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Enhancing junior high school students' numeracy through differentiated contextual worksheets

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Abstract

Improving students' numeracy requires learning that is meaningful and closely connected to real-life contexts. Currently, most materials lack a differentiated numeracy approach, limiting their ability to support diverse student needs effectively. This study aims to develop contextual worksheets embedded with numeracy through a differentiated approach for junior high school students. The research employed a Research and Development (R&D) approach, adopting the ADDIE model, which comprises five stages: Analysis, Design, Development, Implementation, and Evaluation. The study involved 39 eighth-grade students from a public junior high school in Cirebon. The developed product comprises three differentiated worksheet versions tailored to students' learning styles, visual, auditory, and kinesthetic, with numeracy activities linked to real-life contexts. Validation results from five expert validators indicated that the developed contextual worksheets achieved a very high level of validity, with an average score of 97.3% (categorized as very valid) across the content, presentation, and appearance aspects. The test instrument used to measure numeracy improvement also demonstrated high validity, scoring 96.4% (very valid). The trial results showed an average N-Gain of 0.51 (moderate), indicating an improvement in students' numeracy skills after using the differentiated contextual worksheets. Therefore, the developed contextual worksheets are considered valid, practical, and feasible for use in mathematics learning within the framework of the Merdeka Curriculum.

Keywords:
Contextual worksheet, Differeniated learning, Learning preference, Research and development

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1. INTRODUCTION

Numeracy is one of the essential competencies that students must master to face the challenges of the 21st century. Numeracy is not merely the ability to perform calculations but also encompasses the capacity to understand, interpret, and apply mathematical concepts in real-life contexts, enabling students to solve everyday problems logically and critically (Irfan et al., 2023). In line with this, numeracy involves applying mathematical knowledge to interpret various life situations, such as managing data, making data-driven decisions, and reasoning quantitatively (Z. Hidayat et al., 2025).

In Indonesia, the results of the PISA survey indicate that students' numeracy skills remain relatively low, with many students still struggling to comprehend fundamental mathematical concepts and apply them meaningfully in real-life contexts (Marhami et al., 2024; Wijaya et al., 2024). This low level of numeracy is further exacerbated by learning approaches that tend to be uniform and emphasize mechanistic procedures, without considering students' life contexts or individual learning needs (Amalia, 2023). Such conditions call for innovation in the development of learning materials that can help students understand numeracy concepts in a contextual manner. Each student differs in terms of learning readiness, interests, and learning preferences, all of which should be accommodated in the learning process. As one effort to address these issues, the implementation of a differentiated approach offers a potential solution that enables teachers to adapt instruction to the needs and potential of each student.

Differentiated instruction is a dynamic and inclusive approach that adapts the learning process to the unique characteristics of each student. This approach is designed to accommodate diverse student needs by modifying the content, process, and product of learning based on their readiness, interests, and learning styles (Tomlinson & Jarvis, 2023). Content modification refers to what students learn, where teachers adjust instructional materials to align with students' readiness levels, interests, and learning profiles (Demirci-Ünal & Öztürk, 2025). For example, in a diverse classroom, teachers may use visual media, varied activities, and tiered tasks to ensure that the material is accessible to all students (Demirci-Ünal & Öztürk, 2025). Process modification relates to how students learn. Teachers prepare various strategies such as scaffolding support or tiered instruction to accommodate student differences (Tomlinson & Jarvis, 2023). Product modification refers to how students demonstrate their learning outcomes, such as through projects, presentations, or written assignments. Teachers provide students with multiple options to express their understanding, thereby allowing creativity and individual expression to emerge (Tomlinson & Jarvis, 2023). By designing instruction and learning materials based on these modifications, teachers can provide learning experiences that are aligned with the conditions and needs of each student.

Unfortunately, learning materials that support the implementation of differentiation particularly those that integrate numeracy and are based on real-life contexts remain very limited at the junior high school level. This situation highlights the need for innovation in developing learning media that not only align with students' learning needs but also connect mathematical content to real-world contexts. One promising alternative to address this need is the development of contextual worksheets embedded with numeracy. Contextual worksheets emphasize learning that is closely related to students' real-life experiences, thereby promoting active engagement and facilitating the transfer of mathematical concepts to everyday situations (Hidayat & Aripin, 2023; W. Hidayat et al., 2025). Contextual learning has also been shown to enhance students' motivation and conceptual understanding of mathematics by linking theory with practice (Hasudungan, 2022). Therefore, contextual worksheets function not only as practice tools but also as instruments for developing students' critical thinking, creativity, and problem-solving skills.

The development of worksheets that incorporate local contexts and real-world problems has been proposed as an effective strategy to strengthen students' numeracy skills (Putri et al., 2025; Rosita et al., 2025). Therefore, developing contextual worksheets embedded with numeracy principles through a differentiated approach offers several opportunities: (1) providing meaningful learning experiences by connecting mathematical concepts to students' social and cultural contexts; and (2) adapting the learning process to accommodate diverse learning preference, such as visual, auditory, and kinesthetic. This approach enables each student to construct numeracy understanding through learning methods that best suit their individual characteristics, making the learning experience more inclusive, engaging, and meaningful.

Previous studies (Safitri et al., 2023) have shown that the development of mathematics learning materials integrating real-life contexts can enhance students' numeracy competencies. For instance, developed a contextual-based e-module that was validated by experts and tested with students and teachers, with results indicating a high level of validity and positive responses in terms of practicality and effectiveness. In line with this, other studies also emphasize that the use of authentic contexts in mathematics learning helps students connect concepts with real-life situations (Asmara et al., 2026) and strengthens conceptual understanding and decision-making (OECD, 2019; Van den Heuvel-Panhuizen & Drijvers, 2020). On the other hand, the implementation of differentiated learning-based media has also been reported to positively impact both the learning process and outcomes. This is in line with research by Cahya et al. (2024), which developed interactive electronic worksheets based on Liveworksheets designed to support differentiated learning, demonstrating high levels of validity, practicality, and effectiveness. Furthermore, differentiation designed based on students' readiness, interests, and learning profiles has been proven to significantly enhance engagement and learning achievement (Tomlinson, 2014). However, most of these studies still position contextual approaches and differentiated instruction separately and tend to focus more on product feasibility rather than on how task design can explicitly develop students' numeracy components. In fact, the combination of well-designed numeracy tasks and differentiated instruction has the potential to improve both conceptual understanding and procedural skills (Mavrikis et al., 2022), develop problem-solving and critical thinking abilities (Dole & Geiger, 2020), and strengthen estimation skills as well as the application of mathematical knowledge in various contexts (Ketterlin-Geller & Chard, 2011; Winarni et al., 2025). There is still a need to develop learning materials that are not only contextual and differentiated but also systematically integrate numeracy tasks that foster mathematical knowledge, including problem solving, conceptual understanding, procedural skills, and estimation, within a unified instructional design.

Therefore, this study aims to develop contextual worksheets embedded with numeracy through a differentiated approach that are valid, practical, and feasible for use in mathematics learning. It address the gap between decontextualized numeracy task and the need for adaptive and meaningful learning materials that can accommodate diverse learning needs among junior high school students. In addition, the findings of this study are anticipated to support the implementation of the Merdeka Curriculum, which emphasizes student-centered learning and competency-oriented education. Accordingly, the study examines to what extent the development worksheet are valid, how practical they are in classroom, and how feasibility they are in supporting students' numeracy.

