



The Development of Pop-Up Book Learning Media Supported by Technology on Integer Material Based on Type of Children with Special Needs

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Abstract

Concrete learning media are very important for children with special needs because they can improve understanding through visualization and engaging message delivery. Based on observations at Jember Special School Type C (Education and Care Centre), learning media are rarely used, especially when teaching integer material. This study aims to describe the process and outcomes of developing a pop-up book learning medium tailored to the different types of children with special needs, ensuring its validity, practicality, and effectiveness. The study employs a modified 4-D development model within a Research and Development (R&D) framework. Data were collected through validation sheets, user response questionnaires, interview guides, and learning outcome tests. Three methods of data analysis were used: validity analysis, practicality analysis, and effectiveness analysis. The validation results showed average scores of 3.67, 3.69, and 3.54 for learning media designed for students with intellectual disabilities, physical disabilities, and visual impairments, respectively, which are categorized as valid. The media were then tested on nine students at Jember Special School Type C, consisting of seven students with intellectual disabilities, one student with visual impairment, and one student with physical disability. Practicality analysis was conducted based on student and teacher response questionnaire scores, which were 80.25% and 80.75%, respectively, indicating a good level of practicality. The learning outcome test showed a 100% mastery level, indicating that the learning media met the criteria for effectiveness. This research is expected to serve as a reference for other researchers who wish to develop similar instructional media or further develop pop-up book learning media for other types of children with special needs.

Keywords: Children with Special Needs; Integer; Pop Up Book; Technology

Abstrak

Media pembelajaran konkret sangat penting bagi anak berkebutuhan khusus karena dapat meningkatkan pemahaman mereka melalui visualisasi dan penyampaian pesan yang menarik. Berdasarkan observasi di SLB-C TPA (Taman Pendidikan dan Asuhan) Jember, media pembelajaran jarang digunakan, terutama saat mengajarkan materi bilangan bulat. Penelitian ini bertujuan untuk mendeskripsikan proses dan hasil pengembangan pop-up book sebagai media pembelajaran berdasarkan jenis ABK yang valid, praktis, dan efektif. Penelitian ini menggunakan model pengembangan 4-D yang dimodifikasi dalam kerangka R&D. Pengumpulan data dilakukan melalui lembar validasi, angket respon pengguna, pedoman wawancara, dan tes hasil belajar. Terdapat tiga metode analisis data yaitu analisis kevalidan, analisis kepraktisan, dan analisis keefektifan. Hasil validasi menunjukkan skor rata-rata untuk media pembelajaran tunagrahita, tunadaksa, dan tunanetra sebesar 3,67; 3,69; dan 3,54 yang dikategorikan valid. Media tersebut kemudian diuji coba pada sembilan peserta didik di SLB-C TPA Jember, terdiri dari tujuh peserta didik tunagrahita, satu peserta didik tunanetra, dan satu peserta didik tunadaksa. Analisis kepraktisan dilakukan melalui skor angket respon siswa dan guru yang masing-masing sebesar 80,25% dan 80,75%, menunjukkan tingkat kepraktisan yang baik. Hasil Tes Hasil Belajar menunjukkan ketuntasan belajar sebesar 100%, yang menandakan media pembelajaran telah memenuhi kategori efektif. Penelitian ini diharapkan dapat dijadikan referensi bagi peneliti lain yang ingin mengembangkan media pembelajaran sejenis ataupun mengembangkannya media pembelajaran pop-up book untuk anak berkebutuhan khusus lainnya.

Kata Kunci: Anak Berkebutuhan Khusus; Bilangan Bulat; Pop-Up Book; Teknologi

Introduction

The term "children with special needs" refers to a variations in functional abilities, both physical and mental (Kristiana and Widayanti, 2016). Children with special needs require special and different treatment compared to typical children due to developmental disorders and abnormalities they experience (Rezieka et al., 2021). According to Rezieka et al., (2021), children with special needs can be categorized into physical, cognitive/mental, and social-behavioral disorders. Like typical children, children with special needs also study mathematics. According to the law of the Republic of Indonesia Number 20 of 2003, it is stated that: (1) every children has the same right to obtain quality education on an equal basis. (2) citizens with physical, emotional, mental, intellectual, and/or social impairments are entitled to receive special education. Ulva and Amalia (2020) state that mathematics needs to be taught to children with special needs because it: (1) sharpens problem-solving skills; (2) supports intelligent decision-making; (3) broadens knowledge related to other academic subjects; (4) opens broader job opportunities and enhances workplace competence; and (5) provide a strong foundation for becoming knowledgeable parents in the future. Mathematics is a very important subject to

learn because it is closely related to everyday life, and one of the topics taught to children at school is integers.

Integers are defined as non-fractional numbers consisting of positive integers, zero, and negative integers. In terms of operations, integers include four basic operations: addition, subtraction, multiplication, and division (Yanala et al., 2021). Fundamental concept of integers and their operations is closely related to everyday life. Therefore, this foundation material should be mastered by both typically developing children and children with special needs. This view is consistent with Cheong et al., (2017) and Faragher and Brown (2005) who argue that numeracy skills are critical to the daily lives of people with intellectual disabilities (ID). Numeracy skills are indispensable for making sense of and ordering the world. They are important for everyday life and therefore for independent living and social participation. Bowman et al., (2019) and Hord and Bouck (2012) state that arithmetic interventions for students with intellectual disabilities aim to improve knowledge of the four basic operations and mental computation. According to Boru and Hakim (2022), integers are a topic that children with special needs should master because they are highly useful for daily life and for further education.

A study conducted by Zahrah et al., (2023) found that three children with different types of disabilities experienced the same counting difficulties in integer-related tasks. Additionally, Meika et al., (2022) stated that students with intellectual disabilities struggle with solving integer operations in word problems, as well as understanding the concepts of addition, subtraction, multiplication, and division. One factor contributing to these learning difficulties is that teachers continue to use the expository method, which relies primarily on lecturing. The expository method has several weaknesses including making students passive listeners and limiting their engagement during learning. This is align with Mayada et al., (2024) who note that the expository method can lead to student passivity, limited creativity, and a strong dependence on teacher's ability. Based on observations conducted by the researcher at Jember Special School Type C (Education and Care Center), it was found that the method used to teach integer material still relied on the expository approach. One possible solution to overcome the limitations of this method is the use of learning media to support the learning process

The use of learning media for children with special needs has a positive impact, as it can foster curiosity, increase motivation, stimulate learning activities, and provide psychological benefits for students (Suwastarini et al., 2015). This is aligns with Gresilia et al., (2023) who stated that teachers must master the media they present to students, especially visual media, because children with special needs, such as those with intellectual disabilities, tend to rely on and maximize their visual

abilities to absorb information from their surroundings. According to Herwanto and Sugeng (2012), one of the factors contributing to poor numeracy skills in visually impaired children is the use of inappropriate learning media. Therefore, the use of suitable learning media is essential for children with special needs to help them understand the learning material effectively.

Learning media serve as a means of conveying information from a communicator to a recipient (Saleh et al., 2023). According to Fadilah et al. (2023), learning media are tools that can be used to facilitate the learning process, making it more effective and optimal. The benefits of instructional media for teachers include guiding them in achieving learning objectives, enabling systematic presentation of material, and assisting in delivering engaging content that improves learning quality. Meanwhile, the benefits of instructional media for students include increasing their motivation and interest in learning, allowing them to think critically and analyze the material presented by the teacher effectively (Nasution et al., 2024). Based on these definitions, it can be concluded that learning media play a crucial role in supporting teaching and learning activities in the classroom.

Learning media can take various forms depending on the creativity of the creator, ranging from physical materials to technology-based tools or a combination of both. According to Ariyanto et al. (2018), learning media can be categorized into traditional media and advanced technology-based media. One type of learning media that can be used in the learning process is the pop-up book. According to Dzuanda (2011), a pop-up book contains movable parts or three-dimensional elements and provides engaging visualizations, including images that move when the pages are opened. According to Muzdhalifah et al. (2025), the pop-up book is a three-dimensional educational medium that can stimulate children's imagination, helping them better understand how an object is formed. It is beneficial for expanding knowledge, enhancing understanding, and enriching vocabulary. In addition, pop-up books create an engaging effect because each page contains 3D elements, and the content can be customized to suit specific learning needs (Solichah and Mariana, 2018). One of the advantages of pop-up books is their ability to provide surprises on every page and leaving a strong impression on the narrative being conveyed (Sinta and Syofyan, 2021). Meanwhile, some of its drawbacks include the fact that creating this media takes a relatively long time due to the high level of precision and patience required. It is also relatively expensive, and the media is prone to damage after repeated use (Amalia et al., 2024).

