



Design of Differentiated Mathematics Learning Activities on Arithmetic Sequences and Series to Support Students' Computational Thinking Skills

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Abstract:

The projected result of this research is to design valid and practical differentiated mathematics learning activities on arithmetic sequences and series to support computational thinking abilities. These activities were designed utilizing the ADDIE development model, which provides a structured framework for designing, testing, and refining learning tools. This study resulted in a validity score of 90.14% for student worksheets, 92.85% for test questions and 77.4% for practicality. The pretest average was 50.54 with a standard deviation of 18.04, while the posttest average increased to 95.92 with a standard deviation of only 3.57, indicating an increase in student consistency and performance. The findings of the N-Gain analysis conveyed that the learning method incorporating differentiated activities was considered highly effective. Overall, the implementation of the computational thinking-based differentiation learning model has also proven to be very beneficial. Based on the test results, there was a notable increase in scores on each component of computational thinking skills. The findings regarding the validity and practicality of the student worksheet (LKPD) also achieved high ratings, indicating that this learning tool is both effective and practical to use in the learning process. Implication the research differentiated learning not only improves students' understanding of mathematical concepts, but also prepares them with critical and computational thinking skills.

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Introduction

Students often experience differences in skills or abilities in mastering a topic in class. Particularly, in mathematics learning since teachers frequently apply the same teaching method, which may not address the diverse needs of all students. Indeed, it is certain that one size of teaching will not fit all types of students (Bondie, et al., 2019; Magableh & Abdullah, 2020). Accommodating these differences would be more effective if differentiation could be provided according to the characteristics of students, allowing them to achieve learning objectives by implementing differentiated instruction (DI) (Magableh & Abdullah 2020; Kamarulzaman, 2022; Cheng et al, 2023). Awofala and Lawani (2020) found that differentiated teaching improved mathematics learning outcomes. In like manner, students are more motivated and engaged during differentiated teaching (Hapsari, et al., 2018; Erhan & Şen, 2022). The professional establishment of differentiated teaching in mathematics classes has a constructive influence on student achievement (Prast et al., 2018). Likewise, differentiated learning was successfully implemented by teachers through collaborative approaches that meet all students' needs (Ismajli & Imami-Morina, 2018). Significantly, these prior studies offer insights for teachers to carry out differentiated learning in mathematics classes (Anggrasari, 2021; Avital, 2023; Broza, 2023). However, further insights are still required on practical ways to effectively apply this approach. To address this issue, this study aims to explore more deeply the practical application of differentiated teaching in high school mathematics classes (Badri & Krisna, 2013; Pozas et al, 2020). Specifically, it will focus on the implementation processes undertaken by teachers, from planning instructional design to executing it in actual classroom settings. Furthermore, teachers can better design future mathematics lessons to meet the needs of each student's experience in the context of differentiated instruction (Xie et al, 2023).

21st century education calls for students to possess a range of high competencies with various skills, including critical thinking, problem-solving, communication, collaboration, innovation and creativity, literacy, cultural competence, as well as emotional awareness (Umar, 2018). Moreover, the Ministry of Education and Culture of Indonesia (Kemendikbud) has introduced two new competencies within the education system in of the nation. Awaluddin Tjalla, as the Head of the Curriculum and Learning Center of the Ministry of Education and Culture, stated that those two competencies are computational thinking and compassion (Kopcha & Caren, 2023).

Unfortunately, results of the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) conducted in recent years have shown that Indonesian students have relatively low performance in mathematics competencies compared to other countries (Yusmar & Fadilah, 2023). The results of PISA 2018, for example, reported that most Indonesian students ranked at the lowest proficiency level in mathematics, especially in terms of data-based problem solving and pattern analysis (OECD, 2018). This low level of competence reflects an indicator that traditional teaching approaches are less effective at helping students to develop their capacity for logical and analytical thinking skills. One approach suggested to help students develop these mathematical skills is a differentiated learning, which allows students to understand mathematical concepts in a way that suits their distinctive learning abilities (Tilamsari et al, 2023). This

particular approach will provide more specific support to students who have difficulty understanding abstract mathematical concepts and allow them to develop basic computational skills (Danindra et al, 2022; Piatti et al, 2022). The impact of the differentiated learning application was demonstrated in 2022 when Indonesia managed to advance to 5-6 positions in PISA 2022 compared to 2018.