2. METHOD

This study employed a Research and Development (R&D) method based on the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) developed by Dick and Carey Model (Dick, 1996) for instructional system design. This model was selected because it is systematic and suitable for producing learning products that are valid, practical, and effective (Nawali et al., 2024). The product developed in this study is a contextual worksheet embedded with numeracy through a differentiated approach for junior high school students. Data were collected from a total of 39 eighth-grade students from class VIII K at SMP Negeri 4 Cirebon City.

2.1. Analysis Stage

This stage involved an analysis of students' learning needs, curriculum content, and the characteristics of junior high school students as the foundation for developing contextual worksheets embedded with numeracy. Data were collected through interviews with mathematics teachers, the use of the Aku Pintar platform to identify students' learning preference (visual, auditory, and kinesthetic), and an analysis of the Merdeka Curriculum documents. In this study, learning preference were not used to limit students' learning pathways, but rather as a starting point to enhance engagement and facilitate initial understanding. The differentiated worksheets developed were not designed to confine students to a single modality (e.g., auditory, visual, or kinesthetic), but to provide multiple representations and learning experiences. In practice, students were still exposed to various modes of learning, enabling them to develop flexibility and adapt their learning strategies beyond their initial preferences. The results of this analysis were used to understand students' learning needs and characteristics, which then served as the basis for designing three differentiated worksheet versions tailored to students' learning preference. Accordingly, each worksheet was designed to provide a meaningful and enjoyable learning experience aligned with the individual characteristics of students (Tomlinson, 2017).

2.2. Design Stage

This stage aimed to design contextual worksheets embedded with numeracy based on the results of the needs analysis and students' characteristics. At this stage, the structure, content, and learning activities were designed to align with the learning outcomes outlined in the Merdeka Curriculum. The design process included formulating learning objectives, mapping numeracy competencies, identifying real-world problem contexts, and designing student activities that emphasize active engagement and contextual problem-solving.

2.3. Development Stage

The development stage aimed to produce contextual worksheets embedded with numeracy based on the design created in the previous stage. During this stage, the worksheets were constructed, refined, and validated to ensure their feasibility for classroom use. The validation process involved five expert validators, consisting of two mathematics education, one educational technology, one instructional design, and one high school mathematics teacher.

A structured validation form using a 4-point Likert-scale rating was employed to assess content validity and feasibility of the product. The validation instrument covered four main aspects, including (1) content and learning objectives feasibility, (2) presentation and language, (3) media layout and visual design, and (4) the integration of numeracy elements within real-life contexts. Each validator evaluated three types of worksheets developed based on learning preference, namely visual, auditory, and kinesthetic worksheets.

The collected data were analyzed quantitatively by calculating the percentage scores from each validator (see Table 1). The result were then interpreted based on predetermined validity criteria by Riduwan (2010).

Table 1. Contextual worksheet validation criteria

Percentage	Interpretation
81 – 100%	Highly Valid
61 – 80%	Valid
41 – 60%	Moderate Valid
21 – 40%	Less Valid
0 – 20%	Invalid

Feedback and suggestions from the validators were used to revise and improve the worksheets before proceeding to the trial phase.

2.4. Implementation Stage

The implementation stage aimed to test the use of the developed contextual worksheets embedded with numeracy in a real classroom setting. At this stage, the three differentiated worksheet versions visual, auditory, and kinesthetic were distributed to students according to their respective learning preference. All three versions design to address the same mathematical content and learning objectives, particuraly within contextual numeracy task, with variations in representation, task structure, and learning activities.

The mathematics teacher guided students in completing the worksheet activities, ensuring that each student could comprehend the material and apply numeracy concepts within the provided contextual problems. To illustrate how differentiated was implemented, the three worksheet versions described: (1) Visual worksheet: emphasize the use of ilustrations, graphical representation, and diagrams; (2) Auditory worksheet: emphasize the use of verbal explanation and video-based intstruction; and (3) Kinesthetic worksheet: engage students in hands-on activities and physical exploration.

During the implementation process, observations were conducted to assess the practicality of using the worksheets, students' interactions with the material, and their active engagement in the learning process. These data served as the basis for refining the product prior to further evaluation. The N-Gain test was used to measure the improvement in numeracy skills of junior high school students before and after using differentiated contextual worksheets. The average N-Gain score was calculated by dividing the difference between the posttest and pretest mean scores by the difference between the ideal maximum score and the pretest mean score, with the criteria for interpreting the N-Gain levels referring to Hake (1999).

2.5. Evaluation Stage

The evaluation stage was conducted to ensure that the developed contextual worksheets embedded with numeracy were appropriate for use and aligned with students' learning needs. The evaluation activities included product refinement based on expert feedback, reflection on the classroom implementation of the worksheets, and final revisions to the digital learning materials supporting their use. The purpose of this stage was to analyze the validators' suggestions and assess the effectiveness of the worksheets in supporting the learning process according to students' learning preference (visual, auditory, and kinesthetic).

2.6. Data Collection

The data collection technique in this study includes a numeracy ability test for students and a validation sheet used to assess the validity level and feasibility of the contextual numeracy-based worksheet developed.

The numeracy test was developed by the researchers based on relevant theoretical frameworks of numeracy which integrated mathematical content, numeracy processes, and real-life contexts (Dole & Geiger, 2020). The instrument specifically targeted Pythagorean Theorem concepts situated in authentic contexts, such as distance measurement and geometric design. Building on this framework, students' responses were further analyzed to examine how mathematical content, namely problem solving, conceptual understanding, procedural skills, and estimation manifested across different learning preferences. The comparison of these patterns is presented in Table 2.

Table 2. Comparison of mathematical knowledge across learning preferences

Mathematical Knowledge*	Visual Worksheet Task	Auditory Worksheet Task	Kinesthetic Worksheet Task
Problem Solving	Structured and systematic problem-solving	Direct and verbally driven problem-solving	Exploratory and trial-and-error problem-solving
Concept	Strong conceptual organization through visual representation	Conceptual understanding expressed verbally	Conceptual understanding developed through hands-on experience
Skills	Accurate and well-sequenced procedural skills	Procedural skills present but less explicitly documented	Procedural skills developed through repeated practice and manipulation
Estimation	Limited, mostly implicit in contextual interpretation	Implicit through consistency of answers with context	Emerges through iterative adjustments and solution refinement

*Based Numeracy Framework (Dole & Geiger, 2020).

3. RESULTS AND DISCUSSION

3.1. Results

The result of this development research is a contextual worksheet with numeracy content developed in three differentiated versions according to students' learning preference, namely visual, auditory, and kinesthetic. Each worksheet is designed so that students can carry out numeracy activities in real-life contexts, with instructions, illustrations, and types of activities that align with the characteristics of their learning preference. The following presents the analysis results of the worksheet based on the ADDIE design, from the Analysis to the Evaluation stage, which demonstrate the feasibility and effectiveness of the product in supporting numeracy learning.

