Journal of Advanced Sciences and Mathematics Education
Volume 6, Issue 3, 553-568.
e_ISSN: 2798-1606
DOI: 10.58524/jasme.v6i3.1533

Integrating culturally responsive teaching through treasure map-based mathematics learning: supporting students' conceptual understanding and numeracy literacy

Maria Luthfiana* Universitas PGRI Silampari, INDONESIA
Nur Fitriyana Universitas PGRI Silampari, INDONESIA
Anjelia Septyani Universitas PGRI Silampari, INDONESIA

Article Info

Article history:

Received: June 05, 2026
Revised: July 30, 2026
Accepted: Augst 20, 2026

Keywords:

Culturally Responsive Teaching; Mathematical Conceptual Understanding; Mathematics Learning; Numeracy Literacy; Treasure Map.

Abstract

Background: Mathematics learning frequently remains detached from students' cultural experiences, while culturally responsive learning media are still insufficiently integrated into classroom instruction, potentially limiting meaningful conceptual and numeracy development.
Aims: This study aimed to develop and evaluate a Treasure Map-based mathematics learning medium grounded in Culturally Responsive Teaching (CRT) to support students' mathematical conceptual understanding and numeracy literacy.
Method: The study employed a Research and Development (R&D) approach using the 4D model, comprising define, design, develop, and disseminate stages. Data were collected from 24 junior high school students through interviews, validation sheets, questionnaires, observations, and assessments of conceptual understanding and numeracy literacy, and were analyzed using descriptive and inferential statistics.
Results: Expert validation indicated that the developed medium satisfied the established feasibility criteria, while the practicality assessment reached 96.11%, indicating very high practicality. Following classroom implementation, 21 of 24 students (87.5%) achieved the predetermined mastery criterion.
Conclusion: CRT-integrated Treasure Map-based mathematics learning represents a valid and highly practical instructional alternative with promising potential to support students' conceptual understanding and numeracy literacy through culturally meaningful, contextual, and exploratory mathematical experiences.

To cite this article: Luthfiana, M., Fitriyana, N. & Septyani, A. (2026). Integrating culturally responsive teaching through treasure map-based mathematics learning: supporting students' conceptual understanding and numeracy literacy. *Journal of Advanced Sciences and Mathematics Education, 6*(3), 531-552.

INTRODUCTION

Numeracy literacy has become an essential mathematical competency for enabling students to respond effectively to the demands of contemporary society. Beyond computational proficiency, numeracy requires learners to interpret quantitative information, recognize mathematical relationships, and apply mathematical knowledge to problems situated in everyday contexts (Díez-Palomar et al., 2023; Hoogland, 2023; Reyna & Brainerd, 2023; Sakurai & Goos, 2023; Tout, 2020). However, many students continue to experience difficulties in transferring mathematical knowledge acquired through classroom instruction to situations beyond routine exercises (Bobis et al., 2021; Gunzenhauser & Nückles, 2021; Nakakoji & Wilson, 2020; Tai & Wei, 2020). This challenge suggests that successful mathematics learning should not be limited to procedural performance but should enable students to understand when, why, and how mathematical ideas can be applied meaningfully. Numeracy literacy consequently involves the ability to analyze numerical information, interpret mathematical symbols, and employ quantitative reasoning when addressing practical problems (Sari et al., 2021). These competencies are particularly important because mathematical information

***Corresponding author:**
marialuthfiana, Universitas PGRI Silampari, Indonesia
marialuthfiana8@gmail.com

encountered in everyday life can appear in multiple representations, including numbers, graphs, tables, diagrams, and contextual statements. At the same time, numeracy development is increasingly associated with culturally meaningful learning because students interpret mathematical situations through experiences shaped by their social and cultural environments. Developing numeracy therefore requires instructional experiences that enable students to understand contextual problems, formulate mathematical representations, employ appropriate concepts and procedures, and interpret the solutions they generate. These processes demonstrate that numeracy literacy is closely connected to mathematical conceptual understanding because students cannot meaningfully apply mathematics without understanding the concepts underlying their reasoning. Strengthening both competencies should consequently become an integrated priority in mathematics instruction rather than treating conceptual knowledge and contextual mathematical application as separate learning outcomes.

Mathematical conceptual understanding is particularly important at the junior high school level because increasingly complex mathematical content requires students to establish relationships among concepts rather than merely reproduce formulas and procedures. Nevertheless, students may encounter difficulties in constructing such understanding when mathematics is presented without meaningful connections to their experiences and cultural environments (Sari et al., 2021). Conceptual understanding enables learners to explain mathematical ideas, establish connections among concepts, select appropriate representations, and apply their knowledge flexibly when solving problems. These capabilities are difficult to cultivate through mechanical instruction that predominantly emphasizes procedural repetition because meaningful understanding requires students to actively construct relationships between mathematical ideas and relevant contexts. Accordingly, mathematics instruction should provide learning experiences that connect formal knowledge with situations familiar to students and encourage them to interpret mathematics as meaningful rather than isolated symbolic knowledge (Alam & Mohanty, 2024). One pedagogical framework capable of facilitating such connections is Culturally Responsive Teaching (CRT), which recognizes students' cultural backgrounds, identities, experiences, and knowledge as resources for classroom learning. CRT enables mathematical content to be situated within culturally meaningful contexts while simultaneously creating inclusive learning experiences responsive to learner diversity (Abdulrahim & Orosco, 2020; Anyichie, 2025; Kolovou, 2023; Stone et al., 2025). Rather than positioning culture as an additional element detached from mathematical content, culturally responsive instruction can use students' experiences as entry points for constructing formal mathematical meaning. This orientation corresponds with the principle that mathematical thinking can be strengthened by connecting students' intuitive understanding of everyday situations with formal mathematical knowledge. Therefore, CRT provides a relevant pedagogical foundation for mathematics instruction intended to support conceptual understanding and numeracy literacy through contextual, inclusive, and culturally meaningful learning experiences.