Pop-up book instructional media fundamentally can be integrated with technology. In the area of digital transformation, technology-integrated instructional media positively impact students by improving accessibility,

enhancing independent, and supporting multisensory learning. According to Idhartono et al. (2024), in the digital transformation era, assistive technology is highly needed as a modified medium to support children with special needs both inside and outside the learning process. This is in line with Luwes and Widyastono (2020), who state that technology plays a significant role for children with special needs in Indonesia. Well-designed and appropriate technology can serve as an effective and efficient learning medium for children with special needs.

The research conducted by Lutfi and Munizu (2023), on the use of pop-up book media to enhance the learning outcomes of students with mild intellectual disabilities found that this media effectively improved students' learning outcomes. The results of this study indicate that the use of pop-up book learning media is proven to be effective in improving the learning outcomes of students with intellectual disabilities. However, the developed learning media was not integrated with technology and was only designed for one type of special needs student. Another study by Soemantri et al. (2022) on the use of a pop-up book called *Magical Book Geometry Voice Interaction* as a mathematics learning tool for visually impaired students showed that this media improved their cognitive abilities, as evidenced by the results of pre-tests and post-tests. Based on these studies, pop up-book media have been shown to be effective in improving the learning outcomes of students with intellectual disabilities and visual impairments. However, the developed pop-up books are limited to only one type of special needs student, and those developed for students with intellectual disabilities are not integrated with technology. Therefore, it is necessary to develop technology-assisted pop-up book media that can be used by multiple types of students with special needs simultaneously.

This study focuses on developing technology-integrated pop-up book learning media for integer material designed for children with special needs. The participants consist students with intellectual disabilities, visual impairments (low vision), and physical disabilities who are accommodated within the same inclusive classroom.

Method

The type of research used in this study was Research and Development (R&D). According to Rustamana et al. (2024), research and development is a scientific approach aimed at obtaining data to facilitate researchers in producing, developing, and validating a product. The sample used in this study consisted of one eleventh-grade class at Jember Special School Type C, which included several types of students with special needs: 7 students with intellectual disabilities, 1 student with a physical disability, and 1 student

with a visual impairment (low vision). Several reasons for selecting this school as the research site included the school's willingness to participate and the lack of available learning media at the school.

The model used in this study was the 4-D model proposed by Thiagarajan in 1974. This model was chosen because it was specifically designed for children with special needs, making it suitable for the focus of this study. According to Thiagarajan et al. (1974), the 4-D model consists of four stages: 1) Define: In this stage, an analysis was conducted regarding the main problems in the study, identification of needs, objectives, and issues to be addressed. 2) Design: At this stage, the product to be developed was planned in detail, including the preparation of research instruments. 3) Development: In this stage, the developed product was validated and underwent trial testing. 4) Disseminate: The final step was to distribute the completed product to other schools for use in the learning process. Thiagarajan et al. (1974) stated that the dissemination stage is carried out until the product is distributed to other schools and feedback or suggestions regarding the practicality of the media are obtained. However, in this study, the dissemination stage was modified, in which the product was distributed to other schools without waiting for responses due to time constraints in the research process. The details of each step are as follows:

1. Define Stage

This stage consists of five steps: a) Front-End Analysis: which was conducted through observations and interviews with teachers to identify the fundamental problems they faced in the classroom. Based on the observations, it was found that students with different types of disabilities learned together in the same class. Additionally, teachers rarely used learning media during lessons due to limited resources. b) Learner Analysis: this stage was aimed at understanding student characteristics. Based on observations, the class selected as the research sample included students with various disabilities (intellectual disabilities, physical disabilities, and visual impairment (low vision)) who learned together. The teacher divided students into two groups based on their abilities: moderate and high. c) Task Analysis: which was conducted to determine the series of tasks students were required to complete. These tasks include using media, completing quizzes through Quizizz, and taking a Learning Outcome Test. d) Concept Analysis: performed to determine the learning materials to be included in the learning media. The material chosen for the development of this learning media was Integer Numbers for the eleventh-grade level. e) Specifying Instructional Objectives: in which the learning objectives for developing the media were formulated based on the four previous

analyses. The learning objectives for the development of the learning media were that students understood the concept of positive and negative numbers and classified numbers accordingly, compared integers, and performed basic operations, including the addition and subtraction of integers

2. Design Stage

This stage consists of four steps: a) Criterion Test Construction: which included four questions on integer numbers that aligned with the learning objectives from the Define stage. b) Media Selection: which aims to determine the appropriate media for presenting the selected content. The media chosen for this study was printed material in the form of a pop-up book. c) Format Selection: where the format of the pop-up book consisted of a cover page, an introduction (containing learning objectives and usage instructions), lesson content, and practice exercises through Quizizz. d) Initial Design: which involves creating Draft I, involved learning media, a guidebook, and research instruments.

3. Development Stage

This stage consisted of two steps: a) Expert Appraisal: a technique that was used to obtain suggestions for improvements to Draft I. Validation was conducted by two lecturers from the Mathematics Education Program at Faculty of Teacher Training and Education, Universitas Jember, as content and media experts. Additionally, validation was carried out by a teacher from Jember TPA Special School Type C. If Draft I was deemed valid, it proceeds to the trial stage. However, if it was not yet valid, revisions were made until Draft II was produced, which was revalidated until it met the validity criteria and could proceed to the trial stage. The validated Draft I was then referred to as Draft II. b) Developmental Testing, where Draft II was implemented by the teacher during the learning process. During the trial, students used the learning media with teacher assistance. Afterward, students took a learning achievement test to assess the effectiveness of the media. Additionally, both teachers and students completed an user response questionnaire to evaluate the practicality of the developed media. Interviews with teachers and students were also conducted to support the questionnaire data. The final step in this process was analyzing the practicality and effectiveness of the learning media. If the media met the criteria for being practical and effective, the final product was considered ready for the next stage.

4. Disseminate Stage

After the learning media was developed through the three previous stages, the final step was dissemination. The media was be distributed to another school for use in classroom learning. The school would provide feedback on the media's implementation (if any). However, due to time constraints in the research, this dissemination stage was conducted without waiting for feedback from the school. The school selected for dissemination is Jember State Special School. Flow Chart of The Modified 4-D Models can be seen in Figure 1.

