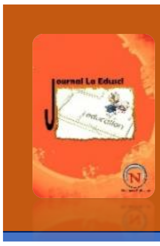

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The Effectiveness of Differentiating Mathematics Learning in Arithmetic Sequence to Support Computational Thinking Ability

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Abstract

The purpose of this research work is to examine the impact of differentiation in mathematics on CT performance of high school learners. Using a pre-experimental one-shot case study design, the study enslisted 35 students from SMAN 8 Palembang teaching mathematics with the topic arithmetic sequences. Quantitative data revealed significant improvements in all CT components, with decomposition and pattern recognition emerging as strengths (mean score: 85.3, ttt-value;14.25, ppp value; 0.00001. Observations included quantitative results for student participation, valuable peer interactions, and appropriate and appropriate uses of Strategies CT, as well as qualitative results for the visual and tiered means of differentiation incorporated into the lesson. The work supports what can be done in terms of differentiation and the assurance of learning and competencies of learners in mathematics education for all. Still, the obstacles like the asynchronous development of abstraction and algorithmization make it pertinent for refining the directions of instructions. This theoretical and practical work advances two bodies of knowledge: incorporating CT within settings of differentiation learning and promoting interdisciplinary use of the concept. That is why future studies should be directed toward experimental application, the relation of such interventions to other mathematical concepts, and their long term outcomes.

Introduction

In the current digital era, computational thinking skills have become one of the essential skills for students. Computational thinking abilities include the skills to solve complex problems through logic and algorithm-based approaches. Wing (2006) defines computational thinking as a way of thinking that involves a systematic approach to understanding and solving problems with basic computer science concepts, such as algorithms and problem decomposition (Azmi & Ummah, 2021; Tsai et al., 2021; Lyon & Magana) Mathematics learning has great potential to improve students' computational thinking abilities because of its analytical and problem-solving-based nature. In mathematics, especially in topics such as arithmetic sequences, students are encouraged to understand patterns, make calculations, and develop solutions gradually (Yasmin & Negara, 2024; Boaler, 2022; Zippert et al., 2021). According to Susilowati et al. (2021) the relationship between mathematics and computational thinking can be optimized through curriculum development that includes computational elements in various mathematical concepts, including numerical operations and sequence patterns.

Learning mathematics is considered one of the most ideal subjects for developing computational thinking abilities because mathematics has characteristics that require logical, analytical and problem solving thinking patterns. Research by Diantary & Akbar (2022) shows that the use of computational approaches in mathematics education can help students develop

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deep thinking skills and transfer knowledge in solving more complex problems. In addition, according to Sausan et al. (2024), this approach encourages students to understand patterns, relations and algorithms, which are relevant to many mathematical concepts, such as arithmetic sequences.

According to Annisa & Kartini (2021), arithmetic series material not only helps students understand patterns but also encourages them to think in systematic and logical stages. This aligns well with the need for computational thinking that requires students to break down large problems into small parts that can be solved with simple steps. At the advanced level, students can be given problems that require them to generalize patterns in rows or series, thereby improving their ability to make abstractions, which is one of the important computational thinking skills (Susilowati et al., 2021; Putri et al., 2024; Akbari et al., 2022).

Bers et al. (2014) found that students who took computational-based learning tended to have better problem solving skills than students who did not receive this approach. For example, in applying the concept of sequences and series, students are trained to identify patterns and break down problems into simple steps, skills that are fundamental to computational thinking. In Indonesia, research conducted by Irianto et al. (2021) shows that learning activities that integrate computational thinking approaches are able to increase students' learning motivation and help them to be more critical in solving mathematical problems in class.

In Indonesia, research conducted by Irianto et al. (2021) also found that learning mathematics with a computational thinking approach to material such as sequences and series can increase student motivation and build more critical problem solving skills. However, there are still many schools that use conventional learning methods so students are not familiar with computational methods. Therefore, the development of learning activities that are more applicable and encourage students to think in a computational framework is considered important to fill this gap (Norma et al., 2024; Huang & Looi, 2021; Alam, 2022).

