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Development culture, technology and context-based performance assessment model to enhance students' problem-solving skills

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Abstract: Problem solving is an approach that bridges mathematical abilities and conceptual understanding. The aims of the current study are the integration of four elements: culture, technology, contextual learning, and performance assessment, which are combined into a single systematic and empirically tested model, namely the CTC-P model. This study employed a research and development (R&D) method. The development stage encompassed three main components: model validation, readability testing, and testing. The study was conducted at a junior high school. The class was selected through random sampling. The research instruments included teaching modules, instructional materials, student worksheets, and a mathematical problem-solving ability test. At the implementation stage, the refined model was disseminated and applied on a large scale using a quasi-experimental design. This design compared students' learning outcomes between an experimental group, which received instruction through the CTC-P model, and a control group, which engaged in conventional learning without intervention. The CTC-P learning model was deemed effective based on three criteria: 1) students are better able to solve math problems using the CTC-P model compared to other models; 2) the classical mastery criterion is achieved, with at least 75% of students scoring above 75; and 3) teachers can effectively implement the CTC-P model.
Keywords: *CTC-P model, Development, Problem solving.*

1. Introduction

The results from international assessments such as PISA 2022 indicate that students' mathematical problem-solving abilities remain low, particularly in indicators related to reasoning and applying concepts to situations. In fact, problem solving is a crucial bridge between procedural fluency and conceptual understanding. Their study further highlights those teachers play a crucial role in enhancing students' problem-solving skills. When teachers are able to foster students' interest in mathematics, students can develop their own problem-solving abilities and continuously improve themselves [1]. Similarly, Fisher [2] emphasizes that developing mathematical problem-solving skills requires attention to the process of solving, the formulas used, and the reasoning behind the solutions obtained. Such practices help students create diagrams, schemes, or problem maps that serve as a foundation for collaboration and discussion in solving mathematical problems. Polya [3] identified four key steps in mathematical problem solving: understanding the problem, devising a plan, carrying out the plan, and reviewing the solution. Furthermore, Murtiyasa and Wulandari [4] classify students' problem-solving ability into four levels: high, moderate, low, and very low. These perspectives offer a more comprehensive understanding of how students construct strategies, select representations, and evaluate solution pathways according to situational demands. Therefore, integrating these updated theoretical frameworks is essential for providing a more current and relevant foundation for analyzing students' problem-solving abilities within the present study.

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Other frameworks for identifying problem-solving indicators have been proposed by Dewey [5] and Krulik and Rudnick [6]. The five stages of problem solving are: (1) identifying the adequacy of given information, (2) formulating mathematical problems or constructing mathematical models, (3) applying strategies to solve problems, (4) interpreting solutions according to the problem context, and (5) using mathematics meaningfully. Similarly, Szabo et al. [7] describe four stages: (1) reading and understanding the problem, (2) planning the solution, (3) selecting appropriate strategies, and (4) finding the answer or solution. Moreover, Liljedahl et al. [8] define problem-solving ability through six stages: (1) formulating problems into mathematical models, (2) understanding the problem, (3) planning the solution, (4) implementing the plan, (5) verifying the obtained solution, and (6) connecting the solution to real-world contexts. Based on these frameworks, it can be concluded that mathematical problem solving involves a process of mathematization, where learners interpret and apply mathematical reasoning to real-life situations.

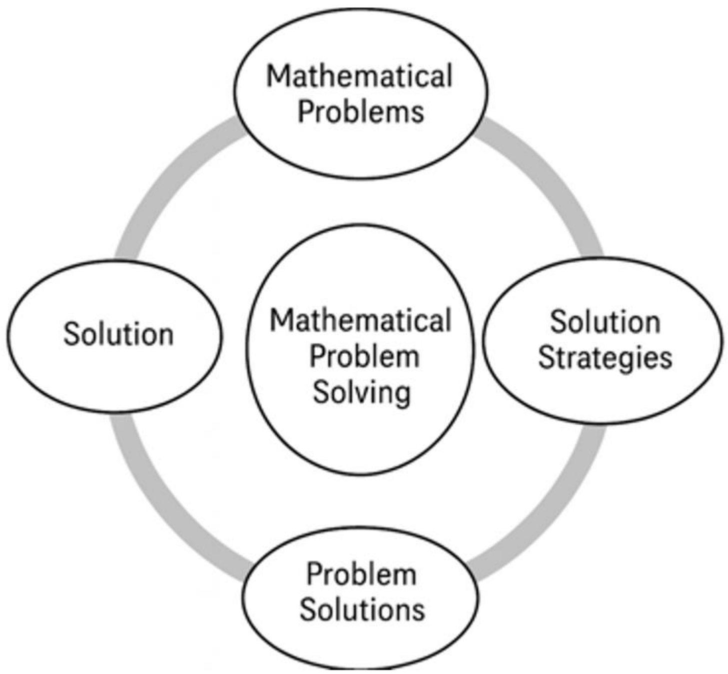

Figure 1.
Problem solving process.