Computational Thinking (CT) is a stage or system of thinking to formulate problems and find effective solutions that can be managed by "information processing agents" (Wing, 2008). In this regard, humans carry out the process of analyzing problems to identify solutions. CT or computational thinking skills are essential and must be developed through practice, representing one of the fundamental skills required by individuals in the 21st century for solving high-level problems (Maharani et al, 2020). CT is an extracurricular activity that is designed to cultivate problem-solving skills in children within the context of the digital era. As a matter of fact, numerous solutions nowadays emerge as applications, software or computer systems, so computational thinking is in demand (Budiansyah, 2020). M. Gunawan et al. (2021) also noted that CT represents a form of Higher Order Thinking Skills (HOTS) that facilitates decision-making and problem-solving for students, as well as enhancing their achievements in mathematics (Maharani et al, 2020).

Computational thinking is a key skill that encompasses the ability to rationalize and systematize in solving problems. This concept was first introduced by Wing (2006), who explained that computational thinking comprises several important components, such as decomposition, pattern recognition, abstraction, and algorithm creation. In differentiated mathematics learning, these skills can be developed through activities involving pattern recognition, step-by-step calculations, and pattern analysis (Kalelioğlu, 2018; Syarifuddin, 2022).

Decomposition, for instance, can be trained by dividing a math problem into small steps which are more manageable and can be solved one by one. In an arithmetic sequence, students can be encouraged to break the problem down into simple calculations, such as calculating the next term in a certain sequence or calculating the difference between terms in an arithmetic sequences and series. In this way, students will find it easier to identify broader concepts since they have been trained in decomposing problems into smaller parts. Furthermore, CT involves the ability to recognize patterns, also known as pattern recognition (Wing, 2014).

The integration of computational thinking into learning is expected to enhance Indonesia's PISA scores and rankings, as well as a form of effort to provide provisions to the young generation of Indonesia by providing competencies and skills aligned with contemporary advancements (Wilkie & Sarah, 2024). This initiative aims to prepare the young generations to become individuals who are able to socialize and effectively compete in a global context (Citta, 2019). Given these points, computational thinking serves as an extracurricular activity that equips students with essential problem-solving skills in this digital era. As many solutions develop through applications, software, and computer systems, computational thinking becomes essential. It works as a means of HOTS, which supports decision-making, facilitates problem-solving, and fosters students' mathematic achievement. Hence, to support CT capabilities that comply with 21st century standards, concrete steps must be taken as

an effort to improve the current situation of Indonesia's low performance in international standardized assessments (Zahid, 2021).

Notably, arithmetic sequences and series provide an ideal opportunity to develop students' computational thinking. This study material is relevant to foster such skill since students not only learn to recognize patterns but also create simple formulas or algorithms to predict the next number. The ability to make predictions based on identified patterns is a vital aspect of computational thinking. Thus, arithmetic sequences can serve as initial practice for students to acquire more complex algorithmic skills. For example, students can be instructed to create simple algorithms that allow them to calculate numbers in a longer sequence efficiently. As a result, they can operate the algorithm to speed up their calculations instead of calculating each number individually.

Research Method

This type of study is Research and Development (R&D) which focuses on developing or designing valid and practical differentiated mathematics learning activities on arithmetic sequences and series to support students' computational thinking ability. The participants in this probe were students from the X-grade at SMAN 8 Palembang. Specifically, this study was conducted from July to October 2024 and used the ADDIE model, which stands for Analysis, Design, Development, Implementation, and Evaluation as its research development framework (Branch, 2009).

This research employed both qualitative and quantitative data. The former comprises questionnaire results that include comments and recommendations for the revision of mathematics learning design development from validators and students. While the latter were collected from test results, validity and practicality tests with the regard to the design of differentiated mathematics learning activities on arithmetic sequences and series to enhance computational thinking skills of the students (Presser et al, 2023).

The data analysis in this study involves validity, practicality, and test analyses. Primarily, the validity analysis is based on data from expert reviews and has been developed in accordance with the outcomes of the validation sheet, which are supported by the results of one-on-one trials. Then, a closed questionnaire with a Likert scale was used for the practical analysis in this probe. Lastly, three test items are included in this study's test analysis to help students advance their literacy skills (Sa'diyyah et al, 2021; Zhang & Wong, 2023).

