, or software errors can disrupt the learning experience. Furthermore, the reliance on internet access means this media may be difficult to implement in areas with limited infrastructure, and some students may struggle with the technical proficiency required to navigate the platform effectively.

4. Conclusion

This research is a development research that produces digital-based differentiated learning media to increase motivation and understanding of social arithmetic concepts. Two conclusions can be drawn from the study's findings. First, the characteristics of the learning media that were successfully developed are: (1) the media were designed with reference to the principles of differentiated learning consisting of three types of learning media, where each media has different learning characteristics, namely: visual e-comics displaying attractive visual displays in flipbook format, audio e-comics developed based on H5P with interactive videos containing AI-assisted voice narration, scratch games containing interactive materials and games; (2) developed in an integrated manner in one Google Sites platform; (3) arranged with a social arithmetic sub- material content structure, including unit values and overall values, the concept of profit and loss, discounts and taxes, single interest, gross, net, and tare; (4) each media is equipped with an assessment feature to determine the level of concept mastery directly. Second, the validity, usefulness, and efficacy of the created educational materials have been examined.

Prior to testing the media, the validity of each study tool was examined to make sure it could measure the desired elements consistently and accurately. With appropriate criteria, the validity test's average score was 4.65. The average score of students' responses was used to determine the practicality findings 4.6 and teacher responses of 4.7, so the media has very high practicality. Meanwhile, the media is said to be effective because it increases learning motivation with an N-Gain of 0.52 and conceptual understanding with an N-Gain value of 0.52. So, based on the results of the trial, it can be concluded that digital-based differentiated learning media is feasible and can be used as a learning medium for social arithmetic material.

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