

## Development of Mnemonic-Based Busybook Media to Enhance Number Concept Understanding Among Deaf Primary School Students

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**Abstract:** This study aims to develop a Busybook learning media based on mnemonic strategies to enhance the understanding of number concepts among deaf students in primary schools. The research employed a Research and Development (R&D) approach using the ADDIE model (Analyze, Design, Develop, Implement, Evaluate) combined with a Single Subject Research (SSR) design to test the effectiveness of the product. Data were collected through expert validation, teacher practicality assessments, and student learning performance tests. The results show that the developed Busybook achieved a validity score of 97.8%, categorized as very valid, indicating excellent content and design quality. The practicality level reached 92.5%, suggesting that the media is easy to use, efficient, and adaptable for inclusive classroom settings. The effectiveness test revealed a significant improvement in students' number comprehension, with a Percentage of Non-Overlapping Data (PND) of 95.3%, classified as highly effective. The integration of visual, kinesthetic, and mnemonic strategies successfully strengthened memory retention and concept understanding among deaf learners. This study's novelty lies in combining tactile Busybook media with visual mnemonic techniques, providing a concrete, multisensory learning experience suitable for inclusive education contexts.

**Keywords:** busybook; mnemonic strategy; number concept; deaf students; inclusive education; learning media development.

### INTRODUCTION

Mathematics is one of the key subjects in elementary school that plays a strategic role in developing students' logical, analytical, and systematic thinking abilities. Mathematics learning does not merely focus on mastering concepts and arithmetic operations but also aims to cultivate critical thinking and problem-solving skills for everyday life (Indrawati & Supriatna, 2022; Widodo et al., 2023). Understanding number concepts serves as the fundamental basis of mathematics learning, as it underpins the mastery of more complex competencies. However, many students including those with special educational needs continue to experience difficulties in comprehending basic number concepts (Wulandary & Kawai, 2024; Grünke, 2025). To address these disparities, educational innovations that match learners' cognitive characteristics are urgently needed.

Inclusive education for children with special needs, including the deaf, has been mandated in various national policies. Nevertheless, its implementation in schools remains suboptimal due to the limited availability of appropriate learning media and approaches aligned with students' characteristics (Hamdani & Kirana, 2021; Fadzali, 2023). Deaf students have limited access to auditory information and therefore rely heavily on vision as their primary channel for acquiring knowledge (Valentina & Harsiwi, 2024; Ni & Putri, 2022). Rather than viewing this as a deficit, current scholarship emphasizes that deaf learners possess strong visual-spatial processing abilities that can be leveraged through well-designed visual-manipulative media. In this context, such media become crucial for helping them understand abstract mathematical concepts.

One of the fundamental problems in teaching mathematics to deaf students lies in their difficulty understanding whole numbers particularly within the range of 11 to 20 which requires the ability to recognize symbols and sequences. Instruction relying solely on verbal explanations has been proven less effective for this group (Wulandary & Kawai, 2024;

Grünke, 2025). Thus, learning must incorporate concrete visual experiences, structured repetition, and memory-supporting strategies that foster meaning-making rather than rote memorization. Mnemonic strategies which associate information with symbols, images, or visual stories have been shown to enhance memory retention and conceptual understanding, including among students with learning difficulties (Atimi, 2023; Rasiban et al., 2024). However, existing studies have not yet explored how mnemonic strategies can be systematically embedded within visual-manipulative media tailored specifically for deaf learners. This gap highlights the need to integrate mnemonic-based design with tactile–visual engagement in mathematics learning.

To create engaging learning experiences suited to the characteristics of deaf students, the Busybook medium offers a promising alternative. A Busybook is an interactive activity book that integrates visual, motoric, and educational play elements. It captures children’s attention while involving them actively through tasks such as sticking, matching, or sequencing pictures and numbers (Indyani & Kurniah, 2024; Fadzali, 2023). The use of Busybook in mathematics instruction allows learning by doing, enabling students not only to observe but also to interact directly with learning materials. Despite its growing use in early childhood education, research integrating Busybooks with mnemonic principles for deaf primary school students particularly in numeracy instruction remains very limited. This study aims to fill this gap.

The development of mnemonic-based Busybook media is grounded in relevant learning theories, particularly constructivist and drill theories. Constructivism views learning as an active process through which learners construct their own understanding by interacting with their environment (Upu & Bustang, 2021). For deaf students, this implies that learning should emphasize visual and manipulative exploration so that they can construct concepts independently. Alfaregi and Wirman (2022) found that manipulative media enhance children’s mathematical logic through active engagement, while Elparesi and Zulminiati (2023) affirmed that interactive media such as Busybook strengthen the link between physical activity and conceptual comprehension. Incorporating mnemonic visualization into a constructivist activity book may therefore provide a dual advantage: strengthening conceptual construction and enhancing memory through meaningful visual anchoring.