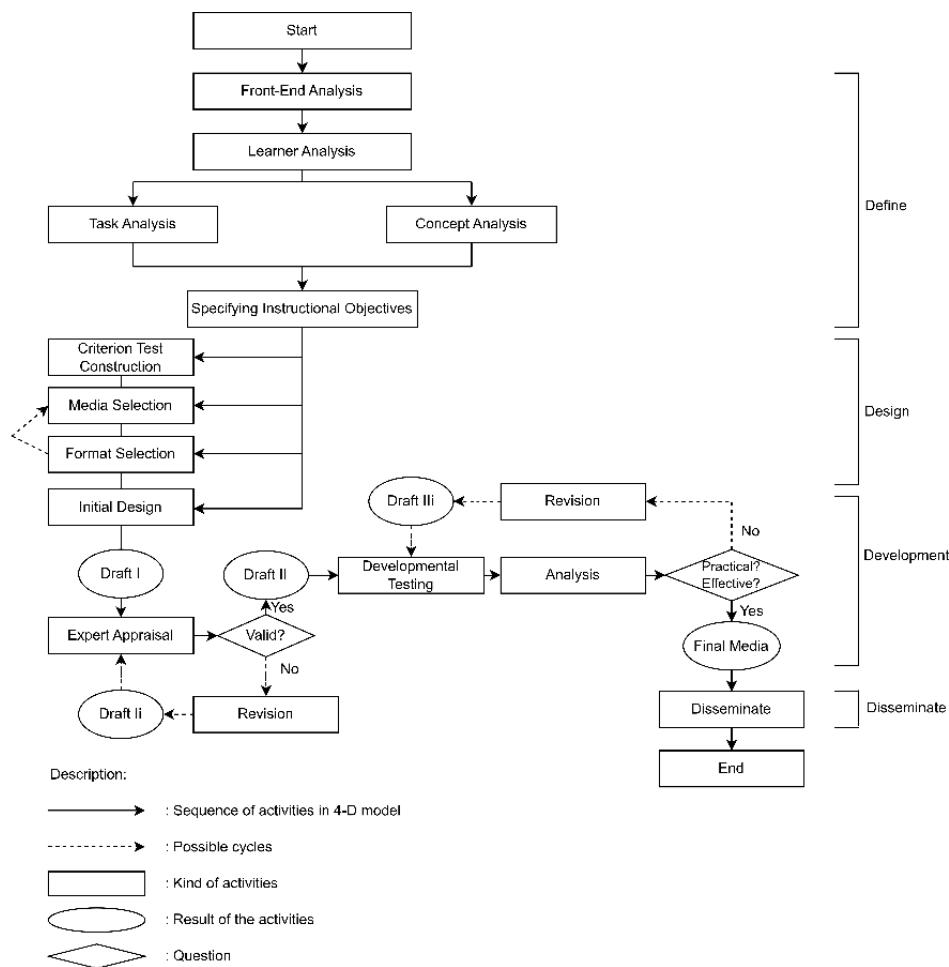


Figure 1. Flowchart of The Modified 4-D Model

There were four instruments used for this study: 1) Validation Sheet: an instrument was used to obtain data on the validators' opinions regarding the developed learning media. 2) User Response Questionnaire: a research instrument that was used to gather opinions from learning media users regarding its practicality. 3) Interview Guidelines: an instrument that was used to provide the questions asked to learning media users, including teachers and students. 4)

Learning Outcome Test: a test was used to collect data on students' understanding after using the learning media. The test consisted of four questions.

There were three data analysis methods used in this study: Validity Analysis, Practicality Analysis, and Effectiveness Analysis. The data used to analyze the validity of the learning media, guidebook, and research instruments (Draft I) were obtained through the validation sheet. The validation sheet was given to validators to gather their opinions on the developed learning media. After the data were collected, the next step was to compile a summary of the validity assessment in a table containing aspects, indicators, and scores. Following this, the average validation score from all validators was calculated for each indicator, and then the average score for each aspect was determined. The next step was to determine the total average score for all aspects (V_a). The media were considered valid if the total average score for all aspects (V_a) fell within the range $3 \leq V_a < 4$. Table 1 below shows the validity categories based on the V_a score.

Table 1. Validity Categories

No	Average Expert Assessment	Categories
1	$1 \leq V_a < 2$	Not Valid
2	$2 \leq V_a < 3$	Less Valid
3	$3 \leq V_a < 4$	Valid
4	$V_a = 4$	Very Valid

(Fairuz et al., 2020)

Practicality data were obtained from student and teacher response questionnaires, supported by interviews. After the data was collected, the next step was to summarize the questionnaire data in a table, then determine the average score of all users questionnaire responses for each indicator and calculate the total average score for all indicators. The final step was to convert the total average score into a percentage of the average questionnaire score (P). The media was considered to have a good level of practicality if the percentage of the average questionnaire score (P) fell within the range of $80\% < P \leq 95\%$. Table 2 presents the categories of user response questionnaire.

Table 2. Questionnaire Percentage Categories

Value of P	Value of Practicality
$P > 95\%$	Very Good
$80\% < P \leq 95\%$	Good
$65\% < P \leq 80\%$	Fairly Good
$50\% < P \leq 65\%$	Less Good
$P \leq 50\%$	Poor

(Fatahillah et al., 2020)

The developed learning media needed to be targeted and effective for use. Therefore, an Effectiveness Analysis was conducted by administering a Learning Outcome Test to students during the trial phase. After the test was administered, the next step was to summarize the student's test scores and classify them based on the Criteria for Achievement of Learning Objectives at Jember Special School Type C. Then, the number of students who meet the passing criteria was determined, and the percentage of students who achieve mastery (E) was calculated. The media was considered effective if the percentage of student mastery (E) reached $\geq 75\%$ (Yuwono et al., 2021),

Results

The technology-assisted pop-up book learning media on integer material was designed for students with intellectual disabilities, physical disabilities, and visual impairments (low vision). This learning media was developed using the 4-D model (Thiagarajan et al., 1974) with modifications in the dissemination phase. The modification involved limiting the dissemination process to distributing the media to other schools without waiting for user feedback. The following are the details of each stage of the modified 4-D model in the development of this learning media.

Define Stage

The development process of learning media begins with the definition stage, which aims to identify and formulate initial problems before the media development process starts. This stage consists of five steps: front-end analysis, learner analysis, task analysis, concept analysis, and specifying instructional objectives.

Front-End Analysis

The first step aims to identify the problems faced by teachers during the teaching and learning process. Based on observations and an interview with a teacher at Jember Special School Type C (Education and Care Center) on 2 August 2024, it was found that students with diverse special needs learn together in the same classroom. This situation causes students without cognitive impairments, such as those with physical disabilities or visual impairments (low vision), to experience slower learning progress. Additionally, when teaching the topic of integers, teachers often use the expository method, which has several drawbacks, such as making students passive listeners and causing the learning process to feel monotonous.

One way to address these shortcomings is by using concrete learning media, such as a pop-up book. Concrete learning media can help children with special needs

understand abstract concepts more effectively. Moreover, in this era of digital transformation, the use of learning media integrated with technology also has a positive impact, especially for children with special needs, such as increasing independence, facilitating access, and supporting multisensory learning. However, based on interviews with teachers, it was found that the number of learning media available at the school is limited. Therefore, it is necessary to develop technology-assisted pop-up book tailored to the types of children with special needs. The technology integrated into the media includes audio accessible via Google Drive and interactive quizzes through the Quizizz platform.

Learner Analysis

This step aims to understand student's characteristic so that the developed media can meet their needs. Based on an interview with an 11th-grade teacher at Jember Special School Type C (Education and Care Center), students were divided into two groups: moderate-ability and high-ability. Students with moderate-ability tend to require a more personalized approach, learn at a slower pace, and need frequent repetition to fully grasp concepts. Their mathematical ability was still limited, as they struggled with counting from 10 to 20 and could not perform basic arithmetic operations independently. Meanwhile, students with high-ability have a faster understanding, so the teacher usually focuses more on reinforcement through practice questions. Their mathematical skills include counting from 1 to 50 and solving basic arithmetic operations independently. It was found that the class consisted of students with different types of special needs, namely intellectual disabilities, physical disabilities, and visual impairments (low vision), all of whom learned together in the same classroom. This factor became a key consideration for the researcher in developing learning media that align with the specific needs of these students based on their disabilities.

Concept Analysis

The next step is concept analysis, which aims to determine the details of the mathematics learning material to be included in the learning media. The chosen topic for this learning media was integers, which was part of the 11 th-grade curricula in Merdeka Curriculum. Figure 2 presents the concept map that serves as the basis for designing the features of the learning media. To support the delivery of this content, the learning media includes several features such as the application of integer numbers in daily life, QR code containing audio explanations, and an interactive number line that allowed students to engage directly with the content.

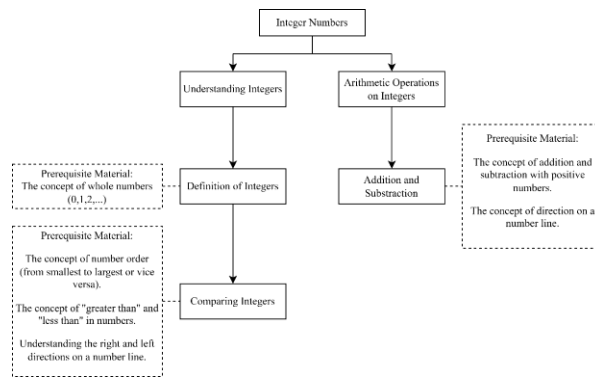


Figure 2. Concept Map of Integers

Task Analysis

The third step identified the task that students were required to complete while using the learning media. The first task for students was to study the integer numbers content using the developed media. After reviewing all the content in the learning media, students were required to complete practice questions via Quizizz, which was provided in the form of a QR code. The purpose of this quiz was to reinforce students' understanding after they used the learning media. Once students had completed this assignment, their final assignment was to take a learning outcome test.

