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Development of Culturally Responsive Teaching-Learning Model Differentiated Learning to Improve Computational Mathematics Skills

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Abstract

The study aims to develop a Culturally Responsive Teaching (CRT) learning model for differentiated learning to improve students' computational thinking skills. The urgency is based on research stating the low computational thinking skills. The importance of the culturally responsive teaching approach as a learning model and its application to differentiated learning in the independent curriculum. The type of development research with the ADDIE model development research design. The steps are Analysis, Design, Development or production, Implementation, and Evaluation. The product of the Culturally Responsive Teaching learning model development is differentiated learning in mathematics as an innovation and is applied to improve computational thinking skills. The research subjects were students of SMP Citra Nusa Cibinong. Data collection instruments were expert validation sheets, observation sheets, interview sheets, student response questionnaires, teachers and five essay-style mathematical computational thinking ability test questions. Data analysis techniques were quantitative and qualitative data analysis. The results of the study were a valid and practical CRT learning model for differentiated learning. The learning model was in groups with group divisions based on the ethnic background of the students and then given learning media in the form of LKPD where each story in the LKPD is different, namely Sundanese Tribe, Javanese Tribe, Minang/Padang Tribe, Betawi Tribe. The increase in mathematical computational ability based on the normalised gain test is 0.49 in the medium category (n-gain criteria 0.3<n-gain≤0.7).

Keywords: Computational Thinking, Culturally Responsive Teaching, Differentiated

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INTRODUCTION

Computational Thinking (CT) is one of the basic thinking skills needed by every individual today for reading, writing and calculating (Kamil, 2021) (Israel-Fishelson & Hershkovitz, 2022). CT provides important meaning in its integration with learning (Bull, Garofalo, & Hguyen, 2020) (Lee, Grover, Martin, Pillai, & Malyn-Smith, 2020). According to experts, this ability supports the development of technology and is an ability and skill that every individual must have in the 21st century in order to solve problems effectively. It is starting to be implemented throughout the world (Kuo & Hsu, 2020) (Kafai & Proctor, 2021). Even when someone is used to computational thinking, their critical thinking skills are better so that they can solve more complex problems well, efficiently, effectively and relevantly (Mubarokah, Pambudi, Lestari, Kurniati, & Jatmiko, 2023) (Montuori, Gambarota, Altoé, & Arfé, 2024) (Manfra, Hammond, & Coven, 2022). Even computational thinking is a way to improve mathematical literacy (Fauji, Sampoerno, & El Hakim, 2022). Our research and several previous studies reveal that CT is important in mathematics learning and can be stimulated in mathematics learning because the characteristics of mathematics are closely related to problem-solving, algorithms, patterns, and critical and rational thinking so as to find the best alternatives in solving problems (Kurniasi, Vebrian, & Arsisari, 2022) (Fadilah & Hakim, 2022). Mathematics achievement has a greater influence on students' CT ability (Polat, Elif; Hopcan, Sinan; Kucuk, Sevda; Sisman, 2021). There is a relationship between good CT ability and students' careers in science, technology, and mathematics (Hava & Koyunlu Ünlü, 2021).

CT in mathematics learning is defined as decomposition, algorithmic thinking, pattern recognition, abstraction (Mubarokah et al., 2023) . CT is a high-level thinking ability (Aisy & Hakim, 2023). All high-level thinking abilities require stimulus in learning (A. Kurniasi, Eka Rachma; Arsisari, 2020). Computational Thinking is a process for students to understand and solve complex problems (Kurniasi et al., 2022). CT can improve students' mathematical abilities (Looi et al., 2023). Problem presentation can be solved with CT steps, namely abstraction, generalisation, decomposition, algorithms and debugging (A. V. R. Kurniasi, Eka Rachma; Arsisari, 2021). The urgency of the importance of CT in mathematics learning has not been optimised. Based on research, not all junior high schools are able to solve CT category questions sequentially (Aisy & Hakim, 2023). Next, it is stated that the process of students' computational thinking skills is still relatively low, as seen from the majority of errors in finding mathematical solutions when given mathematical computation problems (Azizah, Roza, & Maimunah, 2022). England, America, Japan and Singapore include CT in their education curriculum (van Borkulo, Chytas, Drijvers, Barendsen, & Tolboom, 2023). Daily questions at the junior high school level do not yet contain CT elements (Kurniasi, Yopa, & Karennisa, 2020). In 2020, Indonesia will include CT in its curriculum (Astuti, Syahza, & Putra, 2023). However, in the learning and assessment guide for the independent curriculum, no section specifically explains CT, especially in mathematics learning.