In relation to solving mathematical problems in real-education contexts, the current development of mathematics learning methods has become increasingly diverse [9]. Advances in technology, digitalization, social dynamics, and even cultural dimensions have provided new elements that can be incorporated into mathematics instruction [10]. The inclusion of cultural aspects in education is commonly practiced in non-scientific subjects; however, integrating culture into science-related disciplines particularly mathematics remains relatively uncommon. Several studies have shown that embedding cultural elements in learning can foster students' awareness of and appreciation for their local heritage. The integration of culture into mathematics education is not a new phenomenon; rather, it has become a well-established area of enquiry within ethnomathematics. Over the past decades, ethnomathematics research has demonstrated how mathematical ideas are embedded in cultural practices, artistic traditions, local technologies, and community-based knowledge systems. A growing body of literature highlights that incorporating cultural elements in mathematics instruction can strengthen students' identity, enhance contextual understanding, and promote meaningful learning experiences. In this regard, the present study is positioned within the expanding scholarship on ethnomathematics by exploring how cultural practices specific to the local context can be utilized to support students' mathematical problem-solving abilities. This approach does not claim to introduce cultural integration as a rarity, but rather contributes to ongoing discussions on how culturally grounded mathematical tasks can enrich classroom learning.

Beyond learning itself, one crucial component in the educational process is assessment. Learning and assessment are inseparable components of instruction. Both teachers and students must understand their interrelation to achieve the intended competencies. Assessment in the learning process can take various forms, including observation, performance assessment, project-based evaluation, written and oral tests, assignments, and portfolios. Among these, performance assessment has been identified as particularly relevant to mathematics learning. Performance assessment can be used to evaluate students' mathematical knowledge**,** strategic knowledge, and mathematical communication**.**

Furthermore, research has shown that when performance assessment is implemented in mathematics learning, it tends to yield more comprehensive insights than portfolios or written assessments. This suggests that performance assessment offers a valuable alternative for evaluating students' mathematical learning progress, as it provides a more authentic picture of how far students have developed their understanding and problem-solving skills [11]. Performance assessment can be integrated into the learning process through appropriate models or approaches, including the Culture Techno Contextual (CTC) framework. The sequence or syntax of CTC naturally accommodates the use of performance assessment. By employing real-life problems, everyday activities, and culturally relevant contexts, this approach encourages students to engage more actively and perform better in solving mathematical problems.

The novelty of this study lies in the integration of four learning elements, culture, technology, real-world contexts, and performance assessment, into a unified and empirically tested instructional framework known as the CTC-P model. This integration is not merely an aggregation of components; rather, it establishes functional interdependencies that mutually enhance one another. Cultural values serve as the foundation for character formation and meaning-making; digital technology expands opportunities for representation, exploration, and visualization of mathematical ideas; real-world contexts provide authentic sources for constructing conceptual understanding; and performance assessment ensures that students' learning processes and outcomes are evaluated authentically in accordance with their developing competencies. The interaction of these four elements generates a learning environment that is meaningful, relevant, and measurable, an outcome that would not emerge if each element were implemented independently. Therefore, this study contributes theoretically by advancing an integrated learning design and practically by offering an applicable model to improve the quality of mathematics education.

Based on the identified gaps and the theoretical rationale presented in the introduction, this study is guided by the following research questions: How do the four elements, culture, technology, real-world contexts, and performance assessment, interact to form the synergistic mechanism of the CTC-P learning model? How does the implementation of the CTC-P model enhance students' mathematical problem-solving abilities?

2. Literature Review and Method

One effective way to connect students' learning experiences with their real-life contexts is through instructional materials derived from local or indigenous cultures [12]. They further emphasize that teachers must be innovative and creative in utilizing their surrounding environment, including local conditions and social realities, as learning resources. This relationship can be viewed from two perspectives: whether mathematics is inherently embedded within cultural practices or, conversely, how mathematics serves as a foundation for the creation of cultural symbols within society [9]. These two perspectives become the central mechanisms for integrating mathematical learning with local cultural elements [13]. As noted by Setiaputra et al. [14], ethnomathematics and mathematical literacy represent two key ideas in understanding the contemporary nature of mathematics.

The concept and development of culture-based learning are grounded in efforts to explore cultural dimensions while aligning learning objectives with expected outcomes [15]. Furthermore, Okebukola [15] explains that cultural learning can be effectively enhanced through the use of technology. For students, technology serves as a medium for constructing knowledge and facilitating thinking and communication processes, thereby reducing dependency on teachers. One form of technological application is providing students with visual media that link mathematical content to everyday phenomena and experiences. Consequently, the rapid growth of technological tools such as the internet and social media has become a major opportunity for accessible and engaging learning experiences.