Specifying Instructional Objectives

The final step in the definition (define) stage was formulating the learning objectives. These objectives served as the foundation for developing the learning media and ensured that the expected student outcomes aligned with the results of the previous analyses (preliminary-final analysis, learner analysis, concept analysis, and task analysis). The learning objectives were outlined in Table 3.

Table 3. Formulation of Learning Objectives

Main Topic	Learning Outcomes	Learning Objectives
Integer Numbers	At the end of Phase F (mental age of approximately 10 years old), students will be able to perform division operations with natural numbers and calculate mixed operations involving addition and subtraction. They will also be able to perform addition and subtraction of decimals (one decimal place) without carrying	<ol style="list-style-type: none"> Students can understand the concept of positive and negative numbers and classify numbers as positive or negative. Students can compare integer numbers. Students can perform simple arithmetic operations, including

<p>or borrowing techniques. Additionally, students will be able to solve mixed operations problems involving multiplication and addition in real-life situations. Furthermore, they will be able to identify profit or loss in buying and selling activities and calculate profit or loss using a calculator.</p>	<p>addition and subtraction of integers.</p>
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Design Stage

The next stage was the design stage, which consists of four steps: test preparation, media selection, format selection, and initial design. This second stage in the development process aimed to plan the learning media in detail based on the analysis results from the previous stage, the definition stage.

Criterion Test Construction

The first step in the design phase was the preparation of the Learning Outcome Test. This test, consisted of four questions on the integer numbers topic, included short-answer and matching questions with a 30-minute time limit. The test was designed based on the learning objectives formulated in the define stage.

Media Selection

The next step was media selection, which aimed to determine the most suitable medium for presenting the content based on the previous analysis. There were various types of media, such as audio recordings, print materials, models, real objects, filmstrips, and others. In this study, the chosen medium was printed material, specifically a pop-up book. Printed media, particularly pop-up books, offer several advantages, including ease of access and use, especially for children with special needs. Additionally, printed media provided concrete learning materials that children can see and touch directly, helping them better understand concepts through engaging visualizations. The pop-up book was also integrated with technology using QR code that linked to interactive quizzes and audio content when scanned. The interactive quizzes were created using the Quizizz platform, while the audio features were accessed through Google Drive.

Format Selection

The format of the pop-up Book consists of several sections. The cover includes the title on the front and the author's profile on the back. The introduction presents the learning objectives and usage instructions. The content section provides an introduction to integer numbers in daily life, the definition of integers, methods for comparing integers, and how to perform integer operations using a number line. Additionally, the pop-up book includes practice questions through interactive quizzes on the Quizizz platform.

Initial Design

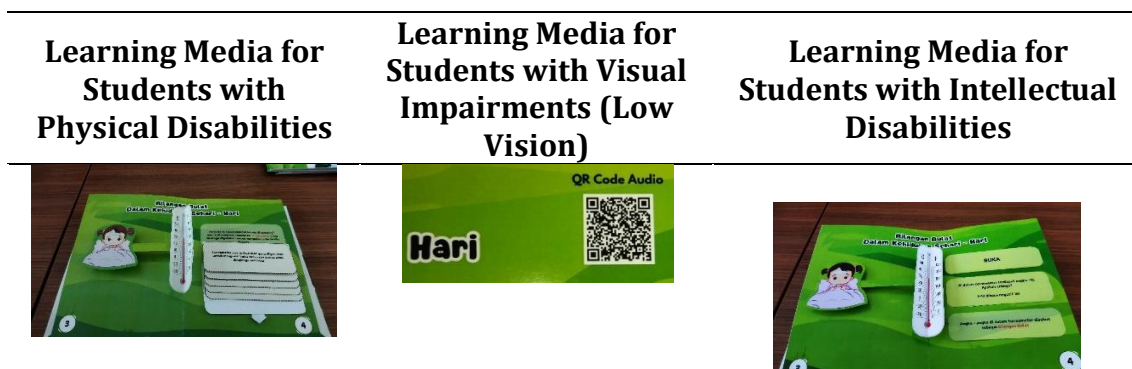
The final step in the design stage was the initial design phase. This phase aimed to develop the learning media based on the analysis conducted in the previous steps. The outcome of this initial design phase was Draft I, which included the learning media, a user guidebook, and research instruments. The details of the initial Draft I design are presented as follows.

a) Pop-Up Book Learning Media

The Pop-Up Book learning media was designed for three types of students with special needs: students with intellectual disabilities, physical disabilities, and visual impairments (low vision). The media was printed using Ivory 250 gsm paper, which was thick and durable, preventing it from tearing or getting damaged easily when the pop-up elements were repeatedly opened and closed. Additionally, this paper was sturdy enough to ensure that the pop-up elements stand upright and remained stable. The Ivory 250 gsm paper was printed in A3 size (29.7 × 42 cm), and after being assembled into a cover, its final dimensions are 20 x 26 cm. The pop-up book is designed with different characteristics to cater to the needs of each type of special needs student, as shown in Table 4.

Table 4. The Characteristic of Learning Media

Learning Media for Students with Physical Disabilities	Learning Media for Students with Visual Impairments (Low Vision)	Learning Media for Students with Intellectual Disabilities
Additional information related to examples of integer use in daily life is provided on pages 3–4, and the pop-up elements are made more varied	A QR code containing audio is provided and can be scanned to facilitate students' use	The Pop-Up Book for students with intellectual disabilities is designed without the additional information on real-life applications of integers on pages 3–4, and the pop-up elements are made simpler.



The content of learning media focuses on integer concept. Prior to the development process, the content for each page was carefully mapped to ensure that the material is organized in a structured and systematic way, as shown in Table 5. Additionally, each page includes learning objectives that have been formulated during the definition (define) stage. The initial design of the developed learning media can be seen in Figure 3.

Table 5. Content of The Learning Media

Page	Content Presented
1-2	Introduction pages containing learning objectives and usage instructions.
3-4	Introduction to integers in daily life using a thermometer. The thermometer is presented as a pop-up element to make it more engaging.
5-6	Explanation of integer concepts, including the definition and comparison of integers. Several pop-up elements are included for interactive learning.
7-8	Steps for operating integers using a number line. A pop-up number line element is added for better understanding.
9-10	A number line presented as a pop-up building element and two QR codes linked to interactive exercises on Quizizz. These exercises reinforce students' understanding of the material.



Figure 3. Initial Design of The Learning Media

To enhance the three pop-up book versions, QR codes were placed in them. These QR codes enable access to audio content and interactive quizzes hosted on the Quizizz platform. Figure 4 Illustrated the interface of the Quizizz activities and the audio materials involved.

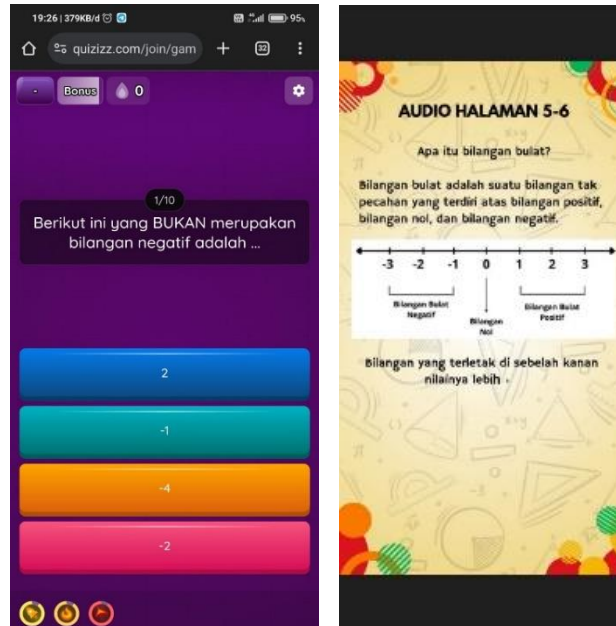


Figure 4. Display of The Quizizz and Audio

b) Guide Book

The guidebook was designed to accompany the three pop-up book learning media that were developed for students with intellectual disabilities, physical disabilities, and visual impairments (low vision). The A5-sized book (14.8 x 21 cm) contained an introduction to the learning media and instructions on how to use it optimally for both teachers and students. Additionally, the book included important aspects that teachers needed consider when assisting students in using the learning media. The initial design of the guidebook for the three types of learning media was shown in Figure 5.