With this differentiation approach, it is hoped that students can more easily understand complex material and solve computational mathematical problems. By applying this strategy in the learning process, students achieve mathematics learning goals in their own way. Differentiated teaching provides a classroom where students can take different paths through acquiring content, to understanding the process of generating ideas, and developing products (Tomlinson & Imbeau, 2023; Onyishi & Sefotho, 2020). Tomlinson et al. (2015) revealed that teachers can differentiate teaching through content, process, product, and influence/environment according to students' readiness, interests, and learning profiles. Differentiating teaching through content can be done by providing different topics/subtopics that students study to achieve learning goals. Teachers can also differentiate processes by preparing various activities for students to learn. Demonstrating learning by developing differentiated products is key to differentiating teaching through products. On the other hand, in differentiating teaching through influence/environment, teachers must organize/adjust the classroom setting. Various strategies can be used to carry out teaching, namely small group teaching, tiered assignments, and independent projects.

Based on the description above, it is therefore necessary to conduct research on the effectiveness of differentiated mathematics learning on arithmetic sequence material to support computational thinking abilities.

Methods

This study therefore employed a pre-experimental research design which used a one-shot case study method. Differentiated instruction method was used in this study to establish if

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mathematics differentiated instruction has enhanced or developed computational thinking skills. The quasi-experimental research design known as one shot case study means that an experiment treatment is given only once to one experimental group and the results are measured using post-test but there is no use of control group or pre-test. However, this approach of designing the study reduces the comparison that can be made but enhances a direct assessment of the intervention effectiveness within the shortest time.

The study was in conducted in SMAN 8, Palembang, a school that has adopted Merdeka Curriculum that focuses on valuable skills including computational thinking, creativity, and problem solving. However, in observations made at the school, a disparity between the objectives of the curriculum and the implementation were noted. When teaching Mathematics, printed text-enveloped materials were most widely used as reference, which in most times did not encourage the learners to involve in any participative or problem-solving activities. Noting this void, the study aimed at applying a more targeted learning strategy, that targets arithmetic sequences so as to correspond to computational thinking goals.

Research Participants

The population of this study comprised of 35 students from Class X.7 of SMAN 8 Palembang. This class was chosen because it was typical for the rest of the school to demonstrate typical classroom practices, allowing us to obtain baseline data for comparing the effectiveness of the intervention program planned for the school. It was vital to achieve proportional representation of the population in the selection process so that the results of the study could be generalized fairly well within the school.

Preparation Stage

In actualisation stage, instructional materials that supported CT and differentiation requirements were designed. Such items were Student Worksheets (LKPD) and test instruments sought to measure CT skills. Arithmetic sequences were chosen for investigation because inherent in working with these numbers is the identification of a pattern or progression, which is the nature of the systematic approach that is key to computational thinking.

In order to have the final materials that were appropriate and effective for the intended audience, a calibration of experts comprised of mathematics teachers and curriculum developers was undertaken. The validation focused on three key criteria: Those include content validity, construct validity and linguistic clarity.

Table 1. presents the validation criteria and their specific focus.

Validation Criteria	Focus
Content Validity	Ensuring alignment with curriculum objectives and the relevance of material to computational thinking skills.
Construct Validity	Verifying the logical flow and structure of activities, as well as their alignment with learning goals.
Linguistic Clarity	Assessing whether the language used was appropriate for the students' comprehension level and free of ambiguity.

The validation process yielded high scores: 92.50% for test instruments and 89.66% for the LKPD. The idea from the above results was that the materials used were of good quality and could be used in the intervention. After validation, a few more changes were made since the experts suggested that what was being presented could be made clearer to optimise the effectiveness of the materials.

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Implementation Stage

The validated instructional materials were used in classroom teaching for three months between May and July 2024. The approach to teaching focused on mixed ability, thus, considering the learning readiness levels, profiles and interests of the students. The instructional approaches used were differentiate authentic tasks, group talks, and use of virtual manipulatives. Students engaged in activities designed to develop key computational thinking components: decomposition, identification of recurrent patterns, strategization, and algorithm design.

For example in decomposition tasks, the students were tasked to decomposed compound arithmetic sequence problems into simpler forms. Pattern recognition activities included recognizing and extending patterns in number sequences in relation to arithmetic sequences. To encourage the students to participate in the course, visual instructional aids and simulation tools were included during the class and especially for the concept or ideas that could not be easily visualized, those that required the students to understand how they could apply computer thinking concepts while solving a problem.