Translating culturally responsive principles into classroom practice also requires instructional resources capable of representing mathematical ideas visually while encouraging students to explore contextual problems actively. Interactive and visual learning media can reduce the perceived abstraction of mathematics by providing representations through which learners can examine mathematical relationships and engage with concepts in more accessible ways (Harianto & Sudatha, 2023; Wedayanti & Wiarta, 2022). Among the exploratory formats that can serve this purpose, Treasure Map-based learning organizes mathematical activities as sequential challenges in which students navigate learning stations, interpret clues, collaborate, and solve contextual problems. The combination of visual representation, adventure-oriented narratives, and structured exploration provides opportunities to position students as active participants rather than passive recipients of mathematical information. Within a CRT framework, these activities can incorporate

culturally familiar objects, environments, and everyday experiences so that mathematical exploration becomes connected to contexts students can recognize and interpret. Previous research has established CRT as an important orientation in mathematics education and has investigated culturally responsive mathematics teaching from the perspectives of instructional strategies, cultural identities, teacher practices, and inclusive mathematics learning (Abdulrahim & Orosco, 2020; Nolan & Xenofontos, 2023; Register et al., 2022). Research has also increasingly connected culturally responsive approaches with particular mathematical competencies, including mathematical conceptual understanding and numeracy literacy (Jovanka et al., 2026; Ruppert et al., 2022; Sirait et al., 2026). Meanwhile, exploratory Treasure Map activities have been introduced separately within mathematics learning to facilitate engagement with mathematical tasks (Sulistyani et al., 2024). Despite these developments, existing research provides limited evidence concerning the systematic integration of CRT principles into Treasure Map-based mathematics learning, particularly when conceptual understanding and numeracy literacy are simultaneously positioned as targeted competencies. This fragmentation leaves an important gap concerning how culturally meaningful contexts can be translated into the visual, exploratory, collaborative, and problem-solving architecture of a Treasure Map learning medium rather than being incorporated merely as supplementary examples.

Previous research has established Culturally Responsive Teaching (CRT) as an important pedagogical orientation in mathematics education, particularly for connecting mathematical learning with students' cultural identities, experiences, and backgrounds (Abdulrahim & Orosco, 2020; Kolovou, 2023). Subsequent studies have extended this perspective by examining teachers' culturally responsive practices, perspectives, and preparation for culturally relevant mathematics instruction, including its potential to promote inclusive learning and social justice (Nolan & Xenofontos, 2023; Register et al., 2022; Ruppert et al., 2022). More recent research has begun to connect culturally responsive approaches with specific mathematical competencies, including numeracy literacy through culturally responsive problem-based learning (Sirait et al., 2026), while culturally responsive pedagogical perspectives have also been investigated in relation to literacy and numeracy development (Jovanka et al., 2026). In parallel, exploratory approaches involving a Treasure Map game have been incorporated into mathematics learning to support students' engagement with mathematical tasks (Sulistyani et al., 2024). Nevertheless, these strands of research remain relatively fragmented: studies of CRT primarily emphasize pedagogical strategies, teacher perspectives, cultural inclusion, or particular learning competencies, whereas Treasure Map-based research has been investigated separately as an exploratory learning strategy. Consequently, limited attention has been directed toward systematically embedding CRT principles within Treasure Map-based mathematics learning and examining how this integration can simultaneously support students' mathematical conceptual understanding and numeracy literacy. The present study addresses this gap by developing and evaluating a CRT-integrated Treasure Map-based mathematics learning medium that combines culturally meaningful contexts with exploratory mathematical activities to support both competencies.

Responding to this research gap, the present study aimed to develop and evaluate Treasure Map-based mathematics learning grounded in Culturally Responsive Teaching to support junior high school students' mathematical conceptual understanding and numeracy literacy. The study specifically sought to transform culturally responsive principles into an exploratory mathematics learning medium that connects formal mathematical ideas with contexts familiar to students. The development was structured using the 4D framework encompassing the define, design, develop, and disseminate stages. Through this process, cultural contexts were incorporated into mathematical activities presented through visual exploration, sequential learning stations, collaborative tasks, and contextual problem solving. The study first examined the validity of the developed medium through

evaluations conducted by experts in relevant areas. It subsequently investigated the practicality of the Treasure Map to determine its feasibility and usability during mathematics instruction. Classroom implementation was also conducted to examine students' achievement of the predetermined learning mastery criterion after experiencing the developed learning activities. These evaluations positioned the study beyond the development of an attractive visual resource by examining the Treasure Map as a pedagogically structured medium for implementing CRT principles in mathematics learning. In doing so, the study seeks to contribute to the emerging intersection between culturally responsive mathematics education, exploratory instructional media, mathematical conceptual understanding, and numeracy literacy. Ultimately, the study is expected to provide a contextual and culturally meaningful instructional alternative through which students can construct mathematical concepts and apply their mathematical knowledge within relevant learning situations.

LITERATURE REVIEW

Numeracy literacy has increasingly been conceptualized as a multidimensional mathematical competency that extends beyond computational proficiency to include conceptual understanding, procedural fluency, strategic reasoning, and mathematical communication (Asmara et al., 2026; Barham et al., 2026; Proshkin & Astafieva, 2025). From this perspective, numeracy requires students to interpret quantitative information and mobilize mathematical knowledge appropriately when responding to contextual problems. The development of these competencies therefore depends on learning experiences that provide opportunities to connect formal mathematical knowledge with situations that are meaningful to students. Technology-supported instructional environments have emerged as one avenue for facilitating such connections by providing interactive and contextual opportunities for mathematical exploration. Demonstrated that Problem-Based Learning supported by MathCityMap can facilitate students' mathematical literacy development. This finding indicates that technology can function not merely as a delivery mechanism but also as an environment through which students encounter, interpret, and solve contextual mathematical problems. Similarly, contextual learning environments encourage students to construct mathematical meaning through active interaction with realistic problems rather than relying exclusively on memorized procedures. Such environments are particularly relevant to numeracy because students need opportunities to formulate problems mathematically, select appropriate concepts and procedures, and interpret their solutions in relation to the original context. Accordingly, effective numeracy instruction should integrate conceptual knowledge, authentic problem situations, mathematical reasoning, and active learner participation within coherent learning experiences. This multidimensional perspective establishes an important theoretical foundation for examining instructional designs that combine contextualization, technology, and culturally meaningful mathematical exploration.