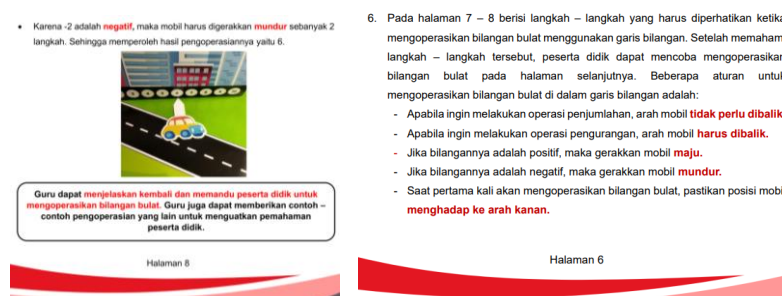


Figure 5. Example Display of The Learning Media Guide Book

c) Research Instruments

There were four instruments that were used in this study: validation sheets, user response questionnaires, interview guidelines, and learning outcome tests. These instruments were used used to collect data so that the validity, practicality, and effectiveness of the media could be measured. The following were details of the aspects observed in each instrument:

1) Validation Sheet: The validation sheets were used to obtain input and suggestions from experts to ensure the quality and feasibility of the components in this study. The components that were validated include learning media, guidebooks, user response questionnaires, interview guidelines, and learning outcome tests. An example of validation sheet can be seen in Figure 6.

PEDOMAN PENSKORAN

LEMBAR VALIDASI ANGKET RESPON GURU

Pengembangan Media Pembelajaran *Pop Up Book* Berbantuan Teknologi pada Materi Bilangan Bulat Berdasarkan Jenis Anak Berkebutuhan Khusus (ABK)

A. Identitas Validator

Nama :

NIP :

Jabatan :

Instansi :

B. Petunjuk Pengisian

- Isilah identitas Bapak/Ibu pada bagian Identitas Validator di atas.
- Berilah tanda centang (✓) pada kolom Penilaian sesuai dengan pedoman penilaian validasi yang terlampir.
- Apabila terdapat komentar/saran perbaikan, mohon untuk menuliskan pada bagian perbaikan dan saran.
- Kategori penilaian:
 1 = Sangat Kurang
 2 = Kurang
 3 = Baik
 4 = Sangat Baik

No	Aspek	Indikator	Penilaian			
			1	2	3	4
1.	Isi	1. Kesesuaian pernyataan dengan aspek yang ingin diamati				
		2. Pernyataan di dalam angket disampaikan secara jelas.				
2.	Kebahasaan	1. Bahasa dan istilah yang digunakan sesuai dengan EYD				
		2. Kosa kata dan kalimat yang digunakan mudah dipahami dan tidak menimbulkan arti ganda (ambigu)				

A. Aspek Isi

No.	Indikator	Rubrik Penilaian
1.	Kesesuaian pernyataan dengan aspek yang ingin diamati	Skor 4 : jika 11-14 pernyataan sesuai dengan aspek yang ingin diamati. Skor 3 : jika 7-10 pernyataan sesuai dengan aspek yang ingin diamati. Skor 2 : jika 3-6 pernyataan sesuai dengan aspek yang ingin diamati. Skor 1 : Jika 0-2 pernyataan sesuai dengan aspek yang ingin diamati.
2.	Pernyataan di dalam angket disampaikan secara jelas	Skor 4 : jika 11-14 pernyataan di dalam angket disampaikan secara jelas. Skor 3 : jika 7-10 pernyataan di dalam angket disampaikan secara jelas. Skor 2 : jika 3-6 pernyataan di dalam angket disampaikan secara jelas. Skor 1 : jika 0-2 pernyataan di dalam angket disampaikan secara jelas.

B. Aspek Kebahasaan

No.	Indikator	Rubrik Penilaian
1.	Bahasa yang digunakan sesuai dengan EYD	Skor 4 : jika 11-14 pernyataan disajikan menggunakan bahasa yang sesuai dengan EYD. Skor 3 : jika 7-10 pernyataan disajikan menggunakan bahasa yang sesuai dengan EYD. Skor 2 : jika 3-6 pernyataan disajikan menggunakan bahasa yang sesuai dengan EYD. Skor 1 : jika 0-2 pernyataan disajikan menggunakan bahasa yang sesuai dengan EYD.
2.	Kosa kata dan kalimat yang digunakan mudah dipahami dan tidak menimbulkan arti ganda (ambigu)	Skor 4 : jika kosa kata dan kalimat yang digunakan pada 11-14 pernyataan mudah dipahami dan tidak menimbulkan arti ganda (ambigu). Skor 3 : jika kosa kata dan kalimat yang digunakan pada 7-10 pernyataan mudah dipahami dan tidak menimbulkan arti ganda (ambigu). Skor 2 : jika kosa kata dan kalimat yang digunakan pada 3-6 pernyataan mudah dipahami dan tidak menimbulkan arti ganda (ambigu). Skor 1 : jika kosa kata dan kalimat yang digunakan pada 0-2 pernyataan mudah dipahami dan tidak menimbulkan arti ganda (ambigu).

Figure 6. Example of Validation Sheets

2) User Response Questionnaire: The user response questionnaires were used to obtain data as well as suggestions and feedback from users of the learning media. There were two types of user response questionnaires: the student response questionnaire, which contained 12 statements, and the teacher response questionnaire, which contained 14 statements. The statements in the questionnaire

were structured based on the aspects were observed, namely appearance and design, readability and comprehension, ease of use, interactivity and motivation, and learning effectiveness. The example of User Response Questionnaire can be seen in Figure 7.

LEMBAR ANGKET RESPON GURU

A. Identitas Responden
 Nama Guru :
 Mata Pelajaran :

B. Petunjuk Pengisian

- Isilah identitas Anda pada bagian Identitas Responden di atas.
- Bacalah setiap indikator terlebih dahulu sebelum memberikan penilaian.
- Berikan tanda centang (√) pada kolom penilaian.

Kategori penilaian:
 1 = Tidak Setuju
 2 = Kurang Setuju
 3 = Setuju
 4 = Sangat Setuju

- Apabila terdapat saran perbaikan terhadap media, mohon untuk memberikan saran pada kolom yang telah disediakan.

No	Pernyataan	Penilaian			
		1	2	3	4
10.	Penggunaan <i>Pop Up Book</i> membuat pembelajaran lebih menyenangkan dan tidak membosankan				
11.	Peserta didik tertarik dengan kuis interaktif yang ada di dalam <i>Pop Up Book</i>				
12.	Penggunaan <i>Pop Up Book</i> dapat memotivasi peserta didik untuk belajar materi bilangan bulat				
13.	Saya tertarik jika <i>Pop Up Book</i> digunakan pada materi yang lain				
14.	Media <i>Pop Up Book</i> memudahkan penyampaian materi bilangan bulat				

Kritik dan Saran:

Jember,
 Responden
 (.....)

No	Pernyataan	Penilaian			
		1	2	3	4
1.	Tampilan <i>Pop Up Book</i> menarik				
2.	Gambar pada <i>Pop Up Book</i> membuat peserta didik menjadi tertarik mengikuti pembelajaran				
3.	Media <i>Pop Up Book</i> sesuai dengan karakteristik peserta didik				
4.	Tulisan yang terdapat pada <i>Pop Up Book</i> mudah untuk dibaca				
5.	Bahasa yang digunakan di dalam media <i>Pop Up Book</i> mudah untuk dipahami				
6.	Petunjuk penggunaan <i>Pop Up Book</i> mudah dipahami oleh peserta didik				
7.	Elemen <i>pop up</i> di dalam <i>Pop Up Book</i> mudah untuk digunakan peserta didik				
8.	<i>QR Code</i> yang terdapat di dalam media mudah untuk diakses dan digunakan				
9.	Kuis interaktif yang terdapat di dalam <i>Pop Up Book</i> mudah untuk digunakan				

Figure 7. Example of User Response Questionnaire

3) Interview Guidelines: The interview guidelines were used as a research instrument to deepen and strengthen the data obtained through the user response questionnaires. The aspects observed in these interview guidelines were aligned with the aspects in the user response questionnaire, allowing researchers to obtain more in-depth information. The Interview Guidelines can be seen in Figure 8.