The results of the researcher's trial on junior high school students in one of the schools in Bogor Regency stated that CT abilities were still low. The subjects were 20 students in one school with an instrument of four CT mathematics category questions. The trial was conducted in November 2023. This shows that computational thinking skills, especially at the junior high school level, are still low and need to be improved. The results of our previous study showed that high school students also experienced low CT abilities. This is because, since junior high school, this ability has not been actively stimulated in learning. CT abilities can be stimulated through learning media in the form of LKPD, which contains CT steps and thinking processes (Kurniasi et al., 2022). Optimisation to overcome weak CT abilities can also be done through learning models (Litia, Sinaga, & Mulyono, 2023) (Sa'adah, Faridah, Ichwan, Nurwiani, & Tristanti, 2023) (Pranata, Lyesmaya, & Maula, 2024). One that is thought to be able to improve CT abilities is Culturally responsive teaching (CRT) differentiated learning. This research will innovate and develop CRT into a learning model in differentiated learning. CRT is a learning approach that is deliberately designed to connect students' cultural backgrounds with the subject matter and accommodate students' cultural diversity to create inclusive learning (Mumpuniarti, Handoyo, Pinrupitanza, & Barotuttaqiyah, 2020) (Kohli et al., 2021). In the context of differentiated learning, it facilitates students' different learning needs in terms of content, process, and product in terms of profile, interests, learning styles, and learning readiness (Gusteti & Neviyarni, 2022). Based on previous research, differentiated learning can improve CT abilities (Noviyanti, Yuniarti, & Lestari, 2023) (Sari, Sari, & Namira, 2023). However, efforts are needed to realise differentiated learning in the classroom, especially when combined with other approaches or the use of technology (Hidayat & Patras, 2024). Indicators of CT decomposition ability and finding alternative solutions to problems can be stimulated through models that bring students closer to or contextualise their daily lives with mathematics.

Based on the explanation above, this study will innovate and develop a CRT learning model for differentiated learning in mathematics subjects to improve CT skills. The innovation plan will develop a culturally responsive teaching-learning model for differentiated learning, namely combining cultural-based learning, cultural-based teaching materials or teaching aids and in accordance with the independent curriculum learning guidelines, that in-class learning is directed at differentiation. So that later, students will learn in groups according to their initial readiness, learning style, or student profile. The impact of this model will be measured against improving CT skills.

METHODS

This type of research is research and development (Research and Development). The steps of the ADDIE development model are stages (Analysis, Design, Development or Production, Implementation or Delivery and Evaluations). Analysis of teaching material needs, analysis of the curriculum used by the school, initial CT ability tests, and analysis of students' cultural backgrounds and learning styles. Design Stage Determine the initial design of the learning model framework. Compile differentiation grouping, Compile learning model design, and Determine use. Development Stage Compile all learning devices for the developed model; Expert Validation Validation involves mathematics material experts and learning media experts; Revision Stage I. Implementation Stage is carried out by practical tests on teachers, limited scale tests on small groups, revisions, implementation to large groups including post-tests to measure CT abilities. Evaluation Stage: Conduct final revisions to the developed design based on the results of the implementation and revise the product stage II—subjects based on purposive sampling techniques. The considerations will later be adjusted to the conditions at the school and suggestions from mathematics subject teachers. Subject selection is also based on considerations of access, distance, and diversity of ethnic backgrounds of students. The subjects are students of SMP Citra Nusa Cibinong, West Java. The small-scale test takes 5-7 students. Moreover, a large-scale test takes two classes of 30 students each. Research Instruments Observation sheet, Interview sheet, Learning style questionnaire, Validation questionnaire of mathematics material experts and learning experts, Student and teacher response questionnaire, Junior high school level mathematical CT questions in the form of essays totalling 5-6 questions with indicators of mathematical decomposition, mathematical pattern recognition, algorithmic thinking, and finding alternative solutions to solving mathematical problems.

This development research produces two types of data, namely qualitative data and quantitative data. Analysing the validity and effectiveness of the learning model product using descriptive quantitative analysis. The mathematical CT score is measured using the normalised gain formula. Qualitative data in the form of interview results and observations will be analysed with qualitative analysis, namely data reduction, data grouping, and data presentation (in the form of tables/diagrams).

RESULTS & DISCUSSION

Results

In the first stage, the researcher conducted an initial test to measure students' mathematical computational understanding abilities. Before developing a learning model, the researcher conducted an analysis and mapping. This analysis and mapping were carried out to see students' needs for mathematical model innovations and the cultural background of students in the subject school. The results showed that students had used the Independent Curriculum, a variety of learning resources, several projects that integrated several subjects, had conducted initial diagnostic tests for mathematics, and had conducted diagnostics of prerequisite material abilities. However, so far, the assignments, questions, and learning provided have not been directed at the students' backgrounds. Usually, grouping when studying is done based on the students' initial abilities. Based on the results of interviews with teachers, this grouping is effective so that students who are still in the middle and low categories can be facilitated with the help of scaffolding. Meanwhile, high-ability students can be facilitated with high-level questions. However, differentiation based on cultural profiles and cultural approaches to learning has never been done.