3.1.1. Analysis Stage

At the analysis stage, data were obtained through the Aku Pintar platform (https://akupintar.id/) to identify the learning preference of junior high school students whether visual, auditory, or kinesthetic. The analysis revealed that among all participants, 15 students had a visual learning style, 10 had an auditory style, and 14 had a kinesthetic style (see Figure 1). These findings indicate that students possess diverse learning preferences, thereby necessitating instructional approaches tailored to individual characteristics. Based on these results, the researcher designed three differentiated versions of contextual numeracy worksheets corresponding to each learning preference. The worksheet for visual learners emphasizes the use of illustrations and diagrams, the auditory version includes clear verbal instructions and explanations, while the kinesthetic version involves manipulative or simple movement-based activities. This approach enables each student to learn numeracy more effectively according to their most suitable learning preference.

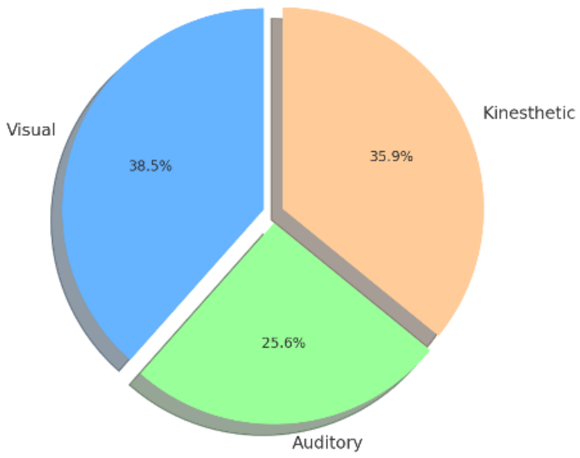

Figure 1. Results of the student learning preference analysis

3.1.2. Design Stage

The design stage focused on developing three digital worksheets tailored to students' learning preference visual, auditory, and kinesthetic. The entire design process was carried out using Canva, as the platform offers various interactive features that facilitate layout organization, integration of visual elements, and incorporation of multimedia components such as images, icons, and instructional video links. The initial stage of the design involved creating a content framework that included learning outcomes, learning objectives, materials and tools, usage instructions, and learning activities to ensure aligment between objectives, assessment, and content adapted from the differentiated learning approach (Linder & Kelly, 2024; Sewagegn, 2020). Once the content structure was established, the researcher proceeded to determine the color scheme, typography, and illustrations appropriate for each learning preference to ensure that the worksheets were visually appealing, communicative, and easy to understand for junior high school students. Furthermore, the design of the worksheets was guided by several key design principles, including contextualization, differentiation, and multimodal representation. Contextualization was implemented by embedding real-life problem situations to support meaningful learning, while differentiation was reflected in the adaptation of content and activities according to students' learning preferences. In addition, multimodal representation was incorporated to provide diverse learning experiences that enable students to engage with mathematical concepts through multiple forms of representation. From the perspective of learning mechanisms, the designed worksheets were intended to facilitate students' active engagement in problem-solving activities, support the construction of conceptual understanding, and encourage reflective thinking. Through this process, students are expected to not only interact with contextual tasks but also develop flexible learning strategies by adapting their understanding across different representations and learning experiences. The design principles and learning mechanisms underlying this study are illustrated in the Figure 2.

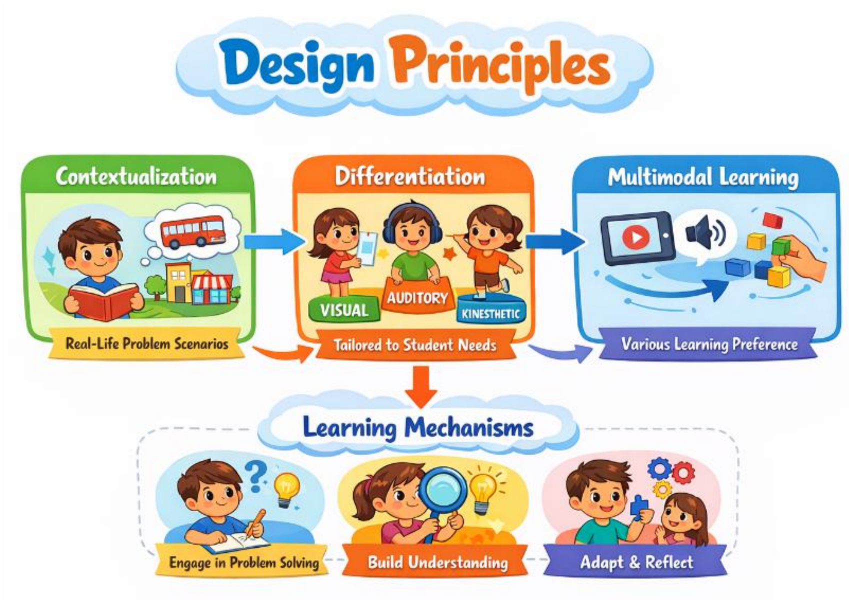

Figure 2. Framework of the contextual numeracy worksheet design process

In the visual learning preference worksheet, the design emphasizes the use of contrasting colors, diagrams, illustrations, and infographics to help students understand the concept of the Pythagorean Theorem through visual representation. The auditory learning style worksheet was designed by incorporating video links (voice explanation dominan) links and narrative elements that encourage listening and discussion activities, allowing students to learn through auditory experiences. Meanwhile, the kinesthetic learning preference worksheet focuses on hands-on activities such as forming triangles using strings, straws, or colored cardboard, enabling students to learn through movement and direct exploration. After the design process was completed, all worksheets were exported into interactive PDF formats to ensure accessibility both online and offline. The results of this design stage indicate that the three worksheets possess visually appealing layouts, coherent content structures, and supporting media that align with students' learning preference and the principles of differentiated instruction. In the visual learning preference worksheet, students are directed to observe diagrams of right-angled triangles accompanied by square illustrations on each of their sides. Students are then asked to compare the areas of each square through visual observation and identify patterns in the relationships among the sides. In the auditory learning preference worksheet, students are engaged in listening to verbal explanations through videos with dominant narration that gradually explain the relationships among the sides of a triangle. Subsequently, students are encouraged to discuss their findings, articulate their understanding verbally, and respond to guiding questions that lead to the discovery of conceptual relationships. This process emphasizes the construction of understanding through verbal interaction and auditory information processing. Meanwhile, in the kinesthetic learning preference worksheet, students engage in hands-on activities by forming right-angled triangles using strings, straws, or cardboard, and then constructing square models on each side of the triangle. Through these manipulative activities, students are able to compare areas concretely and discover the relationships among the sides through physical experience and direct exploration. Each learning preference pathway serves as a means to support this construction process, rather than as an end in itself. The framework of the contextual numeracy worksheet design process using a differentiated approach in Canva is illustrated in Figure 3.