One approach that integrates both cultural and technological elements is the Culture Techno Contextual (CTC) model. In the CTC learning framework, cultural values, technological tools, and contextual problem situations are interconnected and function as a unified system. Several studies have reported that the CTC approach is designed to overcome learning barriers by embedding cultural relevance, thereby creating more meaningful learning experiences. The model involves three key components: 1) Cultural context, in which all students actively participate; 2) Technology integration, which can be developed and adapted by teachers; and 3) Contextual problem situations, which are used as the basis for instructional activities.

This study employed a research and development (R&D) method. The R&D approach is designed to develop a new product or refine an existing one so that it becomes scientifically valid and practically applicable. The term *Research and Development* reflects a twofold process: *research*, which involves systematic investigation and analysis of the product design to be developed, and *development*, which entails refining and producing the final product based on the results of the preceding research phase. In the current study, the R&D design adopted the ADDIE model, a systematic instructional design framework consisting of five stages: Analysis, Design, Development, Implementation, and Evaluation. The cycles consisted of: 1) Analysis: identifying learning needs, problems, and contextual factors relevant to the development of the CTC-P model; 2) Design: formulating the conceptual and structural design of the model, including defining objectives, selecting appropriate learning strategies, and designing performance assessment instruments; 3) Development: producing and validating the prototype of the CTC-P model through expert judgment and revisions; 4) Implementation: conducting field trials to apply and evaluate the model in actual classroom settings; 5) Evaluation: assessing the model's effectiveness and practicality, followed by necessary improvements based on feedback and data analysis.

This systematic process ensured that the Culture, Technology, and Context-based Performance Assessment (CTC-P) Model was developed through empirical, iterative, and evidence-based procedures to achieve both theoretical rigor and practical usability.

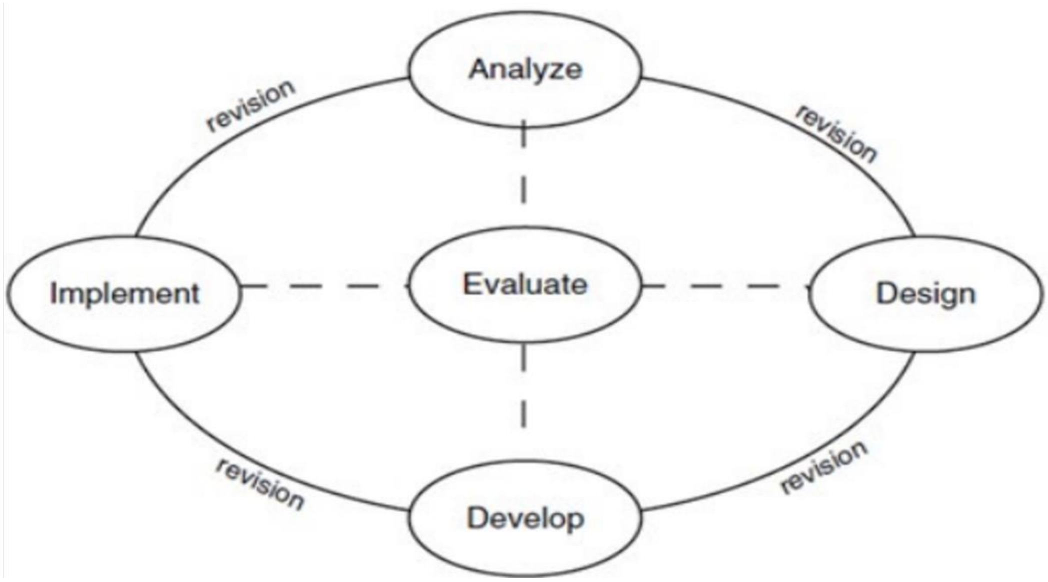

Figure 2.
ADDIE Model.
Source: Branch [16].

At the analysis stage, a comprehensive context analysis was conducted to examine the culture relevant to the development of the learning model. This process involved identifying cultural objects within the Bojonegoro community, such as traditional products, handicrafts, and local art forms, and mapping the mathematical concepts embedded in these cultural artifacts based on topics in the school mathematics curriculum. Additionally, students' learning needs were analyzed to design activity-based tasks that connect mathematical ideas to meaningful cultural contexts. The study also reviewed culturally oriented learning strategies to ensure their feasibility and effectiveness for classroom implementation.

During the design stage, the learning model was systematically constructed. The model design was developed by integrating supporting theories and philosophical foundations of cultural, technological, and contextual learning. Instructional activities were formulated in a structured learning syntax that detailed the procedural flow of the model. Learning resources were identified and selected, including teaching modules, student worksheets, and instructional guides essential for implementing the CTC-P model. Learning topics were derived from familiar cultural phenomena and aligned with mathematical concepts that possess contextual relevance. Additionally, an appropriate instructional design was selected to ensure coherence with the objectives of the model and to guarantee both theoretical soundness and pedagogical feasibility. The theory of culturally based learning is implemented in cultural exploration, where learning activities are designed to guide students in observing and interpreting local cultural objects before linking them to mathematical concepts. Contextual learning theory is applied in the contextual problem mapping stage through activities involving concept mapping, diagram construction, or mathematical modeling derived from real cultural phenomena. Technology integration is operationalized in technology-supported inquiry by utilizing digital media, mathematical applications, and technology-based exploratory activities to deepen students' conceptual understanding. Finally, the principles of authentic assessment are applied in the performance assessment stage through performance assessments that evaluate students' products, projects, and demonstrations within cultural contexts.