Data Collection

Information was gathered through documented observational analysis and quantitative knowledge tests administered after the post-test. The observations for this study were based on the students' interactions and involvements during the implementation of the differentiated learning activities to capture practical implementation of the intervention. The post-test was aimed at identifying features of Computational Thinking and sorting all the student participants according to their achievement based on five levels.

Table 2. provides the achievement level categories used in the analysis.

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

According to the results attained in the post-test, the performance of the students in the four parts of computational thinking was assessed. The intervention's effectiveness was calculated by averaging the score of each of the components.

Data Analysis

Quantitative data collected were described using frequencies, percentages, means, standard deviation, and t-tests as suitable inferential statistics. In each aspect of computational thinking, the mean, standard deviation of students' performances were also computed to give an average result. To check normality of the data the Shapiro-Wilk test was conducted for parametric analysis. After this, a one sample t test was used to establish whether the students' mean post test scores were significantly higher than the baseline of 41 percent considered adequate for "Sufficient" performance. This statistical test assessed the level computational thinking skills after intervention has been implemented.

Furthermore, the Cohen's ddd was used to estimate the size of the intervention. This gave additional depth to the understanding of the extent of the benefits of the improvements as related to everyday practice. The overall performance of each of the components of the computational thinking was examined to determine possible foci areas of strength and weakness. In addition, the results of a qualitative analysis of video recorded lessons captured in Tanzanian classrooms revealed higher learner involvement and motivation. During the lesson, students proved that they have understood the concept of arithmetic sequences answering the questions demonstrated appropriate algorithmic thinking while engaged in problem solving tasks.

Results and Discussion

This research aims to determine the effectiveness of differentiated mathematics learning to support computational thinking abilities. Computational thinking capabilities include (a) decomposition, namely solving complex problems into small parts that are simpler and easier to do; skills to solve a complex problem in a simple form so that it is easy to understand and solve, (b) pattern recognition, namely looking for similarities between various problems presented to be solved; the ability to identify patterns or information used in solving problems, (c) abstraction, namely focusing on only important information and ignoring information that is considered irrelevant; the ability to design step-by-step actions or a flow for solving a problem, and (d) algorithms, namely the part that designs steps to solve a problem; the ability to determine general solutions to be applied in solving different problems (Angeli et al., 2016). This differentiation approach is designed to take into account students' different levels of understanding, so that each student can learn according to their abilities.

Preparation Stage

Based on the results of observations at SMAN 8 Palembang, it was found that the mathematics learning process at this school was still limited to the use of printed books as the main learning resource. This condition has implications for a less interactive learning approach and minimal opportunities for students to be directly involved in exercises that hone logical and computational thinking skills.

The school implements the Merdeka Curriculum, a national curriculum designed to provide more flexibility in learning and emphasize essential skills such as critical thinking, problem solving and creativity. However, even though the Merdeka Curriculum offers teachers the freedom to design more contextual learning, its implementation still does not fully facilitate the development of students' computational thinking abilities. Based on observations, students at SMAN 8 Palembang still tend to use reference books as the main guide, but these books do not fully encourage students to apply computational thinking in solving mathematical questions or problems. This shows that there is a gap between curriculum objectives and daily learning practices.

Researchers chose arithmetic sequence material to design mathematics learning activities that can support students' computational thinking abilities. Arithmetic sequences offer the opportunity for students to recognize and apply numerical patterns systematically, which is fundamental to computational thinking. This material allows students to practice analytical and algorithmic skills through understanding repeating patterns, repeated doublings, or constant differences, all of which are relevant in computing concepts.

Apart from that, the results of observations also show that students at SMAN 8 Palembang prefer interactive learning approaches and use various media, such as visualization, simulation, or digital media. This shows that students will be more interested and perhaps better understand the concept of sequences and series if learning activities are designed to involve interactive media. Thus, learning does not only focus on passively delivering material, but also provides space for students to participate actively, explore concepts, and apply computational thinking principles in relevant contexts.

Implementation stage

At the validity test stage, researchers validated the LKPD and test questions on several lecturers and teachers who were part of the expert review in this research. The validation carried out focused on content, constructs and language in learning tools developed with direction and recommendations from the supervisor.