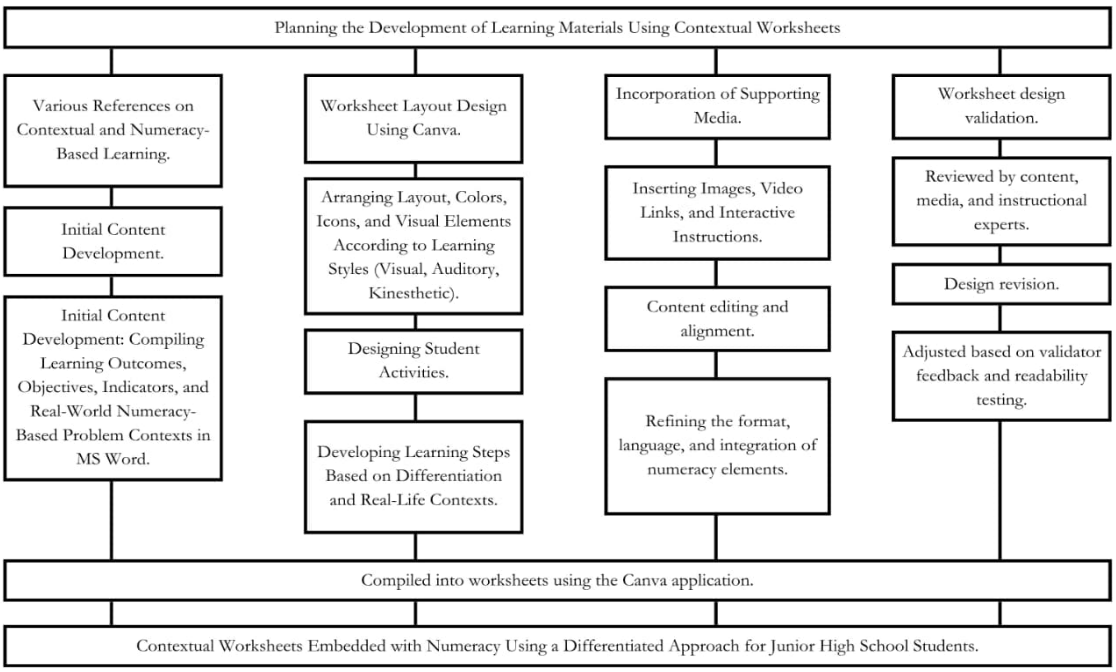

Figure 3. Framework of the contextual numeracy worksheet design process

3.1.3. Development Stage

Worksheet Development

The development stage was conducted after the design process was completed, with the aim of producing contextual worksheets embedded with numeracy that were ready for use by junior high school students. At this stage, the three worksheets, tailored to the characteristics of visual, auditory, and kinesthetic learning preference, were fully developed using Canva. The initial cover designs of the three worksheets are presented in Figure 4.

Figure 4. Contextual worksheet initial cover

The development process involved integrating all elements designed in the previous stage, including learning materials, contextual activities, and numeracy components, into an interactive digital format. Each worksheet was systematically organized, starting from learning outcomes and objectives, usage instructions, core activities, to the reflection section, enabling students to follow the learning sequence in a clear and coherent manner. After the content compilation stage was completed, the worksheets were refined by adding graphic and multimedia elements to make them more engaging and accessible. The visual worksheet featured infographics, diagrams, and colored illustrations to facilitate conceptual understanding through visual representation. The Figure 5 presents a visual learning activity incorporated in the worksheet, designed to support learners with a visual learning preference through structured and meaningful visual representations.

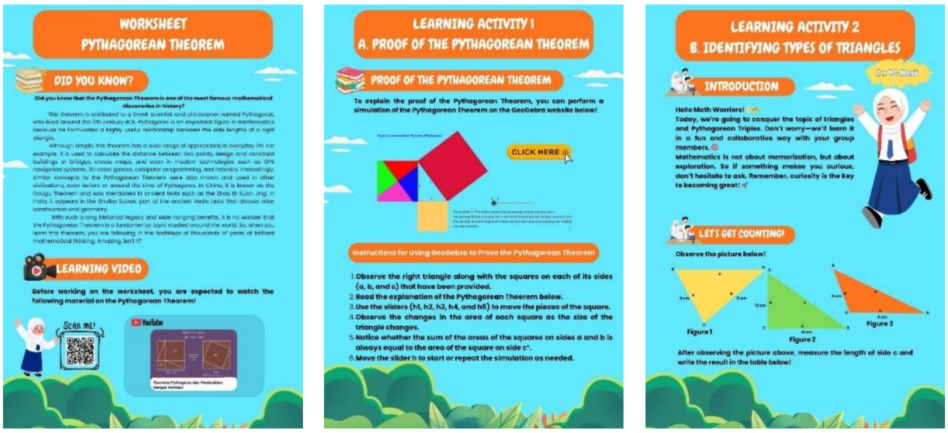

Figure 5. Contextual worksheet initial cover

The auditory worksheet was enhanced by incorporating instructional video links and group discussion activities, encouraging students to comprehend the material through listening and communication. These discussion activities were specifically included in the auditory design to support learners who process information more effectively through spoken interaction and collaborative dialogue. Figure 6 presents an auditory learning activity included in the worksheet, specifically designed to support learners with an auditory learning preference through listening, verbal interaction, and collaborative discussion.

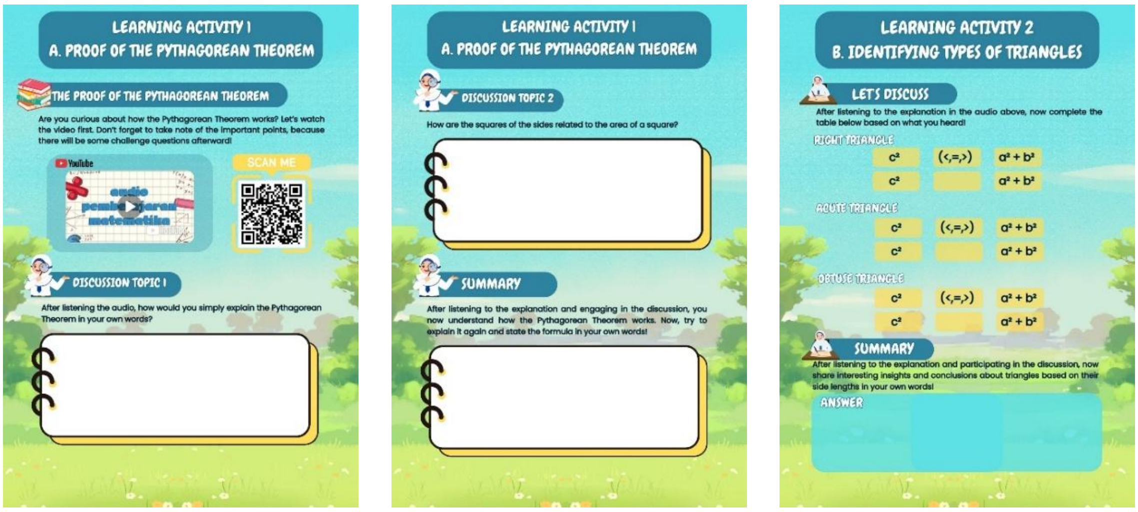

Figure 6. Contextual worksheet initial cover

In contrast, the kinesthetic worksheet included various hands-on activities involving physical movement, such as forming triangles using strings, straws, or colored cardboard, enabling students to learn through direct exploration. The Figure 7, presents a kinesthetic learning activity included in the worksheet.