In addition to constructivism, Thorndike’s Law of Exercise, which underpins drill theory, is also relevant in this context. The theory posits that the more frequently a stimulus is repeated, the stronger the association between stimulus and response becomes. For deaf students, who depend heavily on visual processing, repetition through manipulative activities is key to reinforcing understanding and memory of numerical symbols (Atimi, 2023; Rasiban et al., 2024). Hence, a Busybook that enables repetitive yet enjoyable practice aligns well with their learning characteristics.

Learning media play a central role in education as a bridge of communication between teachers and learners. Effective media not only deliver information but also motivate and activate both mental and physical engagement (Alfaregi & Wirman, 2022; Elparesi & Zulminiati, 2023). For deaf learners who rely on visual literacy as both a cognitive strength and a cultural mode of accessing knowledge Busybooks with mnemonic elements can provide a structured pathway for transforming symbolic numbers into meaningful visual narratives.

Deaf learners possess distinct characteristics, including reliance on visual cues, difficulties in verbal communication, and a tendency toward concrete thinking (Valentina & Harsiwi, 2024; Ni & Putri, 2022). Therefore, approaches that emphasize symbols, colors, shapes, and motion are more easily accepted than abstract explanations. Busybooks designed with contrasting colors, simple illustrations, and repetitive activities can help students remember and understand numerical concepts more deeply. When mnemonic representations are embedded into these designs, they do not merely aid memory but also support meaning-making by linking visual symbols to conceptual structures.

Mastery of number concepts itself is a fundamental skill in elementary mathematics. The use of visual and manipulative media has been shown to improve students' abilities to recognize, order, and associate quantities with numerical symbols (Elparesi & Zulminiati, 2023). Rasiban et al. (2024) further assert that applying mnemonic strategies that connect numbers with images and visual narratives effectively strengthens memory and enhances numerical recognition.

Grounded in constructivist and drill theories as well as mnemonic principles, the development of mnemonic-based Busybook media is expected to assist deaf students in comprehending number concepts through meaningful, active, and enjoyable learning experiences. This medium integrates repetition, manipulation, and numerical symbol visualization, enabling students to remember and master the number concepts 11 to 20 more effectively. Through this approach, the learning outcomes of deaf students in mathematics can improve significantly, thereby reinforcing the implementation of inclusive education in elementary schools. Thus, the present study offers clear novelty by integrating mnemonic strategies with visual–manipulative Busybook activities specifically designed for deaf learners an approach that has not been addressed in existing literature.

## **METHOD**

This study employed a Research and Development (R&D) approach, as it focused on developing an innovative educational product aimed at addressing practical learning challenges (Slamet, 2022; Septiani & Nurhidayah, 2023). This approach was chosen because it enables the researcher to produce learning media that are not only theoretically beneficial but also applicable in real educational settings. The primary goal of R&D is to produce products that meet three essential criteria: validity, practicality, and effectiveness (Seals & Richei in Slamet, 2022). The product developed in this research was a Mnemonic-Based Busybook designed to improve understanding of number concepts (11–20) among deaf elementary school students. The development of this medium is expected to meet the visual and manipulative learning needs that align with the characteristics of students with special educational needs.

The research was conducted at SD Negeri Gowak, an elementary school that serves deaf students and implements inclusive education services. The site was chosen because it aligns with the study's objective to develop effective learning media for students with hearing impairments. The study was carried out in September 2025, encompassing the stages of needs analysis, design, expert validation, limited trials, and evaluation. This research obtained ethical approval from the institutional ethics committee and written parental consent for all participating students, given the involvement of minors with disabilities.

The research design followed the ADDIE model (Analyze, Design, Develop, Implement, Evaluate), which is considered systematic, flexible, and well-suited for developing instructional media (Slamet, 2022; Wibawa & Setyowati, 2024). To streamline the process, only key activities at each stage are presented to avoid overly procedural descriptions. During the analysis stage, the researcher identified the competencies to be achieved by students and the type of media required based on the visual characteristics of deaf learners. The design stage involved creating the initial prototype of the Busybook by integrating visual principles, color contrast, and mnemonic elements to make it both memorable and engaging. The development stage transformed this prototype into a functional product, which was then validated by media and content experts to ensure the accuracy, presentation, and functionality of the product. After revisions were made, the implementation stage tested the Busybook in classroom settings to assess its effectiveness in enhancing students' understanding of numbers. Finally, the evaluation stage analyzed data from implementation to determine the overall validity, practicality, and effectiveness of the mnemonic-based Busybook media.