PEDOMAN WAWANCARA

Petunjuk

1. Wawancara dilakukan kepada pengguna media pembelajaran yaitu peserta didik dan guru.
2. Kegiatan wawancara ini bertujuan untuk mendapatkan data terkait pendapat pengguna yaitu peserta didik dan guru terkait kepraktisan media pembelajaran.
3. Pertanyaan yang terdapat di dalam pedoman wawancara ini bersifat semi-terstruktur atau pertanyaan bisa berkembang saat wawancara berlangsung.
4. Dokumentasi kegiatan wawancara berupa rekaman audio yang dilakukan menggunakan *smartphone*.

A. Wawancara Guru

No	Aspek	Pertanyaan
1.	Tampilan dan Desain	1. Bagaimana pendapat Bapak/Ibu tentang tampilan dan desain <i>Pop Up Book</i> yang digunakan?
		2. Bagaimana pendapat Bapak/Ibu tentang gambar yang ada di dalam <i>Pop Up Book</i> ?
2.	Keterbacaan dan Pemahaman	3. Bagaimana tulisan yang terdapat di dalam <i>Pop Up Book</i> menurut Anda?
		4. Bagaimana bahasa yang digunakan di dalam media pembelajaran <i>Pop Up Book</i> ?
3.	Kemudahan Penggunaan	5. Bagaimana petunjuk penggunaan yang terdapat di dalam media pembelajaran <i>Pop Up Book</i> menurut Bapak/Ibu?
		6. Apa pendapat Anda tentang elemen <i>Pop Up</i> yang ada di dalam buku ini?
		7. Bagaimana pendapat Anda tentang kuis interaktif yang terdapat di dalam <i>Pop Up Book</i> ini?
		8. Bagaimana pendapat Anda terkait <i>QR Code</i> yang terdapat di dalam media pembelajaran <i>Pop Up Book</i> ini?
4.	Interaktivitas dan Motivasi	9. Bagaimana tanggapan peserta didik terhadap kuis interaktif yang ada di dalam <i>Pop Up Book</i> ?
		10. Apakah <i>Pop Up Book</i> ini dapat memberikan pengaruh terhadap motivasi belajar peserta didik khususnya untuk materi bilangan bulat?

No	Aspek	Pertanyaan
5.	Efektivitas Pembelajaran	11. Bagaimana pendapat Anda jika media pembelajaran <i>Pop Up Book</i> ini digunakan untuk materi pembelajaran lainnya?
		12. Bagaimana pembelajaran di kelas saat menggunakan media pembelajaran <i>Pop Up Book</i> ?
		13. Menurut Bapak/Ibu apakah penggunaan media pembelajaran <i>Pop Up Book</i> dapat mempermudah penyampaian bilangan bulat?
		14. Menurut Bapak/Ibu apakah media pembelajaran <i>Pop Up Book</i> sudah sesuai dengan karakteristik peserta didik?

B. Wawancara Peserta Didik

No	Aspek	Pertanyaan
1.	Tampilan dan Desain	1. Bagaimana pendapatmu tentang tampilan dan desain <i>Pop Up Book</i> yang digunakan?
		2. Bagaimana pendapatmu tentang gambar yang ada di dalam <i>Pop Up Book</i> ?
2.	Keterbacaan dan Pemahaman	3. Bagaimana tulisan yang terdapat di dalam <i>Pop Up Book</i> menurutmu?
		4. Bagaimana bahasa yang digunakan di dalam media pembelajaran <i>Pop Up Book</i> ?
3.	Kemudahan Penggunaan	5. Bagaimana petunjuk penggunaan yang terdapat di dalam media pembelajaran <i>Pop Up Book</i> menurutmu?
		6. Apa pendapatmu tentang elemen <i>Pop Up</i> yang ada di dalam buku ini?
		7. Bagaimana pendapatmu tentang kuis interaktif yang terdapat di dalam <i>Pop Up Book</i> ini?
		8. Bagaimana pendapatmu terkait <i>QR Code</i> yang terdapat di dalam media pembelajaran <i>Pop Up Book</i> ini?
4.	Interaktivitas dan Motivasi	9. Apakah <i>Pop Up Book</i> ini dapat membuatmu menjadi lebih semangat dalam belajar materi bilangan bulat?
		10. Bagaimana pendapatmu jika media pembelajaran <i>Pop Up Book</i> ini digunakan untuk materi pembelajaran lainnya?
5.	Efektivitas Pembelajaran	11. Bagaimana perasaanmu saat belajar menggunakan media pembelajaran <i>Pop Up Book</i> ?

Figure 8. Interview Guidelines

4) Learning Outcome Test: The Learning Outcome Test was designed based on the learning objectives formulated in the definition (define) stage. The test on integer material consisted of four questions in the form of short-answer and matching questions, with a completion time of 30 minutes. Additionally, to ensure clarity and accuracy in assessment, a test blueprint, alternative answers, and scoring guidelines were also included. The Learning Outcome Test can be seen in Figure 9.

Nama :
 Kelas :
 No. Absen :

TES HASIL BELAJAR

Nama Sekolah : SLB-C TPA Jember
 Mata Pelajaran : Matematika
 Kelas/Semester : XI/Gasal
 Pokok Bahasan : Bilangan Bulat
 Alokasi Waktu : 30 menit

2. Tulislah lambang dari bilangan berikut ini pada kotak yang tersedia!

- a) Negatif lima :
- b) Negatif delapan :
- c) Negatif tiga :
- d) Negatif sepuluh :

Petunjuk Pengerjaan:

1. Berdoalah sebelum mengerjakan soal.
2. Tulislah identitasmu dan kerjakan soal menggunakan pensil/bolpoin.
3. Bacalah soal di bawah ini dengan cermat dan teliti.
4. Kerjakan secara individu dan tanyakan kepada guru apabila terdapat soal yang kurang jelas.

3. Lingkarilah bilangan berikut ini yang nilainya lebih besar!

- a) 2 atau -2 ?
- b) 10 atau -12 ?
- c) -3 atau -4 ?
- d) -10 atau 11?

Jawablah pertanyaan – pertanyaan di bawah ini dengan benar!

1. Manakah yang merupakan bilangan positif dan bilangan negatif? Tariklah garis dari kotak kiri ke kotak kanan!

16	Bilangan Positif
-8	
-9	Bilangan Negatif
1	
-1	
10	

4. Hitunglah operasi bilangan bulat berikut ini dan tuliskan hasilnya pada kotak yang tersedia! Gunakan garis bilangan untuk mempermudah perhitungannya!

- a) $2 + 6$:
- b) $1 - 6$:
- c) $-1 + 5$:
- d) $-2 - (-4)$:

Figure 9. Learning Outcome Test

Development Stage







The third stage in the 4-D model is the development stage. This stage consisted of two main steps (expert appraisal and trials) and aimed to obtain suggestions to ensure that the developed learning media, guidebook, and research instruments were of high quality and were suitable for use in this study. The following was a detailed process of the expert appraisal and developmental testing step.

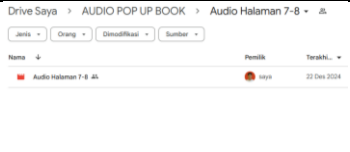
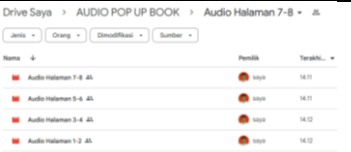




1) Expert Appraisal

The first step in this development stage was expert appraisal, which was conducted to obtain feedback and suggestions of Draft I. The validation process was carried out by three validators, consisting of two lecturers from the Mathematics Education study program at the Faculty of Teacher Training and Education, University of Jember, and one teacher from Jember Special School Type C. The validators provided several suggestions for improving the learning media. Some of these suggestions included replacing the audio component with a real voice-over

recording, converting the audio display into an animated video to make it more engaging, and adding labels to each book to help users distinguish between different types of books. Table 6 presents the complete revision process of the learning media.