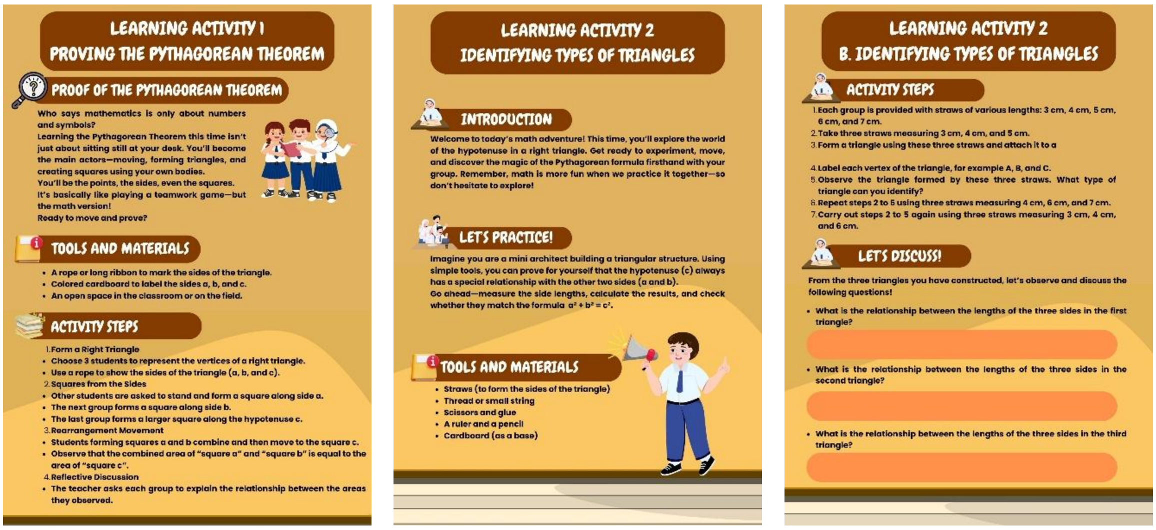

Figure 7. Worksheet activities according to learning preference

Validation of Worksheets

The developed contextual worksheets embedded with numeracy were validated by five experts consisting of two mathematics education lecturers, one educational technology lecturer, one instructional design lecturer, and one experienced junior high school mathematics teacher. The purpose of the validation was to assess the feasibility of the product in terms of content, presentation, layout, and the integration of media. The validation process was conducted using an evaluation sheet with a 1-to-4 rating scale, covering several assessment aspects: (1) content and learning objectives feasibility, (2) presentation and language, (3) media layout and visual design, and (4) integration of numeracy elements with real-life contexts.

Each validator assessed the three developed worksheets, namely the visual, auditory, and kinesthetic learning preference worksheets. The validation results were used to determine the product's feasibility prior to implementation with students. The validation data from the five experts on the contextual worksheets embedded with numeracy are presented in Table 3.

Table 3. Contextual worsksheet validation results

Validator	Number of Items	Total Score	Maximum Score	Percentage (%)	Category
Validator 1	44	176	176	100.0	Highly Valid
Validator 2	44	164	176	93.2	Highly Valid
Validator 3	44	165	176	93.8	Highly Valid
Validator 4	44	175	176	99.4	Highly Valid
Validator 5	44	176	176	100.0	Highly Valid

The expert validation results for the developed worksheets indicated that the overall average score from the five validators was 97.3%, falling into the "very valid" category. This demonstrates that the contextual worksheets embedded with numeracy using a differentiated approach are feasible for use in the learning process. After validating the developed worksheets and obtaining results in the "very valid" category, the next step was to validate the test instruments used to measure the worksheets' effectiveness, namely the pretest and posttest items. The purpose of this instrument validation was to ensure that the test items met the criteria for content, construction, and language feasibility, thereby serving as valid measurement tools for the study. The results of the expert validation of the test instruments in terms of content, construction, and language are presented in Table 4.

Table 4. Contextual worsksheet validation results

Validator	Material Aspect (%)	Construction Aspect (%)	Language Aspect (%)	Total Score	Maximum Score	Total Percentage (%)	Category
Validator 1	100	83.3	100	26	28	92.9	Highly Valid
Validator 2	100	100	100	28	28	100	Highly Valid
Validator 3	100	100	100	28	28	100	Highly Valid
Validator 4	87.5	100	100	27	28	96.4	Highly Valid

Validator	Material Aspect (%)	Construction Aspect (%)	Language Aspect (%)	Total Score	Maximum Score	Total Percentage (%)	Category
Validator 5	100	83.3	100	26	28	92.9	Highly Valid
Average	**97.5**	**93.3**	**100**			**96.4**	**Highly Valid**

Based on the validation results conducted by five experts across three assessment aspects (content, construction, and language), an overall average percentage of 96.4% was obtained, falling into the "very valid" category. The content aspect achieved an average of 97.5%, the construction aspect 93.3%, and the language aspect 100%. These results indicate that the developed test instruments meet the criteria for content, construction, and language feasibility, and are therefore considered suitable for use in the learning process.

3.1.4. Implementation Stage

The implementation stage aimed to test the effectiveness of using contextual worksheets embedded with numeracy through a differentiated approach in classroom learning activities. The trial involved 39 junior high school students, grouped according to their learning preference, visual, auditory, and kinesthetic. At this stage, each student used the worksheet corresponding to their learning preference, with guidance from the teacher in carrying out the contextual numeracy activities. The learning activities focused on applying the Pythagorean Theorem concepts in real-life contexts, such as distance measurement and geometric design. The implementation of each learning style in the classroom is illustrated in Figure 8.

(a) Visual (b) Auditory (c) Kinesthetic

Figure 8. Worksheet implementation

To further illustrate how students with a visual learning preference approached the given task, an example of their written response is provided. This example is presented in Figure 9, which shows students' responses based on the visual learning preference.