Mathematical conceptual understanding constitutes an essential foundation for meaningful mathematics learning because students must comprehend relationships among mathematical ideas before they can apply those ideas flexibly to different situations. Conceptual understanding is reflected in students' capacity to restate previously learned concepts using comprehensible language and appropriately apply those concepts when addressing mathematical tasks (Ncube & Luneta, n.d.; Torres-Peña et al., 2025). This competency differs from procedural reproduction because meaningful understanding requires students to recognize the underlying structure and relationships associated with mathematical concepts. Mathematics instruction should therefore provide opportunities for learners to construct, explain, represent, and apply concepts rather than simply reproduce formulas or algorithms. The central position of concepts in mathematics instruction, indicating that conceptual knowledge provides a basis for developing other mathematical competencies (Tahir et al., 2022).

When students possess coherent conceptual knowledge, they are better positioned to select appropriate procedures and transfer their understanding to unfamiliar mathematical problems. Identify conceptual understanding as a foundational competency for mathematical problem solving, encompassing the ability to define concepts, establish relationships among them, and express mathematical ideas through appropriate forms. These characteristics indicate a close theoretical relationship between conceptual understanding and numeracy literacy because contextual mathematical reasoning requires students to mobilize concepts rather than rely solely on procedural recall. Instructional experiences intended to develop these competencies should consequently provide opportunities for students to connect mathematical representations, contextual situations, and formal concepts through active meaning-making processes. Thus, mathematical conceptual understanding and numeracy literacy can be positioned as complementary competencies that may be developed simultaneously through contextual and exploratory mathematics learning.

Culturally Responsive Teaching (CRT) provides a pedagogical framework through which contextual mathematics learning can be connected more explicitly with students' cultural knowledge, identities, and lived experiences. CRT conceptualizes culture not as an additional classroom topic but as a meaningful resource that can inform the design and implementation of learning experiences. Within this perspective, students enter mathematics classrooms with cultural knowledge and experiences that can provide meaningful points of connection for constructing formal mathematical understanding. CRT therefore seeks to strengthen students' cultural identities while facilitating their engagement with academic knowledge through learning experiences responsive to their backgrounds (Lestari et al., 2024). That culturally responsive instruction integrates students' cultural knowledge into the learning process to establish environments that are both relevant and inclusive. Such integration can influence the selection of learning contexts, mathematical problems, classroom interactions, and instructional resources used to facilitate student participation. Constructivist principles further reinforce this orientation because knowledge is developed through students' active interpretation of learning experiences rather than received passively from instruction. Culturally responsive approaches consequently provide opportunities for students to connect formal mathematical ideas with culturally recognizable situations while developing appreciation for cultural diversity. In mathematics education, this connection is particularly valuable because culturally familiar contexts can provide concrete entry points for understanding mathematical concepts that may otherwise appear abstract or disconnected from everyday experience. CRT can therefore serve as the pedagogical foundation for designing mathematics learning that simultaneously promotes cultural relevance, conceptual meaning, and contextual mathematical reasoning.

The implementation of culturally responsive mathematics learning can be strengthened through instructional media capable of translating contextual experiences into visual, spatial, and exploratory mathematical activities. Instructional media are particularly relevant when mathematical content involves abstract representations that may be difficult for students to interpret without appropriate visual or contextual support. The role of visual instructional media in facilitating students' understanding of mathematical concepts by reducing the abstraction associated with mathematical content. Visual representations can enable learners to observe relationships, organize information, and connect symbolic expressions with more accessible representations of mathematical ideas. A broader synthesis similarly demonstrates the educational value of visualization interventions for mathematics learning, reinforcing the importance of appropriately designed visual representations (Schoenherr et al., 2024). Within this framework, Treasure Map-based learning offers a distinctive instructional structure by combining visual representation with sequential exploration, narrative, and mathematical challenges. Mathematical tasks can be organized into stations or missions that require students to interpret information, identify relevant concepts,

collaborate with peers, and progress through interconnected problem-solving activities. The exploratory structure also creates opportunities to integrate digital resources and contextual problems rather than presenting mathematical concepts exclusively through conventional worksheets or teacher explanations. When culturally familiar objects and situations are embedded within these activities, the Treasure Map can provide an instructional space in which visual exploration and cultural responsiveness operate together to support mathematical meaning-making. Consequently, Treasure Map-based learning has theoretical potential to operationalize CRT principles through an instructional medium that combines contextualization, visualization, exploration, collaboration, and mathematical problem solving.

The integration of Culturally Responsive Teaching and Treasure Map-based mathematics learning consequently provides a conceptual framework for simultaneously supporting students' mathematical conceptual understanding and numeracy literacy. CRT contributes culturally meaningful contexts through which students can recognize relationships between formal mathematics and experiences situated within their social and cultural environments. Treasure Map-based learning, in contrast, provides a visual and exploratory architecture through which those contexts can be transformed into sequential mathematical challenges requiring active participation. This combination is theoretically consistent with evidence emphasizing the importance of contextual environments for constructing mathematical meaning and visual representations for facilitating mathematics learning (Schoenherr et al., 2024). It also aligns with contemporary perspectives that position numeracy as involving interconnected conceptual, procedural, reasoning, and communication competencies (Asmara et al., 2026; Barham et al., 2026; Proshkin & Astafieva, 2025). Within such an environment, conceptual understanding can be developed as students interpret, connect, represent, and apply mathematical ideas while progressing through contextual challenges. Numeracy literacy can simultaneously be exercised when students identify mathematical information within culturally situated problems, determine suitable strategies, employ relevant concepts, and interpret their solutions within the given context. The instructional medium therefore functions not merely as a visual supplement but as a structured environment connecting culturally responsive pedagogy with mathematical exploration. This theoretical integration distinguishes CRT-based Treasure Map learning from approaches in which culture, instructional media, conceptual understanding, or numeracy are treated as relatively independent components of mathematics instruction. Accordingly, the present study conceptualizes CRT-integrated Treasure Map-based mathematics learning as an instructional design through which culturally meaningful, visual, contextual, and exploratory experiences can jointly support students' mathematical conceptual understanding and numeracy literacy.