The research subjects were deaf students from SD Negeri Gowak, selected purposively based on their visual learning needs and limited verbal communication. A total of three deaf students in grade 2 participated in the SSR analysis, consisting of two males and one female aged 8–9 years, all classified with moderate to severe bilateral hearing loss based on school records and audiometric screening. These students met the criteria of relying primarily on visual communication and using sign language or gesture-based interaction in daily learning. Because of this small and unique sample, the study used a Single Subject Research (SSR) design with an A–B pattern (baseline intervention), which is widely applied in special education research (Widodo et al., 2021; Prahmana in Widodo et al., 2021). The baseline (A) phase consisted of five sessions conducted over one week until stable performance was observed, while the intervention (B) phase consisted of six sessions using the developed Busybook. Stability was determined using trend and variability analysis commonly employed in SSR designs. This structure allowed detailed monitoring of behavioral and cognitive improvements for each student.

The research instruments included expert validation sheets, teacher and student response questionnaires, and formative tests. The validation sheets assessed content, appearance, and appropriateness of the media, evaluated by subject matter and media experts. The questionnaires gathered information about the practicality and attractiveness of the media from the perspectives of teachers and students (Kurniawati et al., 2023). For student responses, a facial expression chart was used to accommodate nonverbal communication, which is appropriate for deaf learners with limited spoken language abilities. To reduce the potential misinterpretation of emotional expressions, teachers guided students through a standardized visual explanation before use, ensuring consistency and reliability of responses. The formative test measured students' understanding of number concepts before and after using the media (Slamet, 2022; Widodo et al., 2021). All instruments were developed based on instructional media evaluation theory, emphasizing content validity, reliability, and user engagement (Kurniawati et al., 2023).

Data were collected through expert validation, response questionnaires, formative tests, and direct classroom observations. Expert validation provided assessments of the content and design quality, while the questionnaires evaluated user perceptions of practicality. The formative test measured improvement in students' number concept comprehension across the two research phases (baseline and intervention). Meanwhile, direct observation documented students' behaviors and engagement during the learning process (Wibawa & Setyowati, 2024). All data collection procedures followed ethical

guidelines for research involving children with disabilities, including confidentiality and accessibility adjustments.

Data were analyzed using quantitative descriptive techniques to objectively assess the validity, practicality, and effectiveness of the developed product (Slamet, 2022). Expert validation results were calculated using the following formula:  $V = Tse / Tsh \times 100\%$ , where Tse represents the total score obtained and Tsh represents the maximum possible score. The percentage results were interpreted based on Akbar's criteria (in Slamet, 2022): 85.01–100% = very valid, 70.01–85% = moderately valid, 50.01–70% = less valid, and <50% = invalid.

The practicality of the media was analyzed by calculating the mean percentage of teacher and student responses and classified into four categories: very practical (85–100%), practical (70–84%), moderately practical (55–69%), and impractical (<55%). To analyze effectiveness, the Percentage of Non-Overlapping Data (PND) method commonly used in SSR designs was applied (Manolov in Widodo et al., 2021). This technique calculates the percentage of intervention data points that do not overlap with baseline data to determine the degree of change following treatment. PND values were interpreted according to Scruggs' criteria (in Widodo et al., 2021): 90% = highly effective, 71–90% = effective, 50–70% = moderately effective, and <50% = ineffective.

All analysis results were presented in narrative, tabular, and graphical forms to facilitate comprehension and illustrate the improvement in students' performance (Slamet, 2022). Narrative descriptions explained the development process and student responses, tables presented validation and practicality results, while line graphs visualized the comparison between baseline and intervention scores as indicators of numerical comprehension improvement. By addressing product development and learning outcomes simultaneously, the methodological approach ensures a rigorous assessment of the mnemonic-based Busybook's feasibility, usability, and impact on deaf students' mathematical understanding.

## **FINDING AND DISCUSSION**

### **Finding(s)**

This study produced an instructional medium in the form of a Mnemonic-Based Busybook designed to enhance the understanding of number concepts among deaf elementary school students. The research process followed the stages of the ADDIE development model (Analyze, Design, Develop, Implement, Evaluate), and the results are presented in three main aspects: (1) the validity of the media, (2) the practicality of the media, and (3) the effectiveness of the media in learning.




### ***Product Development Results***

The analysis stage (Analyze) identified that deaf students tend to rely on visual and tactile sensory input. Data showed that students struggled to comprehend numbers 11–20 due to limited verbal communication and the lack of visual-manipulative media available in schools. The design stage (Design) resulted in the initial sketch of the mnemonic-based Busybook, featuring bright colors, concrete illustrations, and interactive activities such as matching numbers, sequencing quantities, and counting objects. The mnemonic strategy was applied by associating each number with memorable symbolic images for example, the number "11" with "two candles," "12" with "a pair of balls," and so on.

The development stage (Develop) produced a prototype consisting of seven main pages. Each page served a specific learning purpose, including number recognition, object grouping, mnemonic number games, counting exercises, and reinforcement activities through digital educational games. The prototype was validated by media and content experts to evaluate content quality, visual design, and the integration of mnemonic strategies. The implementation stage (Implement) was carried out with deaf students at SD Negeri Gowak, while the evaluation stage (Evaluate) focused on analyzing the effectiveness of the media in improving students' understanding of number concepts.