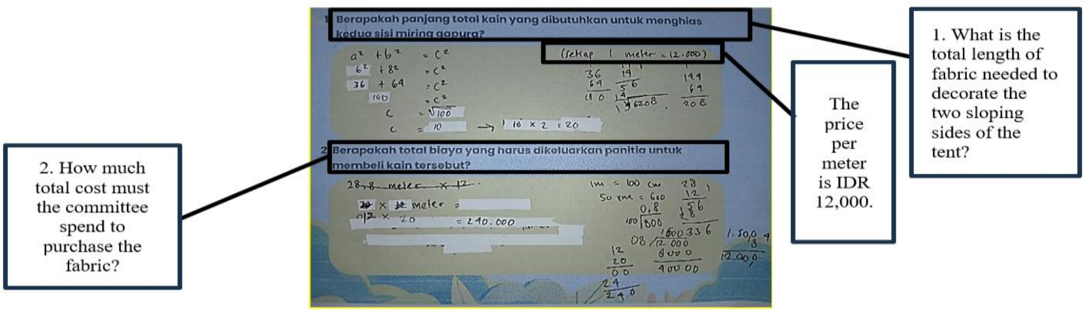

Figure 9. Students' responses based on visual learning preference

Based on the analysis of students' responses with a visual learning preference, it is evident that students are able to present problem-solving processes in a structured and systematic manner. The students clearly wrote the Pythagorean Theorem formula, accompanied by complete mathematical symbols and well-sequenced calculation steps. The use of numerical values, square operations, and square roots was organized coherently, making it easier to determine the length of the hypotenuse of the triangle. However, beyond these observable characteristics, this pattern reflects how visual representation supports students' conceptual organization and cognitive structuring of mathematical information. The use of symbols and orderly procedures indicates that students are not merely applying formulas, but are organizing relationships between quantities in a visually meaningful way. This suggests that visual representation plays a critical role in facilitating conceptual clarity, particularly in connecting abstract mathematical operations with structured problem-solving steps. Furthermore, visual learners demonstrated strong ability in utilizing graphical representations and mathematical notation to interpret the problem context. The determination of the fabric length was not only based on accurate calculations, but also on the ability to connect symbolic representations with the contextual situation of fabric purchasing and cost calculation. This indicates that visual representation serves as a bridge between abstract mathematical concepts and contextual understanding, enabling students to construct meaning more effectively rather than simply executing procedural steps.

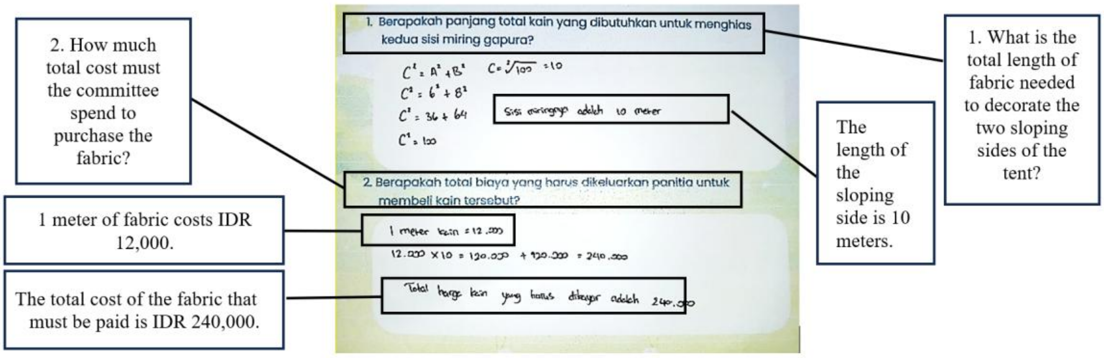

Figure 10. Students' responses based on auditory learning preference

Based on the analysis of students' responses with an auditory learning preference, it is evident that students express their understanding of the Pythagorean Theorem through verbal explanations that are translated into written form (see Figure 10). Auditory learners tend to state the relationships among the sides of the triangle directly, such as indicating that "the hypotenuse is 10 meters," without presenting highly detailed calculation steps. This suggests that their thinking processes are predominantly driven by verbal reasoning, which is then summarized in written responses. Furthermore, auditory learners are able to appropriately relate the calculation results to the problem context, particularly in determining the total cost of fabric purchase. Although the presentation of mathematical symbols and procedural steps is not always complete, their responses still demonstrate correct conceptual understanding, as indicated by the consistency between the final results and the problem context. This pattern indicates that contextual worksheets support auditory learners in understanding mathematical concepts through meaningful verbal explanations and reasoning.

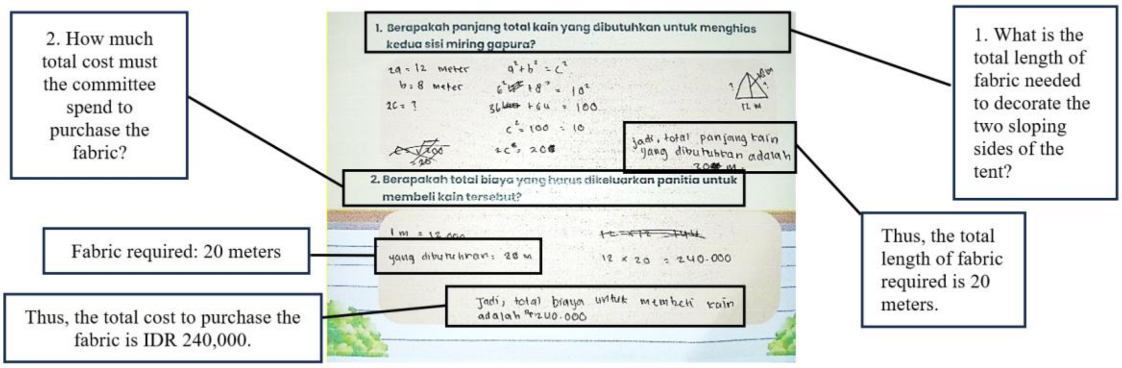

Figure 11. Students' responses based on kinesthetic learning preference

Based on the analysis of students' responses with a kinesthetic learning preference, it is evident that students solve problems through exploratory and step-by-step calculation activities (see Figure 11). This is reflected in the presence of annotations, revisions of steps, and repeated calculations when determining the length of the hypotenuse and the total length of fabric required. Kinesthetic learners tend to try multiple solution strategies until they obtain results that are considered appropriate to the problem context. In addition, students with a kinesthetic learning preference demonstrate active engagement in connecting mathematical concepts with real-life situations. The processes of unit conversion, calculation of fabric quantity, and determination of total cost are carried out directly through repeated manipulation of numbers and arithmetic operations. This pattern of responses indicates that kinesthetic students' conceptual understanding of mathematics develops through hands-on activities, direct calculation, and continuous adjustment of solution steps based on their learning experiences while using contextual worksheets.

The analysis of students' responses indicates that differences in learning preference play a role in shaping how students represent and solve numeracy problems. Students with a visual learning preference demonstrate strengths in the neat use of mathematical symbols and the structured presentation of solution steps. Meanwhile, auditory learners tend to excel in verbal reasoning and the accuracy of final answers, even though the calculation steps are not always written in detail. In contrast, kinesthetic learners exhibit active thinking processes through annotations, trial-and-error steps, and repeated calculation activities as part of their efforts to understand the problem context. These findings suggest that each learning preference possesses distinct strengths, indicating that numeracy instruction should be designed flexibly to accommodate the diversity of students' thinking processes and mathematical representations.

As a follow-up to the qualitative analysis of students' response characteristics based on visual, auditory, and kinesthetic learning preference, the researchers subsequently conducted a quantitative measurement to assess the improvement in students' numeracy skills. During the implementation process, the researcher observed students' activities and collected pretest and posttest data to assess improvements in numeracy skills. The analysis was conducted using the N-Gain test to measure the increase in students' learning outcomes after using the contextual worksheets. The results of the N-Gain analysis of students' numeracy skills are presented in Table 5.