The test questions will be given at the end of the research meeting. Following the completion of the testing process of the validity, practicality and tests. The researchers then performed the data analysis by grouping them based on the categories of validity, practicality, and computational thinking skills.

Data collection techniques involved using tests during the field test stage, validity questionnaires for expert reviews and practicality questionnaires for students.

a) Data of Test Analysis

Scores are made on a scale of 0-100. Next, the scores obtained by students are calculated as follows:

$$\text{Student Grades} = \frac{\text{Total scores obtained}}{\text{Maximum total scores}} \times 100\%$$

Achievement Level (%)	Category
81-100	Excellent
61-80	Good
41-60	Sufficient
21-40	Insufficient
0-20	Poor

(Aulia & Mintohari, 2023)

b) Data of Validity Analysis

The analysis was carried out descriptively through comments and suggestions from experts as input for researchers regarding the revisions made for each prototype.

Analysis of validity data of student worksheet (LKPD – Lembar Kerja Peserta Didik) is calculated using the formula below:

$$\text{Percentage of validity level} = \frac{\text{Total score obtained}}{\text{Maximum score}} \times 100\%$$

Criteria	Category
81%-100%	Highly Valid
61% – 80%	Valid
41%-60%	Moderately Valid
21%-40%	Slightly Valid
0% – 20%	Not Valid

(Aulia & Mintohari, 2023)

c) Data of Practicality Analysis

This data was collected through a questionnaire utilizing a Likert scale. This particular scale features an interval of 1-4, with the following designations: ("4=strongly agree (SS), 3=agree (S) 2=disagree (TS), 1=strongly disagree (STS)").

The data results were analyzed using the following formula:

$$P = \frac{\sum X}{\sum X_i} \times 100\%$$

Details:

P = Percentage of practical value

$\sum X$ = Total value of respondents' answers

$\sum X_i$ = Number of ideal/maximum values

Achievement Rate (%)	Description
0%-20%	Not practical
21%-40%	Less practical
41%-60%	Quite practical
61%-80%	Practical
81%-100%	Very practical

(Aulia & Mintohari, 2023)

Results and Discussion

1. Analyze

Design of Differentiated Mathematics Learning Activities on Arithmetic ...

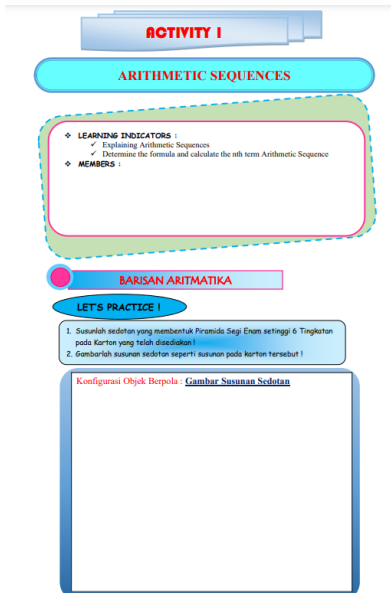
Based on the observations at SMAN 8 Palembang, it was found that this school is currently implementing the Merdeka Curriculum, which is Indonesia's current national curriculum. Surprisingly, it was also revealed that the learning resources used in the mathematics class were limited to teaching modules prepared by the teacher, without the inclusion of students' worksheets or activity sheets (LKPD). Furthermore, during study material related observations, the researchers discovered that students utilized reference books in learning activities. However, they were still unfamiliar to solving problems with computational thinking.

Specifically, as part of this study's implementation, the students will learn about arithmetic sequences and series as the learning material. Therefore, a series of differentiated mathematics learning activities were designed by the researchers to enhance computational thinking. The researchers believed that the aforementioned topic was selected due to its relevance to contextual problems and its capacity to foster computational thinking skills. Additionally, it can be observed that students at this school enjoy interactive learning and engage with various learning media.

2. Design

The researchers designed several research instruments, including student worksheets (LKPD) and test questions.

- Student Worksheet (LKPD) Design

Layout	Details
	The first page of the student worksheet layout for the first meeting contains the title of the selected material, learning objectives, member identities (learner profiles), learning duration, and introductory math problems.

The second to fourth pages of the student worksheet design for the first meeting features more advanced problems related to the topic of arithmetic sequences and series, along with questions that will be answered by the students.