The researcher mapped the students in the experimental class by providing learning style instruments and the ethnic background of the parents. Four ethnic groups were obtained as the background of the students, namely the Javanese, Sundanese, Betawi, and Minang ethnic groups. Meanwhile, their learning styles refer to auditory, visual, and kinesthetic. This mapping is the basis for designing lesson plans, instruments, and LKPD. The RPP contains rules for differentiating student groups based on the Sundanese, Javanese, Minang/Padang, and Betawi ethnic groups. The tasks in the LKPD also refer to this and the student's learning styles that emerge. As for learning planning, the core activities of the CRT model consist of five stages, namely identity, trigger, problem formulation, critical thinking for reflection, and formative construction.

Validation Results of the Culturally Responsive Teaching Learning Model Differentiated Learning

Based on the validation results carried out by experts, the model is declared valid with a good level of validity. The aspects tested for validity in this model include the Learning Plan, which contains syntax, reaction principles, instruments and LKPD. These results indicate that the developed model meets the validity criteria so that it can be continued for practicality testing. During the validity test by learning experts and mathematics experts, several suggestions were obtained regarding the learning model. Suggestions include sentences used in the instructions in the LKPD. Instructions related to activity 1 in the LKPD only read stories, and then some were replaced with demonstrations. This demonstration activity is intended to facilitate students who have a kinesthetic learning style. Then, after the validation test to fix it, the researcher conducted a stage I revision by replacing the instructions in the LKPD so that students could understand it better. The results of the revision will be shown in Table 3.

Table 3. Results of Improvements Based on Expert and Practitioner Suggestions

Before Revision	Revision
Tell us about the following traditional games from the Sundanese Tribe.	Activity 1 Read and demonstrate the traditional games below This game is one of the traditional games of the Sundanese tribe *Cingciripit* Traditional Games 
There are instructions in LKPD activity 2: “Collect data from representatives of each group in the class to choose one of the four games above.”	Because the instruction could be that students only collect representative data, the data collected is only for four students. So, it is difficult to find the mean, median, and mode. Based on the suggestion, I changed it to “Collect data from each group in the class to choose one of the four games above.”

Practicality Test Results of Culturally Responsive Teaching Learning Model Differentiated Learning

Based on the practical test conducted by two mathematics teachers with the teacher response instrument, it was stated that the practical learning model was used with several suggestions. The level of practicality was stated as 61.5% practical with simple revisions. The revision suggestions were the Learning Objective Flow at meetings 1 and 2. Initially, the researcher only made one meeting for seven learning objectives. It turned out that the Learning Objective Flow was not possible, so two meetings were held.

The results of the small-scale trial conducted on students also showed that 79% of students stated that the learning model was practical and could be used. However, the results of the researcher's interview with the small-scale subject students stated that there was one instruction that they misunderstood.

"In activity two in LKPD, we were asked to collect data from classmates. Collect data from representatives of each group in the class. Well, we thought the representative was enough to ask one or two friends, but it turned out that the entire group had to be asked,"

Based on this misunderstanding, the researcher revised the instructions in Activity 2 to "Collect data from each group member in the class". After being changed, they understood that they had to collect data from each student in their class.

CRT Model of Differentiated Learning

The results of the study are the CRT Differentiated Learning model, whose learning stages are identity, trigger, problem formulation, critical thinking for reflection, and formative construction. Each group is given the same stages but a different cultural approach.
In the identity stage, students are divided into groups based on their cultural backgrounds (Javanese, Sundanese, Minang / Padang, Betawi). Each group will be given problems related to the material with their background. In the trigger / cultural understanding stage, the teacher gives different questions to each group. For students from the Javanese Tribe:
Have you ever walked to a traditional market? What types of traditional cakes are often found? Can we make a list?
For students from the Sundanese Tribe:
Have you ever watched/played traditional games? Does every child have the same favourite game? Can we find out what game is the most popular?
For students from the Minang Tribe:
What foods are from the Minang tribe? Which food do you eat most often with your family?
For Students from the Betawi Tribe:
Have you ever been to a Betawi folk festival?
What arts do you still often see between Mask Dance, Ondel-model, Palang Pintu, and Tanjidor? At this stage, the teacher also presents pictures and stories about the cultural elements of each tribe. Problem formulation stage: The teacher asks what mathematical concepts can be used to answer the story and pictures. Critical thinking for Reflection, each group communicates the results of their discussion to the future. Communication of these results is needed to contextualise the results of the discussion with the existing material. The teacher corrects the concept if the student is not correct. Other groups listen and provide comments. In the transformative Construction Stage, students are tested on their understanding through project assessments that will be made in groups

Implementation of Models on Computational Mathematics Ability

Analysing the results of the model's implementation on improving mathematical computational skills, a post-test consisting of five CT questions that were tested for validity was given. If categorised based on the level of student mastery, it will be described in Table 4.