METHOD

Research Design

This study uses a Research and Development (R&D) approach to design and evaluate student worksheets for each post on a Culturally Responsive Teaching (CRT)-based treasure map as an innovative learning medium in mathematics learning. The development process adopts a 4D model, which consists of four systematic stages: defining, designing, developing, and disseminating. In the defining stage, an initial analysis is conducted to identify student characteristics, analyze learning problems, and determine product development objectives. In the designing stage, a preliminary analysis is conducted to identify student characteristics, analyze learning issues, and establish product development objectives. During the design stage, research instruments are prepared, appropriate learning media are selected, and the format of the treasure map is determined. The prototype design incorporates key components such as a cover, directional instructions, and station-

specific processes that emphasize numeracy literacy and students' mathematical conceptual understanding; it also includes learning materials and student activities aligned with indicators of conceptual understanding. In the development stage, the prototype undergoes expert validation involving specialists in mathematics education, instructional design, and interactive media. This validation process ensures the developed product meets quality standards and aligns with student needs. Following validation, a limited trial is conducted to evaluate the product's practicality based on student responses. The effectiveness of the CRT-based treasure map is subsequently tested using a quasi-experimental design involving experimental and control groups. The dissemination stage involves introducing the final product to mathematics teachers through professional forums to support broader implementation.

Participant

The participants in this study were eighth-grade students from SMP Negeri 9 Lubuklinggau, comprising five classes at the same grade level. A total of 128 students were involved across the various stages of the research. During the limited trial phase, one class (Class VIII.3), consisting of 24 students, participated in testing the practicality of the "treasure map" media. For the effectiveness testing phase, a single class was selected using random sampling; Class VIII.2, comprising 22 students, was chosen to use the CRT-based treasure map media during instruction. the comparability of characteristics and academic achievement between the two groups.

Instruments and Data Collection

The data collection process employed several instruments: interviews; expert validation sheets (involving a media expert, a language expert, and a subject matter expert); student response questionnaires; observation sheets; and tests assessing numeracy literacy and students' mathematical conceptual understanding. Interview guidelines were used during the define phase to identify learning issues and student needs. Validation sheets were utilized by experts to assess the quality of the "treasure map" media in terms of content and design. Student response questionnaires were used to evaluate the product's practicality. Observation sheets were used to monitor the implementation of learning activities. The conceptual understanding test was designed based on five indicators: restating concepts, classifying, providing examples and non-examples, presenting concepts, and applying concepts. A detailed description of these indicators is presented in Table 1.

Table 1. Indicators of Mathematical Conceptual Understanding

No.	Indicator
1	Restating concepts that have been learned
2	Classifying objects based on whether or not they meet conceptual criteria
3	Implementing the concept algorithmically
4	Providing examples and non-examples of the concepts that have been learned
5	Presenting concepts in various forms of mathematical representation

At the end of the learning process, all students were administered a test assessing their mathematical concept understanding and numeracy literacy. These instruments were used to determine the effectiveness of the CRT-based "treasure map" media in improving student learning outcomes.

Data Analysis

In this study employed both qualitative and quantitative approaches. Qualitative data obtained from interviews were analyzed descriptively to identify initial learning conditions and instructional needs. Quantitative data from validation sheets and questionnaires were analyzed using descriptive statistics to determine the validity and practicality of the "treasure map" media. The validity assessment involved three validators: one mathematics teacher and two university

lecturers. A Likert scale ranging from 1 to 4 was used, where 1 indicated "strongly disagree" and 4 indicated "strongly agree." The categorization of validity scores is presented in Table 2.

Table 2. Interpretation of Content Validity

No	Koefisien Korelasi	Interpretasi Validitas
1	≥ 0,80	Tall
2	0,60 ≤ < 0,80	quite high
3	0,40 ≤ < 0,60	Enough
4	0 ≤ < 0,40	Bad

The treasure map medium can be used if its validity is sufficiently high. Practicality is assessed based on student response questionnaires. The practicality criteria are presented in Table 3.

Table 3. Practicality test score analysis

No	Percentage (%)i	Category
1	85 - 100	Very Practical
2	70 - 84	Practical
3	60 - 69	Less Practical
4	< 60	Not Practical

The “Treasure Map” method is considered effective if the average score exceeds 60%. To test its effectiveness, student learning outcomes are assessed using evaluation questions designed in accordance with indicators of students’ mathematical conceptual understanding

Procedure

The module development research procedure was adapted from the 4-D instructional materials development model developed by Thiagarajan, Semmel & Semmel (1974) as cited in Trianto (2010), which generally consists of four stages: define, design, develop, and disseminate. The definition stage. This stage aims to establish and define the requirements for learning. It begins with an analysis of the objectives and scope of the material, which includes several key steps: a) a beginning-end analysis. The beginning-end analysis aims to identify the fundamental problems encountered in learning; b) task analysis; c) concept analysis; and d) specific objectives. During the design phase, the structure and content of the treasure map media were developed, including learning objectives, instructions, and activities based on CRT principles. In the development phase, the prototype was validated by experts and revised based on their feedback. Development phase. The objective of this stage is to produce a treasure map that has been revised based on expert feedback. This stage includes: (1) validation by experts followed by revisions, (2) simulation that is, the activity of implementing the lesson plan, and (3) a limited pilot test with actual students. The results of stages (2) and (3) are used as the basis for further revisions. The next step is further testing with students in actual classroom settings. Dissemination phase. The final product is introduced to mathematics teachers through professional forums to support wider implementation.

RESULTS AND DISCUSSION

Results

The needs analysis reveals that mathematics instruction—specifically regarding the topic of circles-remains dominated by conventional worksheets that emphasize procedural practice devoid of contextual or cultural relevance. Students' numeracy literacy skills are closely linked to their self-efficacy. Teacher interviews indicate that students often lack confidence in their ability to master mathematical material; consequently, they fail to grasp the concepts effectively and perceive mathematics as a difficult subject, leading them to give up easily when faced with problems that are slightly more challenging than previous ones. Furthermore, students demonstrate low levels of numeracy literacy, particularly in the process of comprehending problems. Additionally, the instructional media used in the classroom is largely limited to printed worksheets, which lack interactivity and accessibility outside the classroom. These findings highlight an urgent need to develop culturally responsive "treasure map" instructional media to foster meaningful and engaging mathematics learning.