Berdasarkan gambar diatas, tuliskan pola barisan bilangan yang terbentuk!

BARISAN BILANGAN YANG TERBENTUK

Pola barisan bilangan yang terbentuk tersebut merupakan **Pola Barisan Aritmatika**.

Barisan Aritmatika adalah suatu susunan bilangan atau barisan bilangan dengan selisih dua suku berurutan tetap.

MENENTUKAN RUMUS MENCARI SUKU KE-n BARISAN ARITMATIKA

Setiap bilangan pada barisan dinamakan suku satu dan dihubungkan "U". Maka dapat dituliskan :

$U_1, U_2, U_3, \dots, U_n$

$U_2 - U_1 = b$
 $U_3 - U_2 = \dots$
 $U_4 - U_3 = \dots$

$U_3 - U_2 = 2b$
 $U_4 - U_3 = \dots$
 $U_5 - U_4 = \dots$

$U_4 - U_3 = \dots$
 $U_5 - U_4 = \dots$
 $U_6 - U_5 = \dots$

Beda $= b = \dots$

Suku ke	1	2	3	4	5	n
Banyak Suku			10			
Hubungan			$U_1 + 2b$			

Jadi, Rumus suku ke-n dari Barisan Aritmatika adalah :

ARITHMETIC SERIES

◆ **LEARNING INDICATORS :**

- ✓ Explaining Arithmetic Series
- ✓ Determine the formula and calculate the nth term Arithmetic Series

Jika $U_1, U_2, U_3, U_4, \dots, U_n$ adalah Barisan Aritmatika dengan Beda b, Maka Penjumlahan $U_1 + U_2 + U_3 + U_4 + \dots + U_n$ disebut **Deret Aritmatika**.

DERET ARITMATIKA YANG TERBENTUK

$\dots + \dots + \dots + \dots + \dots + \dots + \dots$

Penjumlahan n Suku Pertama dari Deret Aritmatika ini diberi Notasi S_n dengan demikian $S_n = U_1 + U_2 + U_3 + \dots + U_n$.

Perhatikan Deret Aritmatika yang terbentuk, dan Tuliskan Hubungan / Kaitan antara Skematis Penjumlahan Deret Tersebut !

Jika, Notasi Umum dari banyak suku $= n$, Suku Pertama $= U_1$, dan Suku Terakhir $= U_n$, Maka, **Rumus untuk Menghitung Deret Aritmatika yang Menyatakan Jumlah dari n Suku Pertama yaitu :**

BARISAN DAN DERET ARITMATIKA

Jika Anda akan membuat 100 Susunan Stik Persegi yang membentuk suatu Piramida, Maka Tentukan Stik Es yang diperlukan untuk membuat susunan tersebut !

JAWABAN

Design of Differentiated Mathematics Learning Activities on Arithmetic ...

- Design of test items

NAMA :	NAMA :	NAMA :
Mark adalah seorang pedagang buah semangka. Untuk menarik perhatian konsumen, Mark Menyusun buah semangka membentuk Piramida setinggi 10 tingkatan. Jika banyak semangka pada susunan paling atas adalah satu buah semangka dan pada susunan ke-6 sebanyak 6 buah semangka. Maka, Tentukan jumlah semangka yang disusun oleh Mark !	Sebuah acara konser menyiapkan enam buah meja untuk menyusun beberapa gelas penonton. Jika masing-masing meja terdiri dari enam tumpukan gelas dengan banyak gelas pada tumpukan ke-3 adalah sebanyak 14 gelas, dan pada tumpukan ke-5 sebanyak 24 gelas. Maka, tentukan banyak gelas yang disiapkan sebagai fasilitas konser tersebut!	Nathan Menyusun koleksi bolanya dengan menumpukkan bola setinggi 15 tumpukan yang membentuk sebuah Piramida di ruang olahraga dan di museum belakang dengan jumlah bola yang sama. Jika banyak bola pada tumpukan ke-7 adalah 7 bola dan pada tumpukan ke-10 sebanyak 10 bola. Maka tentukan banyak koleksi bola yang dimiliki Nathan!
JAWABAN	JAWABAN	JAWABAN

3. Develop

In this regard, the researchers tested the instructional materials using a one-to-one approach, subsequently followed by expert review validation tests. After obtaining the results from the prior stages, the researchers proceeded with the development of the learning materials.