The development stage encompassed three main components: model validation, readability testing, and pilot testing. Validation was carried out by experts and practitioners to ensure both theoretical and practical soundness. Readability testing was conducted to assess the clarity and comprehensibility of instructional materials and student worksheets. Subsequently, pilot testing was undertaken to examine the model's initial feasibility and to collect constructive feedback for further refinement before large-scale implementation.

At the implementation stage, the refined model was disseminated and applied in a large-scale field trial using a quasi-experimental design. This design compared students' learning outcomes between an experimental group, which received instruction through the CTC-P model, and a control group, which engaged in conventional learning without intervention. Both groups were randomly selected from Grade VII students at SMP Negeri Model Terpadu Bojonegoro. The validity of the model was determined through expert judgment based on evaluators' understanding and experience of the conceptual framework. Each expert provided assessments using a Validation Sheet (VS), applying a four-point Likert scale ranging from 1 (very invalid) to 4 (very valid). The resulting validation data were analyzed according to the criteria summarized in Table 1 below.

Table 1.
Validity Criteria.

Average Score Interval (v)	**Category**
$v > 4$	Very Valid
$3 \le v < 4$	Valid
$2 \le v < 3$	Invalid
$1 \le v < 2$	Very Invalid

The practicality data of the learning model were obtained from both observer observations and teacher assessments. The observers provided evaluations based on their direct observations during the learning process, while the teachers assessed the model according to their professional judgments and experiences. The evaluation employed a Guttman scale with dichotomous "yes or no" responses to obtain clear and consistent answers. The percentage of practicality was then determined using the following formula:

$$\text{Practicality Level} = \frac{\text{Total score}}{\text{Maximum score}} \times 100\%$$

The effectiveness data of the learning model were determined by comparing students' learning outcomes (pre-test and post-test) between the experimental and control classes. To determine the category of students' improvement in learning achievement, the normalized gain score (N-Gain) was calculated using the following formula.

$$\text{N} - \text{Gain} = \frac{1}{\text{N}} \sum_{\text{i}} \left(\frac{\%\text{post}_\text{i} - \%\text{pre}_\text{i}}{100 - \%\text{pre}_\text{i}} \right)$$

N-gain score criteria adopted from Widada et al. [17] are presented in Table 2 below:

Table 2.
N-Gain Score Criteria.

Score (g)	**Category**
$g \ge 0.7$	High
$0.7 > g \ge 0.3$	Medium
$g < 0.3$	Low

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Finally, the evaluation stage can be conducted concurrently with other stages of the development process. This stage serves as a reflective process to assess the outcomes of model development and to identify areas that require improvement or refinement. Evaluation ensures that each phase of the development cycle effectively contributes to achieving the overall objectives of the CTC-P model.

3. Result and Discussion

3.1. Analysis Stage Results

The needs analysis in this study was conducted by examining both student and teacher needs. The student needs analysis was carried out through a questionnaire focusing on learning requirements related to the integration of cultural, technological, and contextual aspects in mathematics education. A total of 98 students participated in the survey. The student needs questionnaire consisted of 12 items, including 10 closed-ended and 2 open-ended questions. The questionnaire items were developed based on a blueprint that incorporated the cultural (culture), technological (techno), and contextual (contextual) dimensions. In the open-ended section, students were invited to express their opinions freely regarding the most appropriate forms of assessment in mathematics learning, as well as types of local cultural elements that could be integrated into classroom instruction.

The results of the needs analysis were not only based on student preferences but were strengthened by objective evidence from the literature and student performance data. A review of the literature indicates that mathematics learning in various contexts continues to encounter several key issues, such as low problem-solving ability, limited connections between mathematical concepts and real-world contexts, and the lack of integration of local cultural elements in instructional activities. In addition, an analysis of students' performance data and school assessment records shows that conceptual understanding in several mathematical topics remains low, indicating the need for a learning model capable of addressing these gaps. These findings were further complemented by student questionnaire responses, which revealed that learners desire instruction that is relevant to daily life, connected to local culture, and supported by technology. Thus, the need for a learning model that integrates cultural, technological, and contextual components is not merely a reflection of student preferences but an instructional necessity validated by both empirical and theoretical evidence.

Table 3.
Results of the Student Needs Questionnaire.