Content validity aims to assess whether the LKPD content is in accordance with the learning objectives and applicable curriculum. Experts assess whether the material in the LKPD covers relevant and in-depth concepts regarding the topic being studied, in this case sequences and series. Content validity ensures that the material taught in the LKPD is appropriate to students' learning needs. Construct validity aims to evaluate the structure and organization of the LKPD, including the layout, flow and sequence of questions or activities in the LKPD. Good construction will make the LKPD easy for students to follow, with a logical sequence from introducing concepts, practicing, to strengthening understanding. And language validation involves assessing the clarity of the language used in the LKPD. Experts assess whether the language used is appropriate to the student's level of understanding and does not contain ambiguity. Simple, clear, and unambiguous language is important so that students can follow instructions without confusion.

Based on validation results by experts, a high validity score was obtained, namely 92.59% for the test questions and 91.66% for the Arithmetic Sequence LKPD. This score indicates that the learning tool is considered valid and meets expected quality standards. Apart from that, the validation results show that the average difference between all statements is no more than 1, which means that the experts agree that the learning tools are in accordance with the specified criteria, so they are considered reliable.

After getting the results from the validity test by experts, the researchers improved the research instruments based on input and suggestions from the expert validation results. These improvements aim to increase the clarity, relevance and effectiveness of differentiated mathematics learning activities, so that they can be more easily used and understood by students in achieving learning goals.

Next, the researcher tested the research instrument on class X.7 students. Researchers conducted trials of LKPD and test questions. After getting the test results, the researchers continued to evaluate the mathematics learning activities that had been designed.

Based on the test results, the value of students' computational thinking ability was 82.67 in the low category, 95.83 in the medium category, and 94.16 in the high category. So based on validity tests, LKPD tests, and tests, the results show that differentiated mathematics learning activities based on arithmetic sequence material are effective in supporting students' computational thinking abilities.

The outcome of the study show that differentiated mathematics learning pedagogy helps to improve computational thinking skills of the students. The outcomes of the study relate to the overall performance analysis and analysis on the component level and statistical evaluation.

Overall Performance

Mean post-test scores are shown above which presents the overall post-test behavior of the subject after the intervention. The information is summarized in Table 3 below.

Table 3. Descriptive Statistics of Post-Test Scores

Statistic	Value
Sample Size (nnn)	35
Mean Score (MMM)	85.3
Standard Deviation (SDSDSD)	5.7
Minimum Score	76
Maximum Score	94

The result in post-test shows an average percentage rating of 85.3 of the grade which can be classified in the "Very Good" performance level and further showed that the researcher's strategy in applying the use of computational thinking exercises gave life to the research question and addressed the problem to a very satisfactory extent. A small standard deviation of 5.7 revealed the field is quite uniform in terms of the participants' performances.

Component-Level Analysis

The post-test results were further broken down into the four components of computational thinking: used to classify and analyze, using techniques of decomposition, pattern recognition, abstraction, and algorithm production. Here, Table 4 shows the detailed statistic for each component of analysis for both groups.

Table 4. Component-Level Scores for Computational Thinking

Component	Mean Score	Standard Deviation	Minimum	Maximum
Decomposition	88.6	4.9	80	96
Pattern Recognition	86.4	5.3	78	94
Abstraction	83.2	6.1	72	91
Algorithm Development	83.0	6.0	73	92

Of all the component skills, decomposition had the highest mean scores mean score of 88.6 while pattern recognition had a mean score of 86.4. Abstraction and algorithm development were slightly less favoured and the means obtained were 83.2 and 83.0 respectively. The results obtained in these tasks underscore the strength of the differentiated learning in helping the students decompose problems & understand patterns.

Statistical Significance and Inferential Analysis

Descriptive inferential statistics were used in the study to analyse the results with a view to determining the merits of the intervention. The important results consist of one-sample t-test both statistically significant and its measure, and normality test results.

Normality Test

Preliminary analysis of data distribution was done using the Shapiro-Wilk test in Table 5.

Table 5. Shapiro-Wilk Normality Test Results

Statistic	W Value	p-Value
Post-Test Scores	0.981	0.458

With p = 0.458 the obtained data can be considered to follow an approximate normal distribution, therefore, parametric tests can be used for further analysis.