Product

The product developed is a CRT-based "treasure map" learning medium designed to integrate conceptual understanding skills with a culturally relevant learning context. The structure of the treasure map includes learning objectives, instructions, and activity stations aligned with indicators of students' conceptual understanding and numeracy literacy. Integrating local cultural contexts into learning activities that utilize "treasure map" media enables students to interact more meaningfully with mathematical concepts and fosters strong numeracy skills.

Figure 1. CRT-Based Treasure Map Learning Medium for Exploring the Surface Area of a Sphere

Product Validity

Validation results from experts indicate that the developed "treasure map" media meets validity criteria regarding content, language, and the medium itself. The research results indicate that the CRT-based treasure map medium is suitable for use in mathematics instruction.

Table 4. Summary of Validator Evaluations

No.	Validator	Validation value	Category
1	Linguist	0,68	Valid
2	Media Exoert	0,67	Valid
3	subject matter expert	0,70	Valid

Product Practicality

The practicality test involved 24 students and evaluated technical usability, visual design, and content clarity.

Table 5. Summary of Data on Teacher and Student Practical Skills (*Small Group*)

No.	evaluation	Practicality Score	Category
1	Teachers' Practicality	88,33%	Very practical
2	Students' Practical Skills	100%	Very practical
	amount	96,11%	Very practical

This research study aims to determine the extent to which the "treasure map" media integrated with cultural principles influences student learning outcomes. A summary of the results is presented in the following table.

Table 6. Results of the Analysis of Potential Effects

Value Range	Number of student	Presentase (%)	category
71 ≤ x ≤ 100	21	87,5%	completed
x < 71	3	12,5%	Not completed
amount	**24**	**100%**	

Discussion

The findings indicate that the CRT-based Treasure Map provides a promising instructional environment for supporting students' mathematical conceptual understanding and numeracy literacy through culturally contextualized and visually mediated learning. The potential-effect analysis showed that 21 of the 24 students (87.5%) achieved the predetermined mastery criterion, whereas only three students (12.5%) remained below the threshold. This result suggests that most students were able to engage successfully with the mathematical competencies addressed through the developed learning activities. One possible explanation is that the Treasure Map transforms mathematical learning from predominantly procedural exercises into sequential activities requiring students to interpret information, explore mathematical relationships, and apply concepts within contextual situations. Its visual structure can also help make relatively abstract mathematical content, such as the surface area of a sphere, more accessible by connecting formal representations with recognizable objects and situations. This interpretation is consistent with emphasize the educational potential of technology-supported and contextually meaningful learning environments for promoting active and meaningful knowledge construction (Alam & Mohanty, 2024). Similarly, indicates that connecting mathematical content with students' experiences can facilitate more meaningful engagement with mathematical ideas (Abrahamson et al., 2020; Koskinen & Pitkäniemi, 2022; Polman et al., 2021; Rehman et al., 2024; Webb et al., 2023). The present findings further suggest that the instructional value of the Treasure Map does not derive exclusively from its visual attractiveness but from the interaction among visualization, contextual problems, collaborative exploration, and culturally meaningful content. Students encounter mathematical concepts through familiar representations and subsequently translate these experiences into formal mathematical relationships, thereby creating a bridge between contextual understanding and abstract reasoning. Accordingly, the observed mastery outcomes provide preliminary evidence that combining culturally relevant contexts with exploratory visual media can create productive conditions for developing mathematical conceptual understanding and numeracy literacy.

The findings concerning numeracy literacy should also be interpreted in relation to students' conceptual understanding and their confidence when engaging with mathematical problems. The study explored students' numeracy processes through essay tasks on the surface area of a sphere and follow-up interviews with students representing different levels of self-efficacy. This procedure

provided qualitative information concerning how students understood contextual problems, selected mathematical concepts, formulated solution strategies, and interpreted their responses. The findings suggest that students who demonstrated stronger confidence and understanding were generally better positioned to navigate the mathematical reasoning required by the numeracy tasks. Conceptual understanding is particularly relevant because students cannot successfully interpret contextual quantitative information when the mathematical relationships underlying a problem remain unclear. This interpretation is compatible with contemporary research that positions conceptual knowledge as a foundational component of mathematical problem solving and numeracy development. It also corresponds with recent conceptualizations of numeracy as a multidimensional competence involving conceptual understanding, procedural fluency, strategic reasoning, and mathematical communication (Asmara et al., 2026; Barham et al., 2026; Proshkin & Astafieva, 2025). The relationship is therefore potentially reciprocal: conceptual understanding provides mathematical resources for solving numeracy problems, while contextual numeracy activities create opportunities for students to apply and consolidate their conceptual knowledge. However, the evidence from the three interviewed students should be regarded as illustrative of different reasoning profiles rather than as sufficient evidence of a statistically significant affective effect or a general relationship between self-efficacy and numeracy. Thus, the results more appropriately indicate that students' confidence, conceptual understanding, and numeracy reasoning may interact during contextual mathematical problem solving, warranting more systematic investigation with validated affective measures and larger samples.

A central contribution of the developed Treasure Map lies in its operationalization of Culturally Responsive Teaching through mathematical contexts that reflect recognizable elements of students' everyday and cultural environments. Rather than incorporating culture as supplementary information, the medium uses familiar objects and settings as entry points for exploring formal mathematical ideas. For example, the spherical form associated with a mosque dome and familiar round objects or foods provides contextual representations through which students can investigate mathematical relationships related to spheres. Such contextualization corresponds with CRT principles that recognize students' cultural knowledge and lived experiences as legitimate resources for constructing academic knowledge similarly emphasize the importance of culturally responsive learning for connecting students' identities and experiences with instructional processes. Within the Treasure Map, this cultural responsiveness is combined with an inclusive adventure-zone structure in which students work collaboratively, share responsibilities, discuss mathematical challenges, and contribute to group problem solving. Consequently, cultural responsiveness operates not only through the objects represented in mathematical problems but also through learning interactions that encourage participation and acknowledge diversity among learners. This distinction is important because meaningful CRT implementation extends beyond the superficial inclusion of cultural symbols and requires cultural relevance to influence how mathematical knowledge is contextualized, explored, and communicated. The present study therefore extends conventional contextual mathematics learning by positioning students' cultural environments as pedagogical resources within a structured exploratory medium. In this sense, the Treasure Map provides a practical mechanism for translating the theoretical principles of CRT into observable mathematics learning activities.