Question Items	Highest Percentage Responses
If you could choose the way to learn mathematics that best suits your needs, what kind of model would you prefer to choose?	Respondents chose integrating cultural (culture) aspects into the learning process at 17.3% (17 students). Meanwhile, 29.6% (29 students) preferred integrating technological (techno) aspects, and 53.1% (52 students) preferred integrating cultural, technological, and contextual (CTC) aspects simultaneously in the learning process.
What type of culture do you prefer to help you in solving mathematical problems?	Respondents preferred acculturated culture at 15.3% (15 students), international culture at 33.7% (33 students), and local or Nusantara culture at 51% (50 students).
What technological features do you consider most effective in helping you understand mathematical concepts?	Respondents selected tutoring applications providing feedback and guidance at 20.4% (20 students), context-based educational games related to daily life at 34.7% (34 students), and learning videos with clearer explanations at 44.9% (44 students).
In learning mathematics, what is the best way to make the material more relevant to daily life?	Respondents preferred linking mathematical concepts to local culture and traditions in problem-solving at 18.4% (18 students). Others suggested using simulations or case studies to explain mathematical concepts in various fields at 19.4% (19 students).
If you could choose how your learning outcomes are assessed, which method best suits your needs?	Respondents preferred oral assessments at 6.1% (6 students), written tests at 32.7% (32 students), and project-based or practical assignments at 61.2% (60 students).

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3.2. Design Stage Results: The CTC-P Learning Model

The Culture Techno Contextual and Performance Assessment (CTC-P) learning model was designed with four main components: Culture (C), Technology (T), Contextual (C), and Performance Assessment (P), which are structured into six sequential learning stages: pre-learning, group formation, exploration, concept alignment, performance assessment, and presentation. Conceptually, the pre-learning stage functions as an exploratory phase that integrates cultural elements into the mathematics learning process. At this stage, ethnomathematics becomes the core foundation of the CTC-P model, where students are introduced to cultural artifacts that are later associated with mathematical content. Culture serves as a contextual bridge connecting students' prior experiences with mathematical understanding. As argued by Hake [18], mathematical thinking emerges from various cultural foundations of human civilization. Therefore, integrating cultural dimensions into mathematics instruction can promote students' awareness of the importance of valuing and preserving their cultural heritage. Those four components can be viewed in Figure 3.

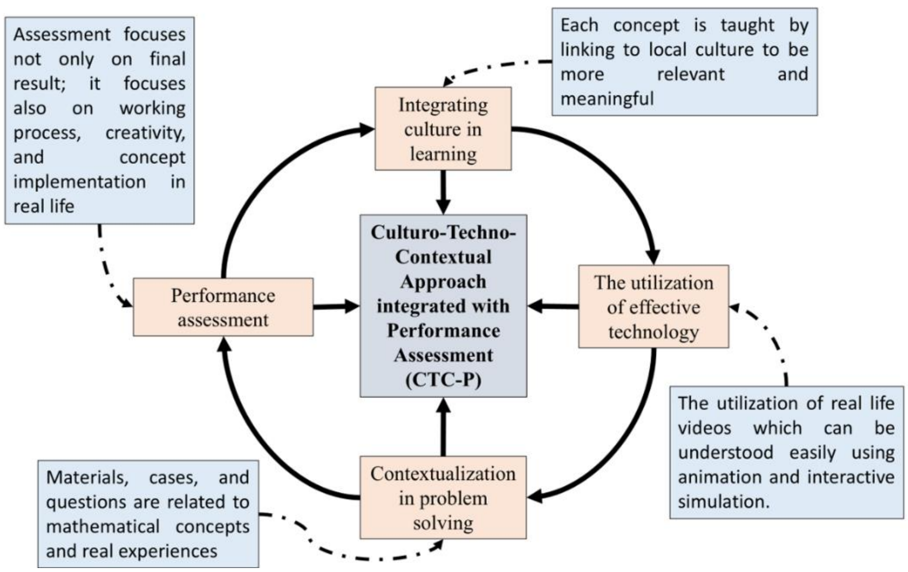

Figure 3.
Components of CTC Integrated with Performance Assessment.

The exploration and concept alignment stages emphasize the development of mathematical reasoning through task-based learning activities grounded in cultural contexts. According to Amit and Abu Qouder [19], ethnomathematics functions as a research framework in mathematics education that plays a crucial role in exploring mathematical ideas derived from the cultural background of specific ethnic, social, or professional communities. In other words, ethnomathematical inquiry applies anthropological approaches to identify mathematical problems by analyzing their underlying logical and structural principles. Task-based activities form the central mechanism of the CTC-P model, aiming to enhance students' ability to mathematize real-life cultural phenomena. However, students often face challenges in the mathematization process itself, as noted by Szabo et al. [7]. This is consistent with Prahmana et al. [20], who emphasize that students' mathematical understanding develops when they begin by observing cultural objects and then proceed to mathematize them through systematic reasoning.