Table 6. Revision Process of The Learning Media

No	Improvement	Before Revision	After Revision
1.	Changing the title on the book into capital letters.		
2.	Replacing the phone number with an email address on the back cover.		
3.	Adding descriptive labels for each book to make it easier for users to distinguish between the different types of books.		
4.	Replacing the AI-generated voice with a real human voice-over for the audio in the pop-up book for students with visual impairments.	Using AI-generated voice	Using real human voice over
5.	Changing the folder that originally contained only		

No	Improvement	Before Revision	After Revision
	one audio file into a folder containing all audio files from the first to the last page to facilitate usage.		
6.	Turning the audio display into an animated video to make it more engaging.		
7.	Creating a designated slot/holder for the car on pages 9-10 so that it does not fall easily.		

The validity of the learning media and research instruments could be analyzed through the scores obtained from the validation sheet. The total average score from the three validators (V_a) indicated the validity coefficient of the learning media, as shown in Table 7. The learning media and guidebook are categorized as valid if the V_a score falls within the range of $3 \leq V_a < 4$.

Table 7. Achievement of the Learning Media Validity Coefficient

No	Component	V_a	Category
1.	Pop-Up Book Learning Media for Students with Intellectual Disabilities	3,67	Valid
2.	Pop-Up Book Learning Media for Students with Physical Disabilities	3,69	Valid
3.	Pop-Up Book Learning Media for Students with Visual Impairments (Low Vision)	3,54	Valid

No	Component	V_a	Category
4.	Pop-Up Book Learning Media Guidebook for Students with Intellectual Disabilities	3,59	Valid
5.	Pop-Up Book Learning Media Guidebook for Students with Physical Disabilities	3,59	Valid
6.	Pop-Up Book Learning Media Guidebook for Students with Visual Impairments (Low Vision)	3,62	Valid

Based on Table 7, it can be observed that the learning media and guidebooks obtained different scores within the interval $3 < V_a \leq 4$. Therefore, it can be concluded that the learning media and guidebooks have met the valid category based on the predetermined validity criteria.

Table 8. Achievement of Research Instrument Validity Coefficient

No	Component	V_a	Category
1.	Teacher Response Questionnaire	3,77	Valid
2.	Student Response Questionnaire	3,74	Valid
3.	Learning Outcome Test	3,74	Valid
4.	Interview Guidelines	3,80	Valid

Table 8. showed the V_a scores obtained from the research instruments. Based on the table, it could be seen that the research instruments received V_a scores within the interval $3 < V_a \leq 4$. Therefore, the research instruments were also be concluded as valid, just like the learning media and the guidebook. From the results of validation, it was found that Draft I which includes learning media, guidebooks, and research instruments - was declared valid. After going through the validation process, Draft I is then called Draft II.

2) Developmental Testing

The developmental testing was conducted on Wednesday, 19 February 2025, from 09:00 to 11:30 at Jember Special School Type C. The sample class for this study was Grade XI, consisting of nine students—one with a physical disability, one with a visual impairment (low vision), and seven with intellectual disabilities—and taught by three teachers. The class teacher divided the students into two groups: the high-ability group (two students with intellectual disabilities, one student with a visual impairment, and one student with a physical disability) and the moderate-ability group (five students with intellectual disabilities). Figure 10 illustrated the seating arrangement of the students in the classroom. Initially, the two high-ability students with intellectual disabilities studied together with other students with intellectual disabilities. However, to enhance the effectiveness of the learning process, these two students were moved to study alongside the student with physical disabilities.

Kritik dan Saran:

Menurut saya pop up book ini sudah menarik tapi tiap lembar ada banyak intruksi yang sama besarnya dan tiap intruksi tidak ada penanda yang timbul

Figure 11. Example of Student Response Questionnaire Suggestions

Kritik dan Saran:

Menurut saya, karena saya mengoptimalkan media pop up book ini kepada peserta didik Netra. Ada beberapa masukan yang diperlukan sehingga kedepannya dapat lebih efektif, yaitu:

1. Ukuran font untuk peserta didik Netra kurang besar, jadi dia susah membacanya
2. Tiap instruksi yang ada, harus ada beberapa yang diberi elemen penanda jadi dia mengulang kata yang sudah dibaca
3. Lebih mudah menggunakan braille untuk peserta didik Netra.
4. Suara (QR) perlu akses ke drive, sementara HP yang digunakan belum punya aksesnya dan peserta didik belum tek cara mengakses drive.
5. Suara yang digunakan ukuran fontnya terlalu kecil dan peserta didik sulit menentukan jawaban.

Figure 12. Example of Teacher Response Questionnaire Suggestions

Based on the questionnaire responses and interview results, it was found that students with visual impairments (low vision) had difficulty reading the developed pop-up book. This was due to the lack of raised textures on the book and the small font size. Additionally, the teacher suggested adding Braille text to the learning media. Some challenges were also encountered when accessing the QR code, which contained audio and interactive quizzes.

The final step in the development stage was analyzing whether the developed learning media met the criteria of practicality and effectiveness. The practicality of the learning media was analyzed using the user response questionnaire, which consists of two types: the student response questionnaire and the teacher response questionnaire. Each response obtained from users was then used to calculate the average questionnaire percentage score (P). Based on the calculations, the percentage score obtained from the student response questionnaire is 80.25%, while the teacher response questionnaire was 80.75%. Therefore, it could be concluded that the learning media meets the practicality criteria since the P score fell within the interval $80\% < P \leq 95\%$ as shown in Table 9. and Table 10.

Table 10. Results of The Teacher Response Questionnaire

Number	Indicators	Average Scores
1.	The pop-up book has an attractive appearance.	3,33
2.	The pictures in the pop-up book make students interested in participating in the learning process.	3,33
3.	The pop-up book is appropriate to the characteristics of the students.	2,66
4.	The text in the pop-up book is easy to read.	2,66
5.	The language used in the pop-up book is easy to understand.	3,66
6.	The instructions for using the pop-up book are easy for students to understand.	3,33
7.	The pop-up elements in the pop-up book are easy for students to use.	3,66
8.	The QR code included in the media is easy to access and use.	3,33
9.	The interactive quiz in the pop-up book is easy to use.	3,33
10.	The use of the pop-up book makes learning more enjoyable and less monotonous.	3
11.	Students are interested in the interactive quiz included in the pop-up book.	2,66
12.	The use of the pop-up book motivates students to learn integer material.	3,33
13.	I am interested if the pop-up book is used for other learning topics.	3,33
14.	The pop-up book facilitates the delivery of integer material.	3,66
Average		3,23
Percentage		80,75%

Table 11. Results of The Students Response Questionnaire

Number	Indicators	Average Scores
1.	The pop-up book has an attractive appearance.	3,22
2.	The pictures in the pop-up book make me interested in participating in the learning process.	3,44
3.	The text in the pop-up book is easy to read.	3,44
4.	I can easily understand the language used in the pop-up book.	3,11
5.	The instructions for using the pop-up book are easy to understand.	3,11
6.	The pop-up elements in the pop-up book are easy to use.	3,44
7.	The interactive quiz in the pop-up book is easy to use.	3
8.	The use of the pop-up book makes learning more enjoyable and less monotonous.	2,77
9.	I feel happy when working on the interactive quiz contained in the pop-up book.	2,88
10.	I enjoy learning integer material after using the pop-up book.	3,11
11.	I would be interested if the pop-up book were used for other topics.	3,44
12.	Learning with the pop-up book helps me better understand the integer material.	3,55
Average		3,21
Percentage		80,25%

The effectiveness of the learning media can be analyzed based on the number of students who achieved the Learning Objective Mastery Criteria in completing the Learning Outcome Test. Based on the calculations, the percentage of student mastery reached 100%. Therefore, the learning media has met the effectiveness criteria because the student mastery percentage (E) was $\geq 75\%$. Table 12 presented the Learning Outcome Test results.

Table 12. Learning Outcome Test Results

Highest Score	96,66
Lowest Score	76,66
Average Score	88,14
Number of students who scored ≥ 75 (pass)	9
Number of students who scored < 75 (not pass)	0
Student mastery percentage	100%

Based on the analysis results, it was found that the learning media met the practical and effective categories. Following suggestions from teachers and students, the pop-up book for students with visual impairments (low vision) was revised to include more raised textures. The revised media was ready to proceed to the next stage, namely the dissemination stage. Figure 13 illustrated some examples of students' errors in the Learning Outcome Test.