Another important feature of the developed medium is the integration of cultural contextualization with digital and interactive resources, including instructional videos, online worksheets accessed through barcodes, GeoGebra, and Quizizz. These resources provide multiple forms of representation and interaction through which students can move between contextual situations, visual mathematical models, formal concepts, and problem-solving activities. Such integration is relevant because contemporary mathematics learning increasingly requires

instructional environments that combine conceptual reasoning with active, visual, collaborative, and technology-supported experiences. The approach is highlighted the potential of MathCityMap-supported learning for developing mathematical literacy through contextual and technology-mediated mathematical activities. Although MathCityMap and the present Treasure Map differ in format, both approaches organize mathematics around exploration and contextual tasks rather than presenting mathematical knowledge exclusively through conventional exercises. This comparison suggests that the educational value of map-based mathematics learning may derive not simply from the map itself but from how spatial exploration, contextual problems, and mathematical reasoning are pedagogically connected. The cultural dimension introduced in the present study adds another layer because the contexts embedded within the learning activities are intended to connect mathematical reasoning with experiences recognizable to students. This interpretation is supported by the recent integrative which identifies culturally responsive pedagogy and culturally grounded mathematics approaches as important directions for strengthening numeracy in Indonesia (Nursyahidah et al., 2025; Payadnya et al., 2025). The present study therefore contributes to this developing literature by operationalizing culturally responsive numeracy through a concrete instructional medium rather than addressing cultural responsiveness only at the level of general pedagogical principles. Importantly, however, the reported mastery percentage combines the classroom outcome into a potential-effect indicator and does not provide sufficiently differentiated evidence to determine the magnitude of improvement in numeracy literacy independently from conceptual understanding. The findings should consequently be interpreted as preliminary evidence that the medium can support a learning environment conducive to numeracy-related activity, while stronger claims require separate pretest-posttest analyses and inferential comparisons for each outcome.

Despite these encouraging findings, the results need to be interpreted within the methodological boundaries of the study rather than as definitive evidence that the CRT-based Treasure Map causes improvements in conceptual understanding and numeracy literacy. First, implementation was situated within a single school and involved a relatively limited number of students during the reported trial, restricting the extent to which the findings can be generalized to different educational and cultural settings. Second, although the study addresses both mathematical conceptual understanding and numeracy literacy, the reported potential-effect analysis primarily presents the proportion of students achieving an overall mastery threshold rather than separate estimates of learning gains for each competency. Third, the three students selected to represent different self-efficacy levels provide useful qualitative illustrations, but this evidence is insufficient to conclude that the intervention significantly enhanced self-efficacy or that self-efficacy statistically determined numeracy performance. Fourth, the relatively short implementation period prevents conclusions regarding whether the observed learning outcomes and student engagement would persist after the intervention had ended. Fifth, the incorporation of videos, online worksheets, GeoGebra, Quizizz, and other digital components means that successful implementation may depend partly on technological infrastructure that is not equally available across schools. Future studies should therefore involve larger and culturally more diverse samples, clearly specified experimental and comparison groups, and separate pretest-posttest measurements of conceptual understanding and numeracy literacy. Longitudinal or delayed post-test designs would also help determine whether students retain and transfer the mathematical understanding developed through culturally contextualized Treasure Map activities. Additional research could further examine mediating or moderating variables such as self-efficacy, mathematical engagement, collaborative participation, prior achievement, and digital learning readiness. Overall, the present findings support the CRT-based Treasure Map as a valid, highly practical, and pedagogically promising approach for connecting culturally meaningful experiences with mathematical conceptual understanding and numeracy

literacy, while more rigorous comparative evidence remains necessary to establish its causal effectiveness and broader applicability.

Implications

The findings indicate that integrating the Treasure Map medium with Culturally Responsive Teaching (CRT) offers meaningful implications for mathematics instruction, particularly in supporting students' mathematical conceptual understanding and numeracy literacy. By incorporating cultural contexts and familiar everyday situations, the medium provides a more contextual, interactive, and meaningful environment for engaging with mathematical ideas. For conceptual understanding, contextual problems can help students connect abstract mathematical concepts with concrete situations and subsequently identify, represent, interpret, and apply those concepts. For numeracy literacy, Treasure Map activities provide opportunities to formulate contextual problems mathematically, select relevant concepts and procedures, interpret quantitative information, and communicate solutions according to the problem context. Its exploratory structure also encourages students to use mathematics as a practical tool for interpreting and addressing situations connected with everyday life. Therefore, the Treasure Map functions not merely as a medium for presenting mathematical content but as an instructional environment connecting formal mathematics with students' cultural and experiential realities. From a pedagogical perspective, this approach provides teachers with an alternative for integrating cultural responsiveness, contextual problem solving, visual exploration, and collaborative activities within mathematics instruction. The findings consequently illustrate the potential of CRT-based Treasure Map learning as an innovative approach for making mathematics more culturally meaningful while supporting conceptual and numeracy-oriented learning.

Limitations and Suggestions for Future Research

Several limitations should be considered when interpreting these findings. The study was conducted in a single school with a relatively limited sample, which restricts the generalizability of the results to broader educational and cultural contexts. In addition, the reported potential effects were primarily based on mastery achievement and did not provide separate estimates of learning gains for conceptual understanding and numeracy literacy. The relatively short implementation period also prevents conclusions regarding the retention and transfer of students' learning over time. Furthermore, the integration of digital resources may create implementation differences among schools with unequal technological infrastructure. Future research should therefore involve larger multi-school samples, clearly defined comparison groups, and separate pretest–posttest assessments of conceptual understanding and numeracy literacy. Longitudinal or delayed post-test designs are also recommended to examine the sustainability of learning outcomes. Further studies could additionally investigate self-efficacy, engagement, collaboration, and digital readiness to provide a more comprehensive understanding of how CRT-based Treasure Map learning influences students' mathematical learning.