The final stages were evaluation and presentation, that allow students to articulate, reflect on, and communicate their problem-solving outcomes through structured group discussions and presentations. This phase is vital for sharing mathematical solutions, engaging in peer feedback, and refining collective reasoning. Students with diverse viewpoints are encouraged to contribute critiques or alternative ideas, fostering collaborative knowledge construction. As highlighted by Maryati and Prahmana [21], presenting and discussing results constitute an essential component of effective learning syntax. Based on these principles, the syntax structure of the CTC-P learning model reflects a coherent integration of cultural awareness, technological application, contextual relevance, and authentic assessment, as summarized in Table 4 below:

Table 4.
Syntax of the CTC-P Learning Model.

Syntax	**Learning Activities**
Pre-Learning	Students are given cultural practice tasks and are encouraged to connect their existing cultural knowledge with the mathematical topic being studied. This stage activates students' prior knowledge and cultural awareness as preparation for learning.
Group Formation	Learning begins by forming groups based on the results of reflection conducted in the previous stage. Grouping is intended to promote collaboration and the exchange of ideas among students.
Exploration	The learning process involves the use of real-life examples found in the students' surroundings. Students explore mathematical concepts embedded in local cultural and contextual settings.
Concept Alignment	Students discuss and align mathematical concepts derived from their exploration of cultural activities and indigenous knowledge. They compare findings with concepts obtained from websites or other references to ensure conceptual understanding.
Presentation	Students present their findings in front of the class. Each group communicates its discussion results and relates them to existing mathematical concepts, fostering collaborative dialogue and mathematical communication.
Assessment and Evaluation	The assessment process employs performance-based evaluation. Teachers ask students to present their learning outcomes by connecting previously explored mathematical concepts with problem-solving tasks. This stage assesses mathematical understanding and strategic reasoning.

The development stage of the CTC-P learning model involved producing several essential components to support implementation and evaluation. These components included the CTC-P Learning Model Guidebook, a teaching module based on the CTC-P framework, student worksheets, instructional materials, and test items designed to assess students' problem-solving skills. The validation of these materials was carried out by expert validators through both online and in-person sessions. Online validation was conducted to accommodate experts who were unable to attend due to geographical constraints, while face-to-face sessions provided opportunities for in-depth discussions between the validators and teachers. These interactions allowed for constructive feedback, refinement of the model, and enhancement of its instructional practicality. Suggestions and revisions from the validators related to the CTC-P Learning Model Guidebook are presented in Table 5.

Table 5.
Draft Revision based on Validation results.

Learning Instruments	Validation Results	Final Results
Learning Instruction	Activities in adjacent phases are designed to be interconnected, ensuring more effective use of instructional time.	Designing activities in adjacent phases to be interconnected and mutually reinforcing enhances the overall effectiveness of the learning process
	Class presentations were reorganized into sequential group presentations to maintain a coherent and structured instructional flow	Each group was allowed to present in different groups, allowing for greater variation and diversity of learning materials.
Instructional Model Manual	The components of the model were refined to correspond with the modifications made to the instructional syntax and classroom activities	Additional instructional steps were incorporated, and the model components were synchronized to promote information sharing and reflective learning
Learning Module	The instructional content was organized in accordance with the sequence of the CTC-P model syntax	The module was improved by adjusting the syntax sequence and student activities.
Worksheets	Activities focus on solving problem-solving test questions	Instructions for completing assignments are added to the LKPD so that students understand the activity instructions well and can complete them.

Meanwhile, the results obtained regarding the validity test, reliability test, and discrimination test of the problem-solving ability question instrument are shown in Table 6 below:

Table 6.
The Summary of Test Instruments.

Test items	Validity	Reliability	Differentiating Power	Difficulty Level	Conclusion
Number 1	Valid	Reliable	Very good	Easy	Not used
Number 2	Valid		Very good	Medium	Used
Number 3	Valid		Very good	Medium	Used
Number 4	Valid		Very good	Easy	Not used

Based on the data shown in Table 6, the questions used for the trial were expanded for questions 2 and 3 with the medium category.

3.3. Results of the Implementation Stage of the CTC-P Learning Model

This study used a non-equivalent control group design, involving one class as the control group and one class as the experimental group. The control group received conventional learning as usually taught by the teacher, while the experimental group implemented the CTC-P learning model. Class determination was carried out randomly, and based on the selection results, class VII D was designated as the experimental class, while class VII E was designated as the control class. The number of students in the experimental class was 32, consisting of 17 male students and 15 female students. The control class had 32 students, with a composition of 16 male students and 16 female students. Most of the students in both classes were Javanese.

Most students are 12 years old, although some are 11 and 13 years old. Most students have a moderate distance to school. Students who live farther away are picked up and dropped off, and some even come from outside the Bojonegoro District. This is because SMP Negeri Model Terpadu (Integrated Model Public Middle School) is a nationally recognized school and is preferred by students pursuing the achievement pathway. Students' basic reading and arithmetic skills vary. Most demonstrate fairly good abilities. Based on observations, all students have relatively equal (normal) learning potential.