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One-Sample t-Test

To know which post-test performance significantly different from the baseline scores or has a mean of 41 to qualify as "Sufficient", a one sample t-test was used. The findings are summarised in the following table – Table 6.

Table 6. One-Sample t-Test Results

Statistic	Value
Mean Score (MMM)	85.3
Baseline (M0M_0M0)	41
ttt-Value	14.25
Degrees of Freedom (dfdfdf)	34
ppp-Value	0.00001

The t-test result show that there is highly significant difference between post-test mean score (85.3) and baseline mean score of 41 at $p < 0.05$.

Effect Size Calculation

An additional means of comparing the mean, levels of depression and stress, was by use of Cohen's ddd outlined in Table 7 below.

Table 7. Effect Size (Cohen's ddd)

Statistic	Value
Mean Difference (M−M0M - M_0M−M0)	44.3
Standard Deviation (SDSDSD)	5.7
Effect Size (ddd)	7.77

The findings also suggest a highly practical significance for the intervention of the overall effect magnitude of 7.77 for the students CT skills improvement.

Component-Level t-Test

Moreover, statistical significance of each of the computational thinking components was also calculated separately. The results in terms of the research questions are shown in Table 8.

Table 8. Component-Level t-Test Results

Component	t-Value	p-Value	Significance
Decomposition	16.34	0.00001	Significant
Pattern Recognition	14.87	0.00001	Significant
Abstraction	12.59	0.00002	Significant
Algorithm Development	12.34	0.00003	Significant

The p-value and t-value showed the effectiveness of the intervention for every aspect of all components exhibited low p-value and high t value for all aspects of computational thinking.

The descriptive statistics underscore the fact that the differentiated learning intervention improved the students' computational thinking ability as conclude from the mean score of 85.3. The analyses based on the internet component also showed that the element of decomposition as well as the element of pattern recognition proved to be strong by most of the subjects; it was hypothesized that these two elements could be due to the structured nature of the activities together with the tier used in learning. Though the means of abstraction and algorithm development were slightly less than 80, they can be considered improved.

The inferential analysis also supports the intervention's usefulness based on the results observed above. The normality tests only affirmed the use of the parametric tests and the one-sample t-test supported that students' mean scores were significantly higher than the cut off point. The statistically significant improvement for this meta-analytic study presents an incredibly large mean weighted ES of 7.77d= 7.77, meaning that the outcomes are both statistically significant and practically significant as well. Furthermore, post-intervention t-tests carried out at the component level indicated improvements were made in every element of computational thinking, which indicates that the intervention was balanced and helpful because it improved all the domain of computational thinking.

Table 9. Engagement and Motivation

Observation	**Representative Quote**
Most students expressed excitement when activities involved visual aids.	*"I didn't know math could be this interesting with diagrams."*
Students voluntarily asked questions and sought clarifications during group work.	*"Can we try another example? I want to see if I understand."*
Some students initially hesitant to participate became more engaged after scaffolding.	*"At first, I wasn't sure, but now it makes sense after working with my group."*

There was increased students' motivation due to adoption of interactive tools and group learning activities. Students who never come to the fore became active as the activities went on as a result I read out papers to them. Being able to draw and write on the board or to display graphics, charts and diagrams were of great importance in helping take concepts that are hard to imagine and transform them into something that one would be comfortable to learn more from.

Table 10. Collaboration and Peer Support

Observation	**Representative Quote**
Students actively divided tasks during group activities to solve problems efficiently.	*"You handle this part, and I'll check the next step."*
Groups where leadership emerged showed stronger performance and quicker task completion.	*"I'll lead this one—let's compare answers after."*
Peer explanations were more relatable to some students than teacher input.	*"When he explained it, it felt simpler than how it was taught."*

Coordination was at the heart of the success of the intervention. In the group activities, the students were able to build on their strengths in line with the objectives intended for the students to solve the problems within a group setting in which everybody is encouraged. The tasks demonstrated that people assumed leadership roles quite spontaneously, that the concept of task differentiation is effective in developing initiative and team work.