CONCLUSION

This study demonstrates that integrating the Treasure Map medium with Culturally Responsive Teaching (CRT) provides a promising approach to supporting junior high school students' mathematical conceptual understanding and numeracy literacy. The medium combines culturally familiar contexts, visual exploration, collaborative activities, and digital resources to connect abstract mathematical concepts, particularly those related to spheres, with students'

everyday experiences. Expert validation confirmed that the medium met the established validity criteria, with coefficients of 0.68 for language, 0.67 for media, and 0.70 for subject matter. The overall practicality score reached 96.11%, indicating that the medium was highly practical for classroom implementation. Furthermore, 21 of 24 students (87.5%) achieved the predetermined mastery criterion, demonstrating promising potential learning effects. The integration of CRT enables cultural contexts to function as meaningful resources for exploring and applying mathematical concepts rather than merely as supplementary examples. Meanwhile, the Treasure Map structure encourages active participation through contextual problems, sequential exploration, collaboration, and technology-supported activities. These characteristics position the developed medium as a contextual and culturally responsive learning environment rather than simply a visual instructional aid. Nevertheless, the findings should be interpreted cautiously because the study involved a limited sample within a single-school context. Overall, CRT-integrated Treasure Map-based mathematics learning is valid, highly practical, and shows promising potential for supporting students' conceptual understanding and numeracy literacy through culturally meaningful mathematical experiences.

AUTHOR CONTRIBUTIONS STATEMENT

Maria Luthfiana contributed to the conceptualization, research design, development of the CRT-based Treasure Map learning medium, instrument preparation, data collection, data analysis, interpretation of the findings, and preparation of the original manuscript. Nur Fitriyana contributed to the research methodology, product development, validation process, data interpretation, supervision, and critical review of the manuscript. Anjelia Septyani contributed to data collection, classroom implementation, data analysis, visualization, interpretation of the findings, and review and editing of the manuscript. All authors contributed to the intellectual development of the study, reviewed the final manuscript, and approved the version submitted for publication.

REFERENCES

Abdulrahim, N. A., & Orosco, M. J. (2020). Culturally responsive mathematics teaching: A research synthesis. *The Urban Review*, *52*(1), 1–25. https://doi.org/10.1007/s11256-019-00509-2

Abrahamson, D., Nathan, M. J., Williams-Pierce, C., Walkington, C., Ottmar, E. R., Soto, H., & Alibali, M. W. (2020). The future of embodied design for mathematics teaching and learning. *Frontiers in Education*, *5*, Article 147. https://doi.org/10.3389/feduc.2020.00147

Alam, A., & Mohanty, A. (2024). Unveiling the complexities of 'abstract algebra' in university mathematics education (UME): Fostering 'conceptualization and understanding' through advanced pedagogical approaches. *Cogent Education*, *11*(1), 2355400. https://doi.org/10.1080/2331186X.2024.2355400

Anyichie, A. C. (2025). Developing and implementing a culturally responsive self-regulated learning framework: Exploring how teachers could empower culturally diverse learners in inclusive classroom environments. *SAGE Open*, *15*(4), 21582440251367830. https://doi.org/10.1177/21582440251367830

Asmara, A. S., Yusuf, Y., Prawiyogi, A. G., Zonyfar, C., Alhamssyah, M. A., & Alfarid, M. N. (2026). Profiling numeracy literacy among ninth-grade students: Empirical evidence from junior secondary education. *Infinity Journal*, *15*(1), 291–318. https://doi.org/10.22460/infinity.v15i1.p291-318

Barham, A., Naccache, H., & Hasan, M. (2026). Assessing the reliability and validity of a numeracy test for pre-service mathematics teachers: Cultivating proficiency in mathematics education. *Social Sciences & Humanities Open*, *13*, 102857. https://doi.org/10.1016/j.ssaho.2026.102857

Bobis, J., Russo, J., Downton, A., Feng, M., Livy, S., McCormick, M., & Sullivan, P. (2021). Instructional moves that increase chances of engaging all students in learning mathematics. *Mathematics*, *9*(6), Article 582. https://doi.org/10.3390/math9060582

Díez-Palomar, J., Ramis-Salas, M., Močnik, I., Simonič, M., & Hoogland, K. (2023). Challenges for numeracy awareness in the 21st century: Making visible the invisible. *Frontiers in Education*, *8*, Article 1295781. https://doi.org/10.3389/feduc.2023.1295781

Gunzenhauser, C., & Nückles, M. (2021). Training executive functions to improve academic achievement: Tackling avenues to far transfer. *Frontiers in Psychology*, *12*, Article 624008. https://doi.org/10.3389/fpsyg.2021.624008

Harianto, N. A., & Sudatha, I. G. W. (2023). Interactive multimedia with problem-based learning in mathematics. *Journal of Education Technology*, *7*(4), 610–618. https://doi.org/10.23887/jet.v7i4.64656

Hoogland, K. (2023). The changing nature of basic skills in numeracy. *Frontiers in Education*, *8*, Article 1293754. https://doi.org/10.3389/feduc.2023.1293754

Jovanka, D. R., Kurniati, E., Suryana, D., & Sagita, D. D. (2026). Early childhood teachers' perspectives on literacy and numeracy in West Papua: A culturally responsive pedagogical approach. *Journal of Early Childhood Teacher Education*, 1–25. https://doi.org/10.1080/10901027.2026.2703782

Kolovou, M. (2023). Embracing culturally relevant education in mathematics and science: A literature review. *The Urban Review*, *55*(1), 133–172. https://doi.org/10.1007/s11256-022-00643-4

Koskinen, R., & Pitkäniemi, H. (2022). Meaningful learning in mathematics: A research synthesis of teaching approaches. *International Electronic Journal of Mathematics Education*, *17*(2). https://doi.org/10.29333/iejme/11715

Lestari, F., Sriyanti, A., & Sulasteri, S. (2024). Pengembangan alat peraga papan trigonometri untuk meningkatkan kemampuan pemahaman konsep peserta didik materi trigonometri kelas X SMA. *Jurnal Silogisme: Kajian Ilmu Matematika dan Pembelajarannya*, *9*(1), 51–62. https://doi.org/10.24269/silogisme.v9i1.9046

Nakakoji, Y., & Wilson, R. (2020). Interdisciplinary learning in mathematics and science: Transfer of learning for 21st century problem solving at university. *Journal of Intelligence*, *8*(3), Article 32. https://doi.org/10.3390/jintelligence8030032