Table 4. Summary of Students' Mathematical Computation Ability Scores

No	Skor	Number of Students
1	0 – 25	3
2	26-50	6
3	51-75	20
4	76-100	11
Total Number of Students		30

Based on Table 4, it is obtained that the highest CT ability score is at a score of 51-75. Furthermore, it was analysed using normalised gain; the n-gain value was 0.49, which is in the medium category (n-gain criteria $0.3 < \text{n-gain} \leq 0.7$).

Discussion

The results of the study above show that CT ability can actually be improved by using the right learning model. One of them is CRT in differentiated learning. These results show that CT is indeed important to develop, especially in the present. When mathematics must be combined with computerised thinking. Even previous studies have shown that many countries include CT in the curriculum (Kafai & Proctor, 2022). The aim of this certainly is to improve CT through learning in schools.

In this study, the CT ability measured decomposition, which is the process of breaking down large problems into smaller subproblems or details by providing detailed explanations of actions. This ability, according to previous research results, can make students simplify mathematical problems so that they understand and solve them better (Budiarti, Wibowo, & Nugraheni, 2022).

The next indicator is Pattern Recognition, Connecting the necessary actions and events with other similar phenomena and previous research results. When the research subject is able to perform pattern recognition on a question, he will be able to solve the question and be able to see the similarity of the pattern in the next question so that he can find a similar solution (Fauji, Sampoerno, & El Hakim, 2023). Then, in the algorithmic thinking section, generalisation and abstraction are high-level abilities. Students who have this ability will be able to solve problems (Budiarti et al., 2022).

Our research on CT also refers to previous research, which suggests the need to develop CT in mathematics learning other than in the field of geometry (Kafai & Proctor, 2022). In addition, CT abilities can be related to other abilities in mathematics learning. (Nordby, Mifsud, & Bjerke, 2024). CT capabilities do not stand alone and are very closely related to the digital literacy that students previously had (Nordby et al., 2024). Our research also found that students who are able to think CT are also able to think at a higher level.

The developed learning model provides a new alternative for learning approaches that emphasise ethnomatic elements. The increase in CT also influences the application of the CRT method. The results of this study are in line with research on the application of CRT in previous learning conducted and obtained results that the application of CRT can improve learning outcomes and student activities during learning (Nordby et al., 2024). Even previous research on the application of CRT in the context of multicultural Indonesian education has been conducted and produced a description of the elements that must be considered in the application of CRT, one of which is learning that involves preserving local wisdom (Nurbatra & Masyhud, 2022). Previously, research on the positive influence of ethnomatics on mathematics learning has been widely conducted (Muhammad, Marchy, do muhamad Naser, & Turmudi, 2023). Meanwhile, differentiation is an approach that emphasises group learning, where the groups are made based on student profiles. In this study, grouping is based on the profile of the students' cultural background. Differentiation with grouping in this study is quite effective because students feel close to the story presented in the LKPD. Previous research supports this research, even previously research has been conducted on differentiated learning as a solution to diverse learning (Wulandari, 2022).

The CRT learning model in differentiated learning emphasises that cultural elements in mathematics are not only in learning objects in the form of learning media but can be carried out fully through learning from beginning to end. Previous research on mathematics learning models developed based on culture also produced research that supports making culture-based learning an alternative to mathematics learning (Baharullah & Satriani, 2021). The development of a Javanese culture-based learning model states that the integration of Javanese culture through traditional games can be applied to mathematics learning (Oktafianti, Purwoko, & Astuti, 2019). The difference between this research and previous research is that this research is combined with a differentiation approach and cultural elements from various tribes. This research also pays attention to the cultural background of students as the basis for compiling teaching modules and worksheets. However, what may need to be noted is that when we group students based on cultural background, the number of students in each group can be different. What we found in the field was a group of students from the Javanese tribe, numbered 11, while from other tribes, there were 4-7 students.

CONCLUSION

The results of the study are a valid and practical Culturally Responsive Teaching learning model in differentiated learning. The learning model is in groups with group divisions based on the ethnic background of students. The instructional steps of the model in the core learning activities are identity, trigger, problem formulation, critical thinking for reflection, and formative construction. Then, given learning media in the form of LKPD where each story in the LKPD is different, namely the Sundanese Tribe, Javanese Tribe, Minang/Padang Tribe, and Betawi Tribe. The increase in mathematical computational ability based on the normalised gain test is 0.49 in the moderate category (n-gain criteria 0.3 <n-gain ≤ 0.7).

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