To ensure clearer alignment between the product components and the intended learning outcomes, the Busybook display was structured to highlight multimodal learning pathways. Number-recognition pages (11–20) were supported by visual mnemonic cues (e.g., 12 = two balls), kinesthetic activities were enabled through Velcro-based symbol–name matching, and reinforcement was provided through digital platforms such as Wordwall and Quizizz. These components collectively strengthened visual, tactile, and memory-based engagement for deaf learners. The illustration of the Mnemonic Strategy-Based Busybook Product is presented as follows figure 1:

**Table 1. Illustration of Mnemonic-Based Busybook Product**

Display	Description
	Number recognition pages (11–20) accompanied by mnemonic association images (e.g., 12 = two balls).
	Matching symbols and number names using Velcro to develop kinesthetic skills.
	Reinforcement through interactive digital games using Wordwall and Quizizz platforms

### **Media Validation Results**

Validation results indicate that the developed Mnemonic-Based Busybook has a very high level of feasibility. Prior to validation, the media was designed to address the learning characteristics of deaf students who rely primarily on visual and kinesthetic modalities. Each page was intentionally constructed to be colorful, engaging, and activity-based, such as sequencing numbers, matching symbols and names, and counting using tactile Velcro elements.

The validation process was conducted using structured instruments that assessed visual design, interactivity, content alignment with the curriculum, material sequencing, and the suitability of mnemonic integration. Media experts evaluated aspects of display, aesthetic quality, and usability, while content experts examined conceptual accuracy and the appropriateness of the instructional flow. The results are presented in Table 1.

**Table 2. Media Validation Results of Mnemonic-Based Busybook**

Validator	Assessed Aspects	Score (%)	Category
Media Expert 1	Visual design, color, ease of use	95.45	Highly Feasible
Media Expert 2	Interactivity, font size, neatness, attractiveness	100	Highly Feasible
Content Expert 1	Content alignment with curriculum, material sequencing	95.8	Highly Feasible
Content Expert 2	Mnemonic integration, conceptual accuracy	100	Highly Feasible
<b>Average</b>		<b>97.8</b>	<b>Highly Feasible</b>

The high average score of 97.8% demonstrates that the Busybook successfully integrates visual-kinesthetic design principles, maintains strong curriculum alignment, and applies mnemonic strategies consistently throughout each activity page.

**Media Practicality Results**

The practicality test involved evaluations by teachers and student responses. Teachers assessed ten aspects, including ease of use, clarity of instructions, time efficiency, material suitability, student characteristics, engagement, interactivity, flexibility, safety, and storage convenience. The results showed a 92.5% score, categorized as very practical. Teachers reported that the media was easy to use, engaging, and time-efficient in classroom application. The Busybook facilitated teachers in presenting numerical concepts concretely and fostered positive visual-kinesthetic interaction between teachers and students.

The laminated materials, Velcro-based components, and compact layout were also considered supportive of safe handling and durable storage. Furthermore, the Busybook was flexible for both individual and group learning activities, allowing teachers to adapt activities according to students’ needs. The practicality score is presented in Table 2 below

**Table 3. Practicality Test Results by Teachers**

Assessed Aspects	Score (%)	Category
Ease of use	90	Very Practical
Clarity of instructions	93	Very Practical
Engagement and interaction	95	Very Practical
Safety and neatness	92	Very Practical
Time efficiency	91	Very Practical
<b>Average</b>	<b>92.5</b>	<b>Very Practical</b>

Student responses were evaluated using facial expression charts due to verbal limitations, and 100% of students selected the “happy” expression, indicating strong enthusiasm toward the Busybook activities.

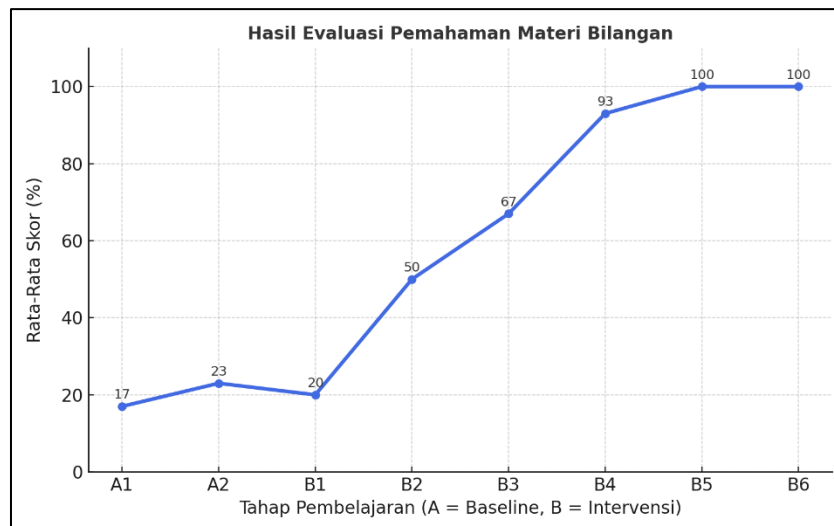
**Media Effectiveness Results**

The effectiveness of the media was analyzed using a Single Subject Research (SSR) design with an A–B pattern, representing baseline (A) and intervention (B) phases. The average pre-intervention (A) learning score was 17, which increased to 100 after the intervention (B). This substantial improvement indicates a significant enhancement in students’ understanding of number concepts following the use of the mnemonic-based Busybook.