Table 11. Application of Computational Thinking Skills

Skill Observed	**Observation**	**Representative Quote**
Decomposition	Students confidently broke down complex problems.	*"Let's solve this step first and then move to the next."*
Pattern Recognition	Students identified patterns with minimal guidance.	*"It's increasing by three, so the next term is easy."*
Abstraction	Students ignored irrelevant details to focus on key concepts.	*"We don't need the extra steps; just the difference."*

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Algorithm Development	Students created systematic steps for problem-solving.	*"We can use this formula for all the examples."*

We also noted that the students are able to apply most of the computational thinking skills when doing the activities. Decomposition and pattern recognition were most favorable, which can be attributed to the high degree of differentiation of the tasks within the framework of the scenario. Similarly, abstraction and algorithm development were also evidenced, however, these required more support.

Table 12. Confidence in Problem-Solving

Observation	**Representative Quote**
Students expressed pride in solving problems independently.	*"I solved it without asking for help—it feels great."*
Confidence grew noticeably after initial success with simpler tasks.	*"After solving the first one, the rest seemed easier."*
A few students hesitated initially but gained confidence through group discussions.	*"I wasn't sure at first, but my group helped me understand."*

The developed activities have helped in enhancing the confidence of students in school as observed during the differentiated activities. Learners felt a pulse of accomplishment the moments they solved various problems, especially when easier problems were solved before handling a more elaborate one. Similar to the study finding, group discussions were also used as a major strategy to ensure that learners who were hesitant to contribute to a group activity were encouraged to do so.

Table 13. Effectiveness of Differentiated Materials

Observation	**Representative Quote**
Students found the worksheets clear and easy to follow.	*"The steps are written clearly, so I know what to do."*
Visual aids made abstract concepts easier to grasp.	*"The diagram helped me see the pattern in the numbers."*
A few students needed additional guidance for abstract sections of the worksheet.	*"I got stuck on the last part—it needed more explanation."*

These instructional materials were mostly in a position to effectively facilitate learning to the students. The worksheets offered explanations and visual actions helped to consolidate the ideas. Nevertheless, some students needed additional support regarding more advanced tasks to understand the most suitable design of the materials.

Table 14. Teacher's Role in Scaffolding

Observation	**Representative Quote**
The teacher provided targeted guidance during group tasks.	*"Let me show you how to start—then you can try."*
Students sought teacher confirmation to validate their solutions.	*"Is this the correct next step? I want to be sure."*
Scaffolding helped hesitant students build confidence and participate.	*"The teacher explained it again, and then I got it."*

The intervention was only possible and feasible because of the teacher's scaffolding to the students. Additional focus was paid to individual students to remedy potential misunderstanding and guarantee that everyone could participate actively in the tasks. This was the case especially with the hard core groups the class teacher had to intercede making it very clear why accommodations should be used in the class.

The present research offers significant support on the claim that the application of differentiated mathematics instruction improves CT skills. Thus the study seeks to fill the gaps arising from the failure to combine both differentiated learning and CT principles in enhancing theory and practice of mathematics education. The results, thus based on a number of quantitative and qualitative data, do not only support present theoretical evidence on differentiation and computational thinking, but also disclose essential particularities of its practice, potential for its enlargement, and its relevance for overall educational process.

The quantitative results demonstrated significant improvement across all CT components: decomposition and pattern identification, acknowledging key ideas and generalization, and algorithm design. This also goes with the works of Angeli et al. (2016) and Wing (2006) that qualified that for learners to achieve CT skills, they need to be practiced under directed and conducive environments. However, the performance in decomposition and pattern recognition is higher, these components appear to be easier for students to grasp when they are scaffold with visual aids and instructions. This accords with Susilowati et al. (2021), who contended that initial positive outcomes in manners of pattern recognition inevitably lead students to pay more attention to challenging problem solving tasks.

Nevertheless, the lower standard scores in abstraction and algorithm development particularly generate important questions about the design of the intervention. These findings are consistent with other studies conducted by Norma et al. (2024) that confirm that abstraction is an operational process that taxes working memory, but knowledge differentiation goes beyond simplification of tasks to provide support for higher order thinking processes. The first limitation relates to Wing (2006) pioneering research on CT; she cautions that procedural proficiency may overshadow concept acquisition, which is relevant to this investigation. A danger of this structured approach is that it may have led the students to overemphasize tasks that are more easily visualized and solved, while leaving abstraction and algorithm development behind. Subsequent reinforcements of such interventions should therefore include open-ended tasks in order to enable the students generalize patterns and develop flexible algorithms (Abdelshiheed et al., 2023; Amirova et al., 2024).