Ncube, M., & Luneta, K. (2025). Concept-based instruction: Improving learner performance in mathematics through conceptual understanding. *Pythagoras*, *46*(1), Article 815. https://doi.org/10.4102/pythagoras.v46i1.815

Nolan, K. T., & Xenofontos, C. (2023). The role of insights in becoming a culturally responsive mathematics teacher. *Education Sciences*, *13*(10), Article 1028. https://doi.org/10.3390/educsci13101028

Nursyahidah, F., Wardono, Mariani, S., & Wijayanti, K. (2025). Integrating technology, Javanese ethnomathematics, and realistic mathematics education in supporting prospective mathematics teachers' numeracy skills: A learning trajectory. *Journal on Mathematics Education*, *16*(2), 671–688. https://doi.org/10.22342/jme.v16i2.pp671-688

Payadnya, I. P. A. A., Prahmana, R. C. I., Noviantari, P. S., Wedasuwari, I. A. M., & Susrawan, I. N. A. (2026). Mathematics, local language, and cultural education: An exploration of Indonesian educators' perspectives. *Journal for Multicultural Education*, *20*(1), 91–103. https://doi.org/10.1108/JME-07-2025-0146

Polman, J., Hornstra, L., & Volman, M. (2021). The meaning of meaningful learning in mathematics in upper-primary education. *Learning Environments Research*, *24*(3), 469–486. https://doi.org/10.1007/s10984-020-09337-8

Proshkin, V., & Astafieva, M. (2025). Implementation of a conceptual and procedural approach in university-level mathematics education using the Moodle LMS. *International Journal for Technology in Mathematics Education*, *32*(3), 91–113. https://doi.org/10.1564/tme_v32.3.01

Register, J., Fernandes, A., & Pugalee, D. (2022). Supporting preservice mathematics teachers' culturally responsive teaching: A focus on teaching for social justice. *Mathematics*, *10*(6), Article 896. https://doi.org/10.3390/math10060896

Rehman, N., Huang, X., Mahmood, A., AlGerafi, M. A. M., & Javed, S. (2024). Project-based learning as a catalyst for 21st-century skills and student engagement in the math classroom. *Heliyon*, *10*(23), Article e39988. https://doi.org/10.1016/j.heliyon.2024.e39988

Reyna, V. F., & Brainerd, C. J. (2023). Numeracy, gist, literal thinking and the value of nothing in decision making. *Nature Reviews Psychology*, *2*(7), 421–439. https://doi.org/10.1038/s44159-023-00188-7

Ruppert, N. B., Coleman, B., Pinter, H., Johnson, D. T., Rector, M., & Diaz, C. (2022). Culturally sustaining practices for middle level mathematics teachers. *Education Sciences*, *12*(12), Article 910. https://doi.org/10.3390/educsci12120910

Sakurai, J., & Goos, M. (2023). Revisiting tools in numeracy learning: The role of authentic digital tools. *Frontiers in Education*, *8*, Article 1291407. https://doi.org/10.3389/feduc.2023.1291407

Sari, I. L., Irawan, E., Aristiawan, A., & Rokmana, A. W. (2021). Analisis tingkat penalaran peserta didik SMP dalam memecahkan masalah soal evaluasi berbasis literasi numerasi. *Jurnal Tadris IPA Indonesia*, *1*(3), 333–342. https://doi.org/10.21154/jtii.v1i3.135

Schoenherr, J., Strohmaier, A. R., & Schukajlow, S. (2024). Learning with visualizations helps: A meta-analysis of visualization interventions in mathematics education. *Educational Research Review*, *45*, 100639. https://doi.org/10.1016/j.edurev.2024.100639

Sirait, S., Mapilindo, & Anim. (2025). Improving students' numeracy literacy through culturally responsive problem-based learning. *The International Journal of Science, Mathematics and Technology Learning*, *33*(1), 159–178. https://doi.org/10.18848/2327-7971/CGP/v33i01/159-178

Stone, R., Smith, E. P., & Ebner, R. J. (2025). Culturally responsive mathematics and curriculum materials: Present realities and imagined futures. *Education Sciences*, *15*(9), Article 1246. https://doi.org/10.3390/educsci15091246

Sulistyani, N., Prasojo, L. D., Purnomo, Y. W., Ardhana, S. S., Fitriya, Y., & Putri, Y. D. (2024). Epistemological didactical situation of learning factors and multiples in elementary school students. *Mathematics Teaching Research Journal*, *16*(5), 66–91.

Tahir, N. N., Ismail, S., Oroh, F. A., Zakaria, P., & Usman, K. (2022). Analisis kemampuan pemahaman konsep matematika ditinjau dari penggunaan multimedia game petualangan dalam limas berbasis mobile learning di SMP Negeri 1 Tilango. *Euler: Jurnal Ilmiah Matematika, Sains dan Teknologi*, *10*(1), 15–25. https://doi.org/10.34312/euler.v10i1.12936

Tai, K. W. H., & Wei, L. (2020). Bringing the outside in: Connecting students' out-of-school knowledge and experience through translanguaging in Hong Kong English Medium Instruction mathematics classes. *System*, *95*, 102364. https://doi.org/10.1016/j.system.2020.102364

Torres-Peña, R. C., Peña-González, D., Lara-Orozco, J. L., Ariza, E. A., & Vergara, D. (2025). Enhancing numerical thinking through problem solving: A teaching experience for third-grade mathematics. *Education Sciences*, *15*(6), Article 667. https://doi.org/10.3390/educsci15060667

Tout, D. (2020). Evolution of adult numeracy from quantitative literacy to numeracy: Lessons learned from international assessments. *International Review of Education*, *66*(2), 183–209. https://doi.org/10.1007/s11159-020-09831-4

Webb, N. M., Franke, M. L., Johnson, N. C., Ing, M., & Zimmerman, J. (2023). Learning through explaining and engaging with others' mathematical ideas. *Mathematical Thinking and Learning*, *25*(4), 438–464. https://doi.org/10.1080/10986065.2021.1990744

Wedayanti, L. A., & Wiarta, I. W. (2022). Multimedia interaktif berbasis problem based learning pada muatan matematika kelas IV SD. *MIMBAR PGSD Undiksha*, *10*(1), 113–122. https://doi.org/10.23887/jjpgsd.v10i1.46320