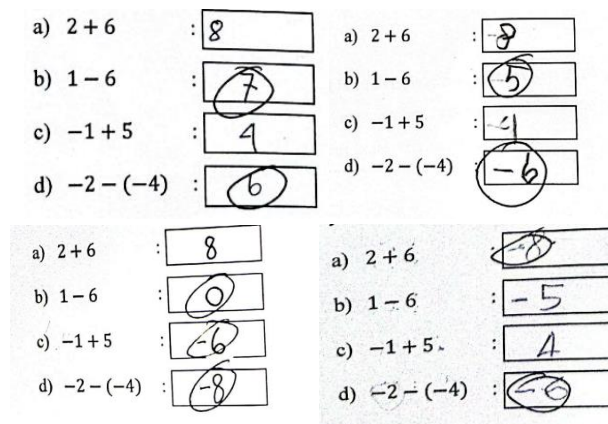


Figure 13. Examples of Student Errors in the Learning Outcome Test

Based on Figure 13, showed that students still faced difficulties in slightly more precise. This is because they are newly introduced to the concept of integers. As learning progresses, teachers can provide drilling exercises to reinforce students' understanding and review previously taught materials.

Disseminate Stage

At this stage, the final product, which has undergone a series of validity, practicality, and effectiveness tests, is distributed to other schools. The dissemination took place on Monday, 24 Februari, 2025, at Jember State Special School located on Dr. Soebandi Street, Krajan, Patrang District, Jember Regency. The steps in the dissemination phase included providing the learning media to the teacher and explaining the developed product or media. Teachers were also recommended to use the learning media during lessons and were informed that any feedback or suggestion could be submitted through the contact information provided on the last page of the guidebook.

Discussion

The developed pop-up book learning media has undergone the development stage, including trial implementations. When the learning media was distributed to students, some of them showed curiosity about the material. Additionally, while using the learning media, students appeared enthusiastic about participating in the learning process. According to Meimulya and Caryoto (in Maulidiyah, 2020) a students with intellectual disabilities experience delays in comprehension and thinking and require learning media in concrete forms (real, physical, visible, and tangible) that can capture their attention, as they tend to get bored easily and lose focus quickly. Furthermore, Fadiana and Rosalina (2020), state that selecting engaging media is crucial because it must be more captivating for students with intellectual disabilities to help extend their concentration span and prevent boredom during activities. In this context, the media used is a pop-up book. The Pop-Up Book learning media also features an interactive number line on pages 9–10, enabling students to engage directly with the material. This feature facilitates students' understanding of integer operations using the number line through direct practice. Agustina (2021) states that students with mild intellectual disabilities tend to retain information more effectively when it is presented in a concrete form, which facilitates their ability to represent their thoughts.

The technology assisted pop-up book learning media for integer topic received diverse responses from students. Figure 13 shows the results of the student response questionnaire for those who did not like the pop-up book learning media. These responses are natural, as each student has their own learning preferences. According to Felder (in Yolanda et al., (2024), everyone tends to have different learning preferences.

The developed pop-up book learning media was tested among 11th-grade students consisting of three types of students with special needs: intellectual disabilities, physical disabilities, and visually impaired students (low vision). During the trial, the classroom teacher grouped students based on their abilities (moderate and high). According to Kachak (in Nurfitriani and Hidayat, 2020), classroom management strategies that teachers can implement include forming groups based on students' learning abilities and preparing backup strategies for students with lower learning abilities so they can improve their skills to a comparable level with other students. Additionally, during the lesson, a student with an intellectual disability was placed in the same group as a physically disabled student. The teacher did this to make classroom learning more effective, as the two students with intellectual disabilities demonstrated stronger abilities than other students with similar conditions. According to Rochyadi (as cited in Widiastutiana and Winaya,

2019), even though students learn together, teachers need to ensure that groupings allow students to interact, collaborate, and work as team members. Furthermore, students' positions in these groups should align with their interests and similar learning abilities.

The developed pop-up book learning media met the practicality criteria based on the analysis of both teacher and student response questionnaires. The learning media has also undergone expert validation and revision. However, after the trial implementation, several suggestions were provided by both students and teachers. To address these suggestions, the researcher revised the final version of smedia after the trial phase. The revisions included making the text in the pop-up book tactile for visually impaired students. Figure 14 showed the revised final media. According to Winarto et al., (2024), for visually impaired students, learning methods that rely on visual perception are less effective; therefore, alternative tactile-based alternative are necessary to help them better understand mathematical concepts. The text size in the learning media was not enlarged because increasing the font size would cause the pop-up elements to cover the text. Additionally, enlarging the book's size was considered impractical, as it would no longer resemble a standard book. According to Sadewo et al. (2017), the developed pop-up book used A3 paper, which is an international standard size. The 21×21 cm format facilitates the arrangement of visual and textual information while making it easier for children to open and use the book.

This learning media does not include Braille due to the researcher's limitation and because the initial purpose of developing the media was for retain partial sight. According to Khaeroh et al. (2020), visually impaired individuals are generally categorized into two groups: totally blind and low vision. Low vision refers to individuals who need to bring objects closer or farther to see them or who experience blurred vision when viewing objects. Additionally, the learning media incorporates a QR code containing audio materials to enhance students' understanding. According to Soemantri et al. (2022), visually impaired individuals require concrete and practical learning media to facilitate comprehension. Specialized media, such as audio recordings, enable them to access information more easily. Furthermore, Praptaningrum (2020), states that visually impaired students understand learning materials more effectively through recorded audio, as spoken words are clearer, easier to comprehend, and more memorable.

The pop-up book learning media met the effectiveness criteria, with a student mastery percentage reaching 100%. The highest score achieved was 96.66, the lowest was 76.66, and the average score was 88.14, as shown in Table 10. This indicates that the developed pop-up book effectively aids students in understanding integer concepts. Overall, most learning objectives were achieved based on the

results of the Learning Outcome Test. However, students still faced difficulties in operating integers. According to Soendari (as cited in Agustina, 2021) the limited intellectual abilities of students with mild intellectual disabilities result in challenges in academic learning, including mathematics. According to Utami et al., (as cited in Agustina, 2021) due to the limited intellectual abilities of students with mild intellectual disabilities, teachers should provide repeated explanations to ensure that students fully comprehend the material being taught. Regular reinforcement and practice will help students gradually improve their mathematical skills and reduce errors in integer operations.

Conclusion

The development process of the learning media followed four stages: a) Define Stage, where an analysis was conducted to identify the main problem. b) Design Stage, which resulted in Draft I, including the learning media and research instruments. c) Development Stage, where Draft I was validated by subject matter experts, special needs education experts, and learning media experts, leading to the creation of Draft II. A trial was then conducted in 11th grade, followed by an analysis of the media's effectiveness and practicality. d) Disseminate Stage where the learning media was distributed to Jember State Special School. The results show that the developed learning media met the criteria for validity, practicality, and effectiveness. The validity coefficient scores for students with intellectual disabilities, physical disabilities, and visual impairments (low vision) were 3.67, 3.69, and 3.54, respectively. The average response percentages from teacher and student questionnaires were respectively 80.75% and 80.25%, categorized as good. Additionally, the student mastery percentage reached 100%, indicating the effectiveness of the learning media.

The results of this study provide several benefits. For students, the developed learning media can help them better understand the learning material, especially in mathematics on the topic of integers. For teachers, this media can be used to improve the quality of the learning process and support more effective mathematics instruction. Additionally, for other researchers, the findings of this study can may serve as a reference or foundation for conducting similar studies in the future. The limitation of this study lies in the type of children with special needs involved as research subjects, which includes only three categories, namely students with intellectual disabilities, physical disabilities, and visual impairments (low vision). Several recommendations are provided: (a) Are encouraged that teachers can utilize this pop-up book learning media in mathematics instruction, especially when teaching the topic of integers. (b) It is hoped that other researchers can use the results of this study as a reference for developing learning media, particularly

Pop-Up Books, for other mathematics topics or for other types of children with special needs such as those with speech impairments or hearing impairments. (c) Other researchers investigating similar topics are encouraged to conduct a more in-depth analysis during the student analysis and initial design stages, so that the developed pop-up book media can be improved in quality. (d) Researchers with relevant expertise are encouraged to develop pop-up Book media for students with visual impairments, ensuring the inclusion of Braille where appropriate.

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