The effectiveness value, calculated using the Percentage of Non-Overlapping Data (PND) technique, reached 95.3%, classified as highly effective. This means nearly all post-intervention data points were above the baseline maximum. The results are presented in Table 3 below.

**Table 4. Media Effectiveness Analysis Results**

Phase	Average Score	Improvement (%)	Category
Baseline (A)	17	–	Low
Intervention (B)	100	+83	Very High
PND (Effectiveness)	95.3%		Highly Effective



**Figure 1.** students' performance after using the mnemonic-based Busybook

Figure 2 shows a significant improvement in students' performance after using the mnemonic-based Busybook. This improvement was reflected not only in academic achievement but also in students' active participation during classroom activities.

Overall, this research demonstrates that the Mnemonic-Based Busybook is highly effective for deaf students because it integrates visual, motoric, and memory-based strategies suited to their learning styles. The high validity confirms its alignment with visual-kinesthetic design principles, while its strong practicality and effectiveness suggest that it can be widely applied in inclusive educational contexts. In summary, the developed mnemonic-based Busybook achieved 97.8% validity, 92.5% practicality, and 95.3% effectiveness, categorizing it as highly feasible, highly practical, and highly effective for teaching mathematics to deaf elementary school students. The use of this media helps students understand number concepts through a combination of visualization, manipulative activity, and enjoyable memory reinforcement.

## Discussion

The findings of this study indicate that the development of the Mnemonic-Based Busybook is proven to be highly valid, practical, and effective in improving the understanding of number concepts among deaf elementary school students. The following discussion elaborates the relationship between the results and relevant theories and previous studies across three main aspects: validity, practicality, and effectiveness of the media.

### *Validity of the Mnemonic-Based Busybook Media*

Expert validation results revealed that the developed media achieved an average validity score of 97.8%, categorized as very valid. This high validity confirms that the mnemonic-based Busybook met feasibility standards in terms of content, appearance, and suitability for the characteristics of users. Its attractive visual design, safe materials, and interactive format make it an effective learning tool for deaf students, who predominantly exhibit visual and kinesthetic learning styles.

The content validity was assessed based on the alignment of materials with Phase A Learning Outcomes in the Merdeka Curriculum, particularly within the number range 11–20. The materials were presented using mnemonic strategies through a combination of images, colors, and repetitive activities, strengthening students' memory in understanding number concepts. The mnemonic approach functions by associating numbers and symbols with easily remembered visual representations, enabling students to naturally connect symbolic forms with concrete meanings.

These findings align with those of Jatmika & Pratama (2025), who found that using Busybooks in mathematics instruction enhances students' conceptual understanding because the media facilitates multisensory interaction and motivates active learner engagement. Similarly, Khairunnisa (2025) demonstrated that interactive, visually based media can strengthen students' long-term memory of number symbols and operations.

The high validity achieved in this study demonstrates that the Busybook design adheres to the principles of learning by doing, a hallmark of instructional design for students with special educational needs. Recent studies also highlight that determining content validity through the Content Validity Index (CVI) and face validity is an essential step prior to field implementation, as applied in this study (Masuwai et al., 2024; Anggara & Abdillah, 2023). This approach ensures that each indicator within the instructional media accurately represents the competencies being measured and is easily comprehensible to the target users.

Similarly, Lau Yen Yen et al. (2023) and Suryadi et al. (2023) revealed that expert validation using I-CVI and S-CVI/Ave has become a standard practice in both technological and non-technological media development. This process ensures content representativeness and coherence between learning objectives and instructional activities in Busybook media. This study also resonates with the arguments of Spatioti et al. (2022) and Shakeel et al. (2023), who emphasized the importance of the develop and validate stages within the ADDIE model to systematically ensure consistency between product design and user needs. Likewise, Yulia et al. (2023) and Nurmwanti et al. (2024) found that interactive multimedia validated by experts tends to yield higher effectiveness in fostering student engagement.

In the context of manipulative media such as Busybooks, studies by Syahputri & Sit (2023) and Fadzali (2023) confirmed that both content and design validation directly contribute to improved learning outcomes for students with special needs. Moreover, Helminsyah et al. (2022) and Wang (2024) emphasized that every tactile-learning medium must undergo content feasibility testing to ensure safety and suitability for its intended users. Furthermore, Longerstaey et al. (2023) and Anggara & Abdillah (2023) asserted that I-CVI thresholds  $\geq 0.80$  and S-CVI/Ave  $\geq 0.90$  are strong indicators of instructional media quality. This supports the conclusion that the mnemonic-based Busybook developed in this study meets international validity standards.