In the pretest stage, this study employed two essay items designed to measure students' initial understanding of bar charts and averages. Nevertheless, these items were selected through a careful review of indicators and conceptual alignment to ensure they represented the fundamental aspects of problem-solving skills relevant to the topics assessed. The descriptive statistics from the pretest for both classes are shown in Table 7.

Table 7.
Descriptive Statistics of the Extended Trial Pretest.

Descriptive Statistic	Control Class	Experimental Class
Number of students	28	28
Minimum score	48	48
Maximum score	74	70
Average	58.86	58.07
Median	60	58
Mode	60	58
Standard Deviation	6.264	4.570

Based on the data shown in Table 7, students' pretest scores obtained from the experimental and control classes indicate equality in initial abilities. Both students in the experimental and control classes have similar levels of achievement. Meanwhile, regarding the normality test, the control class obtained 0.322 and the experimental class 0.398 (greater than 0.05), indicating that the pretest scores in both classes are normally distributed. This is supported by the results of the homogeneity test, which shows a significance value of 0.106 (greater than 0.05), indicating that the pretest scores in the control and experimental classes have the same variance (homogeneous).

Furthermore, the practicality aspect was evaluated through student and teacher responses to this learning model. A total of 14 statements were used to assess these responses. Based on the evaluation results, it was found that students gave positive responses to more than 78% of all statements. They also showed confidence in each item, indicated by a low percentage of doubtful responses, which did not exceed 12%. Thus, the CTC-P learning model was deemed to have met the practicality criteria from the students' perspective. Meanwhile, teachers gave 91% positive responses and only 9% doubtful responses to all statements. Teachers showed hesitation in responding to statements related to the use of time and learning support resources. Nevertheless, teachers assessed that the CTC-P learning model remained relevant for implementation. It was indicated that the CTC-P learning model has met the practicality criteria from both students' and teachers' perspectives. The differences between pretest and posttest results were analyzed using normalized gain scores. The distribution of gain scores in the experimental and control classes is shown in Tables 8 and 9 below.

Table 8.
Descriptive statistical results of the control class.

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
NGain	32	0.00	0.08	0.0442	0.01440
Valid N (listwise)	32				

Based on the data shown in the table above, it can be seen that the NGain value between the Pre Test and Post Test in the control class is 0.0442, so it is included in the low category because the value is <0.30.

Table 9.
Descriptive statistical results table for the experimental class.

Descriptive Statistics					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
NGain	32	0.42	0.73	0.5267	0.06283
Valid N (listwise)	32				

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
NGain	32	.42	.73	.5267	.06283
Valid N (listwise)	32				

Based on the table above, it can be seen that the NGain value between the Pre Test and Post Test in the experimental class is 0.5267 included in the medium category because the value is in the range $0.30 \leq g < 0.70$.

Based on the data shown in Tables 8 and 9, compared to the average gain score in the control class, the experimental class showed an increase. This indicates that students in the experimental class experienced more significant development in their abilities. Students in the experimental class also appeared more consistent in solving word problems, as reflected in the narrower distribution of scores and smaller standard deviations compared to the control class. The following descriptive statistics from the post-test results are presented in Table 10.

Table 10.
Descriptive Statistics Result of Post-test.

Descriptive Statistic	**Control Class**	**Experimental Class**
Number of students	32	32
Minimum score	50	70
Maximum score	76	92
Average	59.66	79.69
Median	59	80
Mode	59	79
Standard Deviation	5.83	4.77

Based on the information in the table above, it can be seen that the minimum, maximum, average, median, and mode values in the experimental class are higher than those in the control class. Meanwhile, the range and standard deviation values in the control class are larger, indicating that the data in the control class are more spread out and less consistent. Conversely, the data in the experimental class are more concentrated or dense. This indicates that most students in the experimental class achieved higher and more evenly distributed results than students in the control class. Regarding the normality test, the control class obtained a value of 0.080, and the experimental class 0.447 (greater than 0.05), indicating that the posttest scores in both classes are normally distributed. This is supported by the results of the homogeneity test, which showed a significance value of 0.370 (greater than 0.05), indicating that the posttest scores in the control and experimental classes have the same variance (homogeneous). Furthermore, the results of the t-test of the data can be seen in Table 11 below.

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Table 11.
t Test Result.