In the one-to-one stage, a series of trials was conducted on the first prototype, including the student worksheet (LKPD), learning media and test questions, involving six students. These students then observed, understood, and solved problems in the LKPD. These one-to-one trials were carried out to identify students' difficulties while working on the LKPD, assess the clarity of language used in it, along with their comprehension of the instructions, as well as their interest in the context presented in the LKPD. While students were completing the exercises on the LKPD, the researchers observed the challenges they encountered.

At the validity test stage, the researchers validated the LKPD and test questions for several lecturers and teachers who participated in the expert review for this study. The validation process focused on content, learning instructions, and language used in the learning materials which developed under the guidance and recommendations of researchers' supervisor.

Based on the validation results, the average difference for all statements is less than 1, confirming that all statements are declared as agreed according to the predetermined criteria. It can be concluded that the validation sheet for the LKPD is reliable. Next, the validity of the LKPD is evident from the validity scores obtained, which account for 90.14% for student worksheets and 92.85% for test questions. Consequently, based on the validators' comments and suggestions, several aspects need to be revised or further developed, including the language adjustment, the layout of competency achievement indicators, the math problem presentation, the sequence of the tasks, as well as the statements and questions in the student worksheet (LKPD).

Finally, the researchers proceeded to the advanced development stage after acquiring the results from the two previous stages. At this point, the researchers improved the learning material based on the feedback and recommendations from

expert validation and student observations. These improvements aimed to increase the clarity, relevance, and effectiveness delivered in the learning material. As a result, it can be utilized and understood more easily by students so as to meet the learning objectives.

4. Implement

The researchers tested the learning tools in small groups, conducted tests, and provided practicality questionnaires. After performing small group trials, field tests, tests, administering questionnaires, and obtaining the results, the researchers continued to evaluate the mathematics learning activities that had been designed.

In this small group, the trial of the designed computational thinking-based LKPD was conducted offline on students of grade X.2 at SMA Negeri 8 Palembang. The purpose of this trial was to determine the practicality of the designed mathematics learning activities. In this first learning session, the researcher applied the Concrete-Pictorial-Abstract (CPA) approach or the CPA-based LKPD related to arithmetic sequences and series learning topic.

At the concrete phase, students understood the LKPD and then attempted to use the teaching aids that have been distributed to them. Secondly, in the pictorial phase, students described the results of their experiment using teaching aids. Then, in the third phase, known as the abstract phase, students identified and understood the patterns formed from the previous experiment activities. After all, students drew conclusions from the results of the experiment related to the discussion of arithmetic sequences and series.

The field test is a trial stage of the LKPD, which is grounded in computational thinking and has been specifically designed for students of grade X.5 at SMA Negeri 8 Palembang. This trial was carried out offline at this school, which consisted of two meetings. The first meeting of the trial focused on the project activity related to the concept of arithmetic series and sequences. On the other hand, the second meeting concentrated on the incorporation of computational thinking skills. The researchers then administered a trial of computational thinking-based test questions that are also designed for grade X.5 students. In the same way, the trial was conducted in person at the school. The test included three questions that progress through three levels, which were arranged based on computational thinking skills.

5. Evaluation

The researchers evaluated the design of differentiated mathematics learning activities on arithmetic sequences and series by analyzing the results from validity tests, LKPD trials, follow-up tests, and practicality tests. Based on the validation results, the validity score obtained was 90.14% for LKPD, with details of 90.37% for content, 88.33% for construct, and 92.22% for language.

Additionally, the validity score of the test questions was 92.85%, which represents 91.66% for content, 91.66% for construct, and 94.44% for language. Therefore, by the results of the validity test, the design of differentiated mathematics learning activities is classified as highly valid.

Design of Differentiated Mathematics Learning Activities on Arithmetic ...