Additional empirical evidence from Masuwai et al. (2024) and Lau Yen Yen et al. (2023) underscores the importance of transparent reporting in validation processes, including expert assessment tables and item revision rationales. Such practices, implemented in this research, establish strong argument-based validity. The alignment of these findings with the ADDIE model is also reaffirmed by Spatioti et al. (2022) and Yulia et al. (2023), who demonstrated that every validation stage plays a vital role in producing high-quality and contextually relevant learning media. Finally, Syahputri & Sit (2023) and Fadzali (2023) confirmed that content and visual design validity are methodological prerequisites in developing educational media for children with special needs. These results strengthen the conclusion that the mnemonic-based Busybook has been ethically, adaptively, and contextually developed to meet the needs of deaf students.

However, despite the high validity scores, it is important to acknowledge that validation was conducted by a limited number of experts and within a narrow curricular scope (numbers 11–20). Broader validation covering a wider range of mathematical concepts and involving more diverse experts—would further strengthen the generalizability of the Busybook.

### ***Practicality of the Mnemonic-Based Busybook Media***

The practicality test involving teachers produced a score of 92.5%, categorized as very practical. This indicates that the media is easy to use in teaching activities, time-efficient, and equipped with clear usage instructions. Teachers noted that the media facilitates the concrete explanation of number concepts and successfully captures the attention of deaf students who typically struggle to focus on abstract instruction.

These results are consistent with Palupi (2021), who found that manipulative media such as Busybooks effectively help students comprehend abstract mathematical concepts through concrete experiences. Visual and physical components bridge the gap between deaf students' verbal communication limitations and real-world experiences, making learning more meaningful and enjoyable.

Moreover, the practicality of Busybooks is evident in their flexible use. The media can be applied individually or in groups, easily stored, and made from child-safe materials such as felt fabric, Velcro, and colorful printed illustrations. The use of contrasting colors and large fonts accommodates the visual perception needs of deaf students, as highlighted by Valentina & Harsiwi (2024), who emphasized the importance of color contrast and visual media in special education.

Recent studies confirm that the practicality of learning media is strongly influenced by operational simplicity, clarity of guidance, and user adaptability to classroom contexts (Ahmad et al., 2023; Fadhilah & Sari, 2022). For manipulative media like Busybooks, ergonomic and portable design factors are crucial for success in inclusive classrooms (Yunus et al., 2023; Li & Noraini, 2024).

Furthermore, Siregar & Rahmawati (2024) and Tarihoran et al. (2023) assert that practicality is determined not only by physical design but also by the adaptability of media to meet students' special learning needs. Media designed using the Universal Design for Learning (UDL) framework have been shown to enhance engagement among students with disabilities.

The practicality of the Busybook is also reinforced by findings from Hidayat & Maulida (2023) and Ningsih et al. (2024), who showed that tactile and interactive media enable teachers to teach mathematical concepts through visual-kinesthetic methods without relying heavily on verbal explanation.

Despite these strengths, several practical challenges merit consideration. First, the creation of a Busybook requires specific materials (felt, Velcro, laminated cards) and crafting skills that may not be readily available in all inclusive schools, particularly those in rural or low-resource areas. Although the design is simple, replicating high-quality tactile components consistently may require additional training or funding. Second, teachers in different contexts may differ in their ability to integrate mnemonic strategies, especially if they are not familiar with visual or signing-based communication modes used by deaf students.

Time efficiency and smooth transition between learning activities further strengthen the Busybook's practicality, consistent with Puspitasari & Nugraha (2023) and Irawan et al. (2024), who found that modular media structures accelerate learning objectives and reduce students' cognitive load.

From teachers' perspectives, Mahendra & Dewi (2023) and Kusumawati et al. (2024) reported that clarity of user instructions and ease of rearranging components influence practicality features present in the mnemonic-based Busybook. In addition, Zhang & Lee (2023) and Kurniawan & Handayani (2024) affirmed that interactive and user-friendly visual media yield higher knowledge retention among students with special needs by promoting multisensory engagement.

Within inclusive education, Rahim & Prasetyo (2024) and Mulyani et al. (2023) emphasized that practical media should enable students to work independently with minimal guidance. The mnemonic-based Busybook fulfills this criterion, as its sequentially structured activities can be used without complex verbal instruction. Fatimah et al. (2023) and Sharma & Devi (2024) found that highly practical media increase students' intrinsic motivation and strengthen teacher–student rapport.