Table 5. Descriptive statistics N-Gain score

	N	Minimum	Maximum	Mean	Std. Deviation
Ngain_Score	39	0.38	0.59	0.5053	0.07295
Ngain_Persen	39	37.50	58.54	50.5259	7.29479
Valid N (listwise)	39				

Based on the presented data in Table 5, the mean N-Gain score of junior high school students' numeracy skills was approximately 0.5053, with a standard deviation of 0.07295. This finding indicates that, overall, students experienced an average improvement of about 0.51 from their pretest scores after participating in learning activities using differentiated contextual worksheets. The N-Gain scores ranged from a minimum of 0.38 to a maximum of 0.59, reflecting variability in students' responses to the implementation of differentiated contextual worksheets in enhancing numeracy skills. In terms of percentage, the average N-Gain was 50.5259%, with a standard deviation of 7.29479%. This suggests that, on average, students improved their numeracy skills by approximately 50.53% following the implementation of differentiated contextual worksheets.

This improvement indicates that the use of contextual worksheets provides a more meaningful and adaptive learning experience for students. Numeracy activities linked to real-life contexts help students understand mathematical concepts concretely, while the implementation of a differentiated approach ensures that each student learns according to their individual learning preference and ability.

3.1.5. Evaluation Stage

The evaluation stage was conducted after the implementation of learning using contextual worksheets embedded with numeracy through a differentiated approach. The purpose of this stage was to assess the extent to which the developed worksheets could support the numeracy learning process and to identify aspects that required improvement. The evaluation was based on observations during the implementation process, feedback from teachers and students regarding the use of the worksheets, and reflections on challenges encountered in the classroom. The classroom observations were conducted by the researchers using an observation sheet, focusing on students' engagement, participation, and their ability to apply the Pythagorean Theorem in contextual numeracy tasks. In addition, teacher input was gathered through semi-structured interviews to capture their perspectives on the practicality and effectiveness of the worksheets. Several challenges were encountered during the classroom observations and teacher feedback during the implementation stage. Some students had difficulty accessing interactive links due to device limitations, while others required more time to understand the activity instructions on the worksheets. These findings, derived from observations and informal discussions with the teacher, indicate that the obstacles were technical in nature and did not significantly affect the learning process. Consistent with these findings, the integration of technology in learning requires both student and teacher readiness to ensure that digital media can be utilized optimally. The evaluation stage was conducted to review the development results of the worksheets based on feedback from the five validators. The suggestions and revisions provided by the validators are presented in Table 6.

Table 6. Expert judgment

Validator	Suggestion	After Revision
Validator 1	1. The learning outcomes section is incomplete, it is necessary to add *irrational number* words to each worksheet. 2. Improve the writing in the activity instructions section to make it clearer.	1. The learning outcomes have been revised by adding the concept of *irrational numbers*. 2. The activity instructions have been clarified with more communicative language.
Validator 2	1. Videos on visual worksheets should be replaced with reading activities or making *mindmaps* to match the characteristics of visual learning preference. 2. In the second learning activity, change the word *count* to *measure*.	1. The video on the visual worksheet has been changed to reading and *mindmapping* activities. 2. The word *count* has been changed to *measure so* that the activity is more contextual.
Validator 3	1. Match the numbers in the first problem so that they are consistent throughout the worksheet. 2. In the case of gates, change the numbers 10 and 8 meters so that the result is not irrational.	1. The numbers in the first problem have been standardized to 15 and 8. 2. The gate was revised to 12 and 8 meters so that the results were rational.
Validator 4	1. Add practice questions similar to *the pretest* and *posttest* to help students recognize the pattern of the problem. 2. Add a short reflection activity at the end of the worksheet.	1. Additional practice questions have been included in a similar form *pretest* and *posttest*. 2. Reflection activities have been added at the end of the worksheet.
Validator 5	1. Contextual questions should be adjusted to students' daily lives to make them more meaningful. 2. Add illustrations or supporting images to the activity instructions section.	1. Contextual questions have been revised to fit the real situation that is close to the student's life. 2. Illustrations and supporting images have been added to each learning activity.

Overall, this evaluation stage indicated that the contextual worksheets embedded with numeracy using a differentiated approach were feasible and effective for learning, although further development is still needed to enhance their practicality and accessibility across diverse learning environments.

3.2. Discussion

The results of the study indicate that the contextual worksheets embedded with numeracy, developed through a differentiated approach, achieved a very high validity level of 97.3% and were proven effective in enhancing students' numeracy skills, with an average N-Gain of 0.51, which falls into the medium category. These findings suggest that the use of the worksheets had a positive impact on improving numeracy skills, although the improvement was not yet optimal for all students. The variation in N-Gain values reflects differences in individual understanding, likely influenced by students' learning preference and initial readiness.

The N-Gain score falls within the moderate category due to several interrelated factors, particularly those related to students' initial conditions, the characteristics of the intervention, and differences in learning preference within the context of differentiated instruction. Students' prior knowledge and learning readiness significantly influence the magnitude of learning improvement (Yang et al., 2018). Students with low initial numeracy skills tend to require more time and repeated exposure to internalize conceptual understanding, especially when transitioning from procedural solutions to contextual problem-solving. In addition, differences in learning preference influence how students process information and construct numeracy understanding (Sheromova et al., 2020). Visual learners tend to more quickly understand relationships between concepts through symbolic and diagrammatic representations, demonstrating more structured thinking processes. In contrast, auditory learners rely more on verbal reasoning; thus, although they are able to reach correct answers, their mathematical representation processes are not always fully documented. Meanwhile, kinesthetic learners exhibit exploratory thinking patterns through trial-and-error activities and direct manipulation, which require more time to achieve stable understanding. These differences in cognitive mechanisms lead to variations in the pace and depth of understanding, ultimately contributing to the moderate N-Gain results.

These findings are consistent with VARK model (Dey & Panda, 2024), which suggests that learning preferences influence how students receive, process, and express information. Furthermore, El-Sabagh (2021) emphasize that although aligning instruction with learning preference can increase engagement, it does not necessarily lead to significant improvements in learning outcomes in the short term (She et al., 2018), particularly when students are not yet accustomed to varied instructional approaches (Entwistle, 2021). Moreover, the relatively limited duration of the intervention restricts students' opportunities to optimally adapt to differentiated instruction. In this context, students are not only learning new content but also adjusting to learning approaches that may differ from their previous habits. This is supported by Pasira (2022), who states that the effectiveness of differentiated instruction requires time for students to adapt to the various learning strategies provided.

The integration of contextual problems in the worksheets increases students' cognitive demands. This process involves the ability to connect real-life contexts with mathematical representations, requiring coordination among multiple forms of representation (visual, verbal, and kinesthetic). This condition may increase cognitive load, especially for students who must adapt to different learning preference while simultaneously understanding new concepts (Firman et al., 2018). Thus, the moderate N-Gain score does not merely reflect the effectiveness of the intervention but also represents students' cognitive adaptation processes to differentiated learning based on learning preference. These findings indicate that although differentiated approaches can enhance engagement and provide more meaningful learning experiences, their impact on improving learning outcomes requires time, consistency, and sustained scaffolding support.

The improvement in numeracy skills observed in this study can be explained through three main learning mechanisms: contextualization, representation, and active knowledge construction. Contextualization enables students to relate abstract mathematical concepts to meaningful real-life situations (Reyes et al., 2019). This process facilitates conceptual understanding by connecting prior knowledge with new information, allowing students to interpret problems more meaningfully rather than merely applying formulas mechanically. These findings align with Setioningsih et al. (2025), within the Realistic Mathematics Education approach, which emphasizes the importance of context as a starting point for constructing mathematical understanding. Additionally, Geiger et al.'s (2015) findings indicate that strong numeracy skills are highly influenced by students' ability to connect mathematical concepts with real-life situations, rather than relying solely on procedural mastery.