Independent samples test										
		Levene's Test for Equality of Variances					t-test for Equality of Means		95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Nilai Siswa	Equal variances assumed	0.816	0.370	-15.047	62	0.000	**-20.031**	1.331	-22.692	-17.370
	Equal variances not assumed			-15.047	59.658	0.000	**-20.031**	1.331	-22.694	-17.368

Based on Table 11 above, it can be concluded that there was a difference in student learning outcomes in the control and experimental classes. It can be seen from the sig value (0.000) < 0.05. Because there is a difference in learning outcomes between the control and experimental classes, it is seen from the average scores of each class that the experimental class's learning outcomes are better than those of the control class. The result identified that the average score of the experimental class was 79.69, which is greater than the average score of the control class (59.66). These results indicated that the CTC-P learning model has met one of the effectiveness indicators. However, this model is categorized as effective; three other criteria must also be met. The second effectiveness criterion states that the CTC-P learning model must achieve classical learning completion, with at least 80% of students obtaining a score above or equal to 75. Based on the post-test results, 26 students or 81.25% of the total participants obtained a score above 75. Thus, the CTC-P learning model has successfully fulfilled the classical learning completion requirements, so it can be declared an effective model. The difference in learning outcomes between the experimental and control classes not only reflects a statistical distinction but also demonstrates the instructional impact of the mechanisms embedded within the CTC-P model. The higher scores achieved by the experimental class can be explained through the synergistic contributions of the model's four core components. The integration of local culture enables students to connect mathematical concepts with meaningful real-life experiences, thereby strengthening their conceptual understanding. The use of technology supports independent exploration and effective data visualization, which enhances students' accuracy in solving problems. The contextual learning component further helps students recognize the relevance of mathematics in everyday situations, resulting in greater engagement and learning motivation compared to conventional instruction in the control class. Additionally, the implementation of performance-based assessment allows students to demonstrate their competencies authentically, reinforcing continuous learning. These findings align with previous studies indicating that culturally grounded and technology-supported learning improves students' conceptual mastery and problem-solving skills. Thus, the effectiveness of the CTC-P model is evident not only from the differences in scores but also from the alignment between its instructional mechanisms and students' actual learning needs.

The third effectiveness criterion is the teacher's ability to optimally implement the CTC-P learning model. Based on observations, teachers' ability to manage learning showed improvement from one meeting to the next. The average score for teachers' ability to manage learning was recorded at 3.56 in the first meeting, 3.78 in the second meeting, and 3.84 in the third meeting, all indicating successful implementation. Overall, the average syntax implementation across the three meetings was 3.72, which falls into the "very well implemented" category. It was indicated that teachers can effectively implement learning according to the CTC-P model, thus meeting the effectiveness criteria. The CTC-P learning model was deemed effective based on three criteria: 1) Students are better able to solve math problems using the CTC-P model compared to other models; 2) The classical mastery criterion is achieved, with at least 80% of students achieving a score above 75; and 3) Teachers can effectively implement the CTC-P model.

Design of the CTC-P model was developed through principal stages. The first stage involved constructing a theoretical foundation that serves as the paradigmatic basis for the learning model, drawing on social constructivism, meaningful learning theory, and ethnophilosophical perspectives [22]. The learning design was formulated to produce a series of instructional activities synthesized from several established learning models, including Problem-Based Learning (PBL), Realistic Mathematics Education (RME), Contextual Teaching and Learning (CTL), and Culture Techno Contextual (CTC) [23]. The components of the developed learning model consist of syntax, social system, reaction principles, supporting materials, and the assessment system. The initial version of the CTC-P learning model is referred to as Draft I.

The development of the CTC-P model aims to examine junior high school students' ability to solve mathematical problem-solving tasks, ensuring that the model meets the criteria of validity, practicality, and effectiveness through several stages. First, Draft I was validated by experts and practitioners to determine its level of validity. Revisions from this stage resulted in Draft II. Second, the readability of Draft II was tested in a small-group setting. Feedback from the readability test informed further revisions, producing Draft III. Third, Draft III was subjected to a limited trial to determine its practicality and effectiveness [24, 25]. The results of this limited trial led to the version of the CTC-P learning model deemed effective.

Draft IV was subsequently tested on a larger scale to further evaluate its practicality and effectiveness. The results indicated that the CTC-P learning model met both criteria and was therefore established as the final product. The implementation of the final version of the CTC-P learning model was carried out on a broader scale. The findings consistently demonstrated that the model fulfills the criteria of practicality and effectiveness.

Based on the implementation results, the CTC-P learning model was categorized as having a high level of practicality, as indicated by the average implementation score. Based on observations of the learning implementation, the syntax implementation score was considered good. The average implementation score for the first meeting was 3.56, the second meeting 3.78, and the third meeting 3.84, all indicating successful implementation. Overall, the average syntax implementation score across the three meetings was 3.72, which is considered very well implemented.

4. Conclusion

The study concludes that the CTC-P learning model is effective in enhancing junior high school students' mathematical problem-solving abilities. The evidence from multiple stages of validation and field testing demonstrates that the model fulfills the criteria of validity, practicality, and effectiveness. Theoretically, the CTC-P model contributes a structured learning framework that integrates contextual, cultural, and problem-based learning principles, offering a novel approach to strengthening conceptual understanding and problem-solving performance. Practically, the model provides teachers with an applicable instructional design that improves classroom engagement, supports meaningful learning processes, and yields consistent improvements in students' mathematical outcomes. Thus, the CTC-P model stands as a robust and applicable learning innovation that can be implemented broadly to support mathematics learning in junior high schools.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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