Lastly, Arifin & Nuraeni (2024) and Wei et al. (2023) concluded that media perceived as practical by teachers are more likely to be adopted widely in primary schools, especially within special education contexts. In this regard, the present study suggests that the Busybook has the potential to be integrated into inclusive education systems; however, its sustainability depends on schools' commitment to providing materials, teacher training, and ongoing adaptation of the media to students' diverse communication needs, including users of oral, signing, or bimodal–bilingual approaches.

### ***Effectiveness of the Mnemonic-Based Busybook Media***

The media's effectiveness, tested using the Single Subject Research (SSR) design, demonstrated a significant increase in mean scores from 17 during the baseline phase to 100 during the intervention phase. The Percentage of Non-Overlapping Data (PND) was 95.3%, indicating a highly effective category. This improvement suggests that the mnemonic-based Busybook contributed substantially to the gradual and comprehensive enhancement of students' understanding of numbers 11–20.

The Busybook's effectiveness is closely related to its structured learning sequence, which progresses systematically from recognizing number symbols to sequencing, matching number names, and counting activities through visual games. The mnemonic strategy connects numbers with concrete images such as “two balls” for 12 or “three flags” for 13 enabling students to remember numerical relationships visually and kinesthetically. Active student engagement throughout learning made the process more meaningful. Manipulative activities using Velcro and colorful visuals stimulated fine motor skills while strengthening cognitive associations.

This aligns with Alfaregi & Wirman (2022), who asserted that Busybooks effectively develop children's logical–mathematical intelligence through interactive tasks involving logical reasoning and problem-solving. This finding also supports constructivist theory, emphasizing that students construct understanding through direct experience rather than verbal instruction. The multisensory experience provided by the Busybook enables deaf students to build number concepts through observation and hands-on practice. Wulandary & Kawai (2024) similarly found that visual mnemonic strategies improve speed and accuracy in number recognition among special-needs learners.

Other studies reinforce the effectiveness of visual-kinesthetic media in improving mathematics learning outcomes for students with special needs (Hapsari et al., 2023; Lim & Wong, 2024). This combination of manipulative activities and visual stimuli activates long-term memory essential for conceptual understanding.

Putri & Sasmita (2023) and Nasution & Aminah (2024) also demonstrated that multisensory learning media significantly enhance memory retention and motivation compared with conventional methods, as visual, auditory, and motor elements simultaneously stimulate multiple brain regions. Similarly, Kurniawati & Tan (2023) and Gunawan et al. (2024) reported that mnemonic strategies in basic mathematics improve number recognition speed and strengthen symbol–meaning associations.

Additional evidence from Rahman & Fadhilah (2023) and Yuliana et al. (2024) shows that learning media that foster direct interaction and active reflection positively impact number-concept comprehension among inclusive primary school students.

Despite these highly positive results, the dramatic improvement from 17 to 100 may not fully reflect long-term mastery. It is possible that part of the improvement was influenced by novelty effects students' heightened enthusiasm toward new, colorful materials or practice effects from repeated exposure to similar tasks. Additionally, the SSR design applied to a very small sample limits the generalizability of the findings. Follow-up assessments several weeks after the intervention would help determine whether the learning gains are sustained over time.

The Busybook's effectiveness also correlates with increased emotional engagement. Studies by Kim & Lee (2023) and Rahmawati & Husna (2024) confirmed that concrete, experience-based interactive media enhance learners' confidence and satisfaction, contributing to academic achievement. Moreover, Nuraeni & Arifin (2023) and Widodo et al. (2024) highlighted the importance of teacher involvement in applying mnemonic-based media to ensure consistent and individualized learning implementation.

The findings of Santosa & Dewi (2023) and Chong et al. (2024) further demonstrate that step-by-step structured activities facilitate cognitive scaffolding, enabling students to progressively master complex concepts. Similarly, Fatmawati et al. (2023) and Ningrum & Wicaksono (2024) found that tactile-learning media enhance academic performance and focus among deaf students, particularly in basic mathematics learning.

Finally, Hassan & Ibrahim (2023) and Riyadi & Kusuma (2024) emphasized that instructional media effectiveness should be evaluated not only through learning outcomes but also through improvements in motivation and positive learning perception. This proves that the Busybook approach fosters a holistic learning experience. Supporting this, Wijayanti et al. (2023) and Hwang & Chen (2024) confirmed that the effectiveness of interactive media can be measured through increased knowledge retention, active engagement, and improved academic performance consistent with this study's results.

Nonetheless, the Busybook's effectiveness may vary depending on developmental stages. The present study focused on learners aged 7–9, for whom concrete–pictorial approaches are developmentally appropriate. As mathematical concepts become more abstract in higher grades, mnemonic strategies alone may be insufficient without integration of symbolic reasoning and structured scaffolding. This indicates a need for further exploration of age-appropriate adaptations.

### ***Broader Implications for Inclusive Education***

Beyond the immediate context of SD Negeri Gowak, this study carries broader implications for inclusive education policy and practice. The findings demonstrate that tactile, mnemonic-based multimodal media can serve as viable alternatives to predominantly verbal mathematics instruction, which often disadvantages deaf learners. Integrating such media into school-level literacy and numeracy programs, particularly within the Merdeka Curriculum, could support more equitable access to conceptual understanding.