	N	Minimum	Maximum	Mean	Std. Deviation
Pre-test	24	10.00	83.00	50.5417	18.04338
Post-test	24	88.00	100.00	95.9667	3.57426

The results of the descriptive statistical analysis showed a fairly high increase in the middle of the pretest and posttest scores. In the pretest, the average score was 50.54 with a minimum score of 10.00 and a maximum of 83.00, and a standard deviation (SD) of 18.04, indicating a fairly large variation in the data. Meanwhile, in the posttest, the average score rose to 95.92 with a minimum score of 88.00 and a maximum of 100.00, and a standard deviation of only 3.57, indicating more consistent data. Based on the N-Gain analysis, the results showed that there was a significant improvement due to the learning method applied. As many as 95.8% of participants (23 out of 24 people) reached $N\text{-Gain} \geq 0.7$, which was placing them in the high effectiveness category. Only 4.2% of participants (1 person) were in the moderate effectiveness category with $N\text{-Gain} < 0.7$, and no participants were classified in the low effectiveness category ($N\text{-Gain} < 0.3$).

From the outcome of the descriptive statistical analysis of the statements in the practicality questionnaire, it can be inferred that most statements were rated fairly high, with an average score ranging from 3.00 to 3.50, implying that the statements were considered practical by the respondents. Most of the statements, such as Statement_11 with an average of 3.4194 and Statement_6 with an average of 3.1613, are included in the practical category (70-84%), indicating that the majority of respondents considered these statements to be quite useful or applicable. Several statements, such as Statement_1 with an average of 2.7097 and Statement_9 with an average of 2.8710, are in the fairly practical category (50-69%), reflecting a degree of disagreement or doubt among the respondents regarding the statement. Furthermore, statements with a larger standard deviation, such as Statement_3 with a standard deviation of 1.06458, suggested a greater variation in respondents' answers, which potentially reflected differences in interpretation or understanding of the statement (Cansu, 2019). These findings showed that the majority of statements are regarded as practical. However, some statements still require clarification or improvement to increase agreement among respondents and belong to the highly practical category (85-100%) (Kong, 2022; Ramaila & Shilenge, 2023).

In this regard, the differentiated mathematics learning activities on arithmetic sequences and series were designed to enhance computational thinking skills, resulting in the development of student worksheets (LKPD), computational thinking-based test questions, and supporting learning media. Based on the outcomes of the validity test (walkthrough), the learning tools that support learning activities were categorized as highly valid, for instance student worksheets (LKPD) and tests. Equally important, according to the practicality test conducted on 24 students of grade X at SMAN 8 Palembang, it was shown that the designed mathematics learning materials were considered practical (Minasari, 2023; Reichert & Kist, 2023). Lastly, the results of tests conducted with the same of group of students indicated that the designed mathematics learning materials and activities were found to support the enhancement of students' computational thinking skills (Indriani, 2018; Hidayati, 2020).

Overall, the practicality test obtained a score of 77.4%, which means that the design of differentiated mathematics learning activities is categorized as practical. Then, according to the results of validity test, LKPD test, and questionnaire test, it was shown that the differentiated mathematics learning activities designed for the arithmetic sequences and series material are categorized as valid, practical, thus supporting students' computational thinking skills ([Kamal, 2021](#); [Mulyono et al, 2023](#); [Ostian et al, 2023](#)).

By applying a differentiated learning approach in mathematics, teachers can adapt their teaching methods to accommodate the unique needs, learning styles, and perspectives of each student ([Chan et al, 2021](#); [Fauzi et al, 2022](#)). This approach allows teachers to develop computational thinking skills more efficiently. In detail, this differentiation encompasses modifications in content, processes, products, and learning environments that enable each student to engage in learning at their own level of understanding ([Tomlinson, 2017](#); [Città et al, 2019](#); [Xu et al, 2022](#)). Additionally, this type of instruction not only improves students' ability to understand mathematical concepts in depth but also trains them in identifying patterns and constructing simple algorithms, both of which are the basic foundations of computational thinking ([Bas & Sarigöz, 2021](#); [Septiana et al, 2023](#)). Hence, differentiated instruction (DI) not only plays a role in improving student learning outcomes but also supports the development of abilities oriented towards computational thinking ([Fauji et al, 2022](#); [Aminah et al, 2023](#)).

Conclusion

As indicated by the findings and discussion of this research, it is concluded that the design of differentiated mathematics learning activities on sequences and series is categorized as valid and practical in fostering students' computational thinking skills. Computational thinking skills can go hand in hand with differentiated learning assisted student worksheet. Implication the research differentiated learning not only improves students' understanding of mathematical concepts, but also prepares them with critical and computational thinking skills.

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