The use of multiple representations (visual, verbal, and physical) supports cognitive processes by providing various entry points for understanding concepts. Visual representations help students organize relationships among quantities, auditory explanations support verbal reasoning and conceptual articulation, while kinesthetic activities enable experiential learning through direct manipulation. Active engagement in problem-solving activities promotes knowledge construction, where students are not passive recipients of information but actively involved in exploring, testing, and refining their understanding. This is consistent with constructivist theory proposed by Hannula (2012), which emphasizes that knowledge is constructed through active interaction with the environment and through social processes.

Furthermore, when viewed from the perspective of differentiated instruction, these three mechanisms operate synergistically in accommodating differences in students' learning preference. Tomlinson and Jarvis (2023) emphasizes that effective differentiation not only adjusts content but also provides variation in learning processes and representations. Therefore, the combination of contextualization, multiple representations, and active engagement not only enhances overall numeracy understanding but also ensures that each student can access learning through cognitive pathways that best suit their characteristics. In this study, differentiated instruction is operationalized through adaptations in content, process, and representation, rather than merely grouping students based on learning preference. This approach aligns with the conceptual framework proposed by Gheyssens et al. (2022), which asserts that effective differentiation must involve adjustments in content, process, and product to accommodate students' diverse readiness levels, interests, and learning profiles.

At the content level, tasks are designed with varying levels of complexity and contextual relevance, allowing students with different levels of readiness to remain meaningfully engaged. This strategy is supported by Lawson et al. (2023), who found that adjusting the level of task difficulty can improve accessibility without reducing conceptual depth. Additionally Rosita et al. (2026) emphasize that content differentiation helps students with diverse abilities achieve the same learning objectives through pathways appropriate to their readiness.

At the process level, students interact with learning materials through pathways aligned with their dominant learning preferences, visual (structured diagrams and symbols), auditory (verbal explanations and discussions), and kinesthetic (direct manipulation and exploration). However, these pathways are not rigid, rather they serve as entry points that gradually introduce students to multiple modes of learning. This finding is consistent by El-Sabagh

(2021), which suggests that accommodating learning preferences can enhance student engagement. However, as argued by Cuevas (2015), the effectiveness of learning preference lies not in rigid grouping but in the flexibility of providing varied instructional approaches, as implemented in this study.

At the representation level, differentiation provides opportunities for students to express their understanding in various forms. Visual learners demonstrate structured symbolic reasoning, auditory learners articulate conceptual understanding verbally, while kinesthetic learners display iterative and exploratory problem-solving processes. This is supported by Rau and Matthews (2017), who emphasizes that multiple representations can enhance conceptual understanding by helping students see connections between concepts from different perspectives. Differentiation does not function by simplifying content; rather, it optimizes access to understanding, allowing all students to engage with the same core concepts through different cognitive pathways. This aligns with the principle of equity in education emphasized Devaki (2025), which advocates providing equal learning opportunities through adaptive approaches rather than uniform instruction. Thus, differentiation in this study not only enhances student engagement but also strengthens the quality of the learning process by providing multiple cognitive pathways toward the same understanding. The findings of this study reveal distinct yet complementary cognitive processes across different learning preference, collectively explaining how numeracy understanding develops.

Visual learners tend to exhibit analytical and organized thinking patterns, characterized by structured use of symbols, systematic procedures, and clear representation of relationships among quantities. This cognitive process emphasizes pattern recognition and spatial organization, supporting accurate and efficient problem-solving. These findings are consistent with Schoenherr and Schukajlow (2024), who highlights the important role of visualization in understanding structural relationships in mathematics. Additionally, Callejo and Zapatera (2017) emphasizes that visual representations strengthen conceptual understanding by facilitating interpretation and generalization. Auditory learners, on the other hand, demonstrate verbal thinking patterns in which understanding is constructed through internal and external dialogue. They process information by articulating relationships between concepts conceptually and often reach correct conclusions even when procedural steps are not fully documented. This finding is consistent with Sfard (2020), who emphasizes that mathematics learning is also a discursive process, where understanding is constructed through language and mathematical communication. Meanwhile, kinesthetic learners exhibit experiential and iterative thinking patterns, characterized by trial-and-error strategies, repeated calculations, and continuous refinement of solutions. Their cognitive processes involve active exploration and direct interaction with problems, supporting the development of deep understanding through experience rather than immediate abstraction. This is consistent with Matriano's (2020) experiential learning theory, which emphasizes that knowledge is constructed through cycles of concrete experience, reflection, conceptualization, and active experimentation. Across these three groups, a common pattern emerges: numeracy development involves progressive stages, beginning with interpreting context, forming representations, executing procedures, and engaging in reflective evaluation. However, students differ in which stage becomes dominant in their thinking processes. These variations explain not only the overall improvement in numeracy skills but also differences in N-Gain scores among students. This finding is also supported by Polotskaia et al. (2022), which indicates that success in numeracy is determined not only by conceptual mastery but also by students' cognitive flexibility in transitioning between representations and problem-solving strategies. Based on these findings, it is recommended that future implementation of these worksheets be accompanied by teacher usage guidelines, remedial strategies for students in need, and improved digital accessibility. Such efforts are expected to maximize the effectiveness of differentiated instruction, ensuring a more equitable and optimal impact on all students.

4. CONCLUSION

This study developed differentiated contextual worksheets embedded with numeracy for junior high school students, consisting of visual, auditory, and kinesthetic versions designed to support meaningful learning through real-life contexts. The development process, guided by the ADDIE model, ensured a systematic approach to producing learning materials aligned with students' diverse learning preferences. The results indicate that the developed worksheets are highly valid, as reflected by expert validation scores averaging 97.3%, while the numeracy assessment instruments also achieved high validity (96.4%). In terms of effectiveness, the implementation findings revealed a moderate improvement in students' numeracy skills (N-Gain = 0.51), demonstrating that the worksheets effectively support students in applying mathematical concepts within contextual situations. The development of contextual worksheets embedded with numeracy through a differentiated approach makes a significant contribution to fostering adaptive, meaningful, and student-centered learning. This study highlights that differentiation is not merely a teaching strategy, but also a structured design principle that accommodates the diversity of students' potential and learning preferences in constructing numeracy understanding. By integrating contextual learning, numeracy tasks, and differentiated pathways within a single framework, this study extends prior research that tends to treat these components separately. Furthermore, it provides empirical evidence on how differentiated task design shapes students' mathematical thinking processes, including problem solving, conceptual understanding, procedural fluency, and estimation. Practically, the implementation of these worksheets supports more personalized, collaborative, and life-relevant mathematics learning experiences. Therefore, this study contributes both theoretically and practically by offering a validated model for designing inclusive numeracy-oriented learning materials in alignment with the Merdeka Curriculum. Future research may focus on optimizing the integration of digital technology and strengthening the teacher's role as a facilitator of differentiated instruction to enhance broader implementation and impact.

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Declarations

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