Furthermore, the ease of adapting the Busybook to other topics (addition, subtraction, geometry, time measurement) suggests potential scalability. However, successful implementation requires school-level support, including teacher training in visual-based pedagogy, provision of crafting materials, and institutional recognition of the unique cognitive profiles of deaf learners.

## CONCLUSION

This study produced a Mnemonic-Based Busybook that is valid, practical, and effective for use in basic mathematics learning, particularly in the topic of numbers 11–20 for deaf elementary school students. From the validity aspect, expert assessments yielded an average score of 97.8%, categorized as very valid. This result confirms that the developed media meets the standards of content accuracy, visual design quality, and suitability for the characteristics of deaf learners. The visual design and mnemonic activities embedded in the Busybook enable students to associate numbers with concrete forms systematically. The mnemonic strategy, grounded in visual memory reinforcement, successfully stimulates understanding of abstract concepts, aligning with the principles of learning by doing and the constructivist approach in special education.

From the practicality aspect, teacher implementation tests produced a score of 92.5%, classified as very practical. Teachers evaluated the Busybook as easy to use, time-efficient, and supported by clear instructional guidelines. The media is also flexible for both individual and group learning, easy to store, and made from safe, visually appealing materials. Visual elements such as color contrast and large font sizes were adjusted to the visual perception needs of deaf students, making the Busybook not only practical for teachers but also engaging and accessible for learners with hearing impairments.

From the effectiveness aspect, results of the Single Subject Research (SSR) design showed a significant improvement from an average baseline score of 17 to 100 during the intervention phase. The Percentage of Non-Overlapping Data (PND) reached 95.3%, indicating a highly effective category. These results demonstrate that incorporating mnemonic strategies into the Busybook effectively improves students' understanding of number concepts through visual, concrete, and multisensory learning experiences. Manipulative activities also promoted active engagement, concentration, and memory retention in students.

The primary novelty of this study lies in the integration of Busybook media with visual–kinesthetic mnemonic strategies specifically designed for deaf learners. Previous Busybook developments have predominantly focused on literacy skills or fine motor activities for early childhood education. In contrast, this research expands the Busybook's function as a conceptual mathematics learning medium for students with verbal communication barriers. The applied mnemonic approach emphasizes not only repetitive memory training but also the connection between numerical concepts and concrete visual representations combined with physical activities, making it innovative within the context of inclusive education. Furthermore, the integration of the ADDIE development model with Single Subject Research (SSR) testing provides a robust methodological framework that is rarely used simultaneously in special media development studies.

This study also contributes more broadly to disability-inclusive pedagogical design by demonstrating how visual–kinesthetic mnemonic strategies can systematically reduce cognitive barriers for deaf learners, especially in navigating abstract mathematical concepts. The Busybook model developed here offers a replicable approach that can be adapted by other inclusive schools with appropriate contextual adjustments. Beyond its immediate

classroom application, the findings support ongoing efforts to strengthen inclusive education policies that emphasize flexible, multisensory instructional media tailored to diverse learner needs.

In addition, the practical implications of this study extend to the feasibility of teacher adoption. The physical materials and production techniques used in the Busybook are relatively simple, making reproduction possible in most inclusive school settings with basic craft resources. Future development may also consider digital or hybrid adaptations such as interactive e-Busybooks to expand accessibility for schools with technological readiness and to reach learners who rely on different communication modes, including sign language, lip-reading, or bimodal bilingual approaches.

This study has several limitations that should be addressed in future research. First, the number of research subjects was limited to a small group of deaf students from one inclusive elementary school, making generalization of the findings less comprehensive. Second, the effectiveness test focused only on the topic of numbers 11–20 and did not include other mathematics areas such as arithmetic operations, geometry, or measurement, which are equally essential for future development. Third, long-term evaluation of students' memory retention was not conducted, leaving the sustainability of mnemonic effects over extended periods unexamined. Fourth, this study has not yet incorporated digital or interactive audiovisual components, which could potentially enhance learning experiences for students with diverse sensory characteristics.

Moreover, the significant improvement observed in the intervention phase may also be influenced by factors such as novelty effects, repeated exposure to similar tasks, or heightened motivation due to the individualized nature of SSR design. Future studies should therefore consider including comparison groups, broader participant profiles, and extended observation periods to strengthen causal inferences. Developmental variations must also be considered, as mnemonic strategies that are effective for early-grade learners may require adaptation when applied to more abstract or symbolic mathematical content.

Future research should explore cross-context implementation in multiple inclusive schools, evaluate digital adaptations, and investigate how the Busybook functions for deaf learners with differing communication preferences. By doing so, the model can continue evolving as a scalable, evidence-based instructional medium that enriches inclusive mathematics education.

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