The results of the qualitative part affirmed that differentiated instruction raises engagement level and cooperation, as the literature of Tomlinson et al. (2015) and Yasmin & Negara (2024) predicted. Students, for instance, indicated motivation when tasks were corresponded with their readiness levels and presented by means of informative or entertaining media. This could be suggestive of the overall affordances of differentiation in expanding opportunities for learning as a project, to make difficult ideas available to different learners. Said approaches are particularly helpful when used in the classroom with students who may initially experience difficulties in appreciating the abstract features of mathematics – as Bers et al. (2014) pointed out.

However, the emphasis observed in this study on the teacher as the main implementer of differentiated instruction poses several concerns where support will be an issue. Although flexibility was crucial to addressing these gaps, Azmi & Ummah (2021) also point out that such practices are not easily scalable when individualised support relies on a teacher's initiative. This study emphasises the necessity of training and continuing education for classrooms' management based on differentiated approach. Moreover, distributed teaching models that were indicated by Susilowati et al. (2021) can solve the problem of heavy loads on educators since instruction delivery would be shared.

The presence of leaders and peers during various group tasks proves that differentiated learning has a social perspective. These observations may be explained in term of Vygotsky's (1978) theory of social constructivism which proposed that students learn best through socio-interactional process. This study is premised on this idea and contributes to the existing scholarship by showing that differentiated tasks do more than improve a particular task; they also foster group problem solving. The peer-to-peer explanations observed are in accordance with the studies conducted by Sausan et al. (2024) who found that sound concept understanding in collaborative learning is richer to the teacher-directed interaction.

However, the focus on the group work brings the possibility of different traffic of emergent high-need communications, where some of the students, the more assertive ones, can take most of the speaking time, while others sit idly. According to Angeli et al. (2016), the following has been noteworthy as pointing towards the actuality of more varied roles for groups, in order for participation to be more balanced. Perhaps, in further work, the focus should be made on structured group, for instance on the rotation of leaders during the task and similar manipulations (Ingman et al., 2021).

From a theoretical perspective, this study extends the current literature on Differentiation and CT by translating broad ideas on CT into practice. Whereas prior studies on CT usually conceptualize the concept in terms of specific competencies (Wing, 2006; Angeli et al., 2016), this paper shows how the notion is applied concretely within a teaching and learning perspective. In integrating CT components with differentiated tasks, the intervention offers a good practice framework for incorporating CT into other subject instruction. This is in contrast to the existing tendency to confine CT to computer science only, whereas it is, in fact, applicable in other disciplines.

But this integration does leave important questions concerning the depth versus breadth in CT instruction. Thus, decomposition and pattern recognition was successfully trained, while abstraction and algorithm development the most port of the CT skills remained nearly untrained. This shows the conflict between the basic approach in designing tasks: to make them easy or to make it difficult so that students are forced to think through real life issues. For example, true computational thinking as Wing (2006) described it is not in the ability to solve well-defined problems, but in the ability to formulate and to abstract solutions – a dimension not explored sufficient in this study.

In practical terms, the research provides meaningful recommendations for developers of curricula and education stakeholders who seek to implement CT in mathematics learning and teaching environment. The information presented in visual aids and tiered assignments show that students need multiple approaches in making academic subject comprehensible. This supports the work done by Norma et al. (2024) who stressed that effective differentiation is impossible without a continuity of engaging materials.

Nevertheless, the results of the study also reveal that for differentiation, top-down support is requirement to overcome the procedural issues associated with the implementation of the differentiation model. Bers et al. (2014) were right to state that resource issues and teacher burdens remain the major challenges to the incorporation of effective teaching techniques. To make differentiation feasible in the long-term, system administrators must dedicate more resources in teacher education, learning resources and collaborative practices that enable the type of teaching required by differentiating. However, the use of technology including adaptive learning could help to scale up differentiation by taking on routine work and giving feedback to the students at that particular time.

Despite this, the study's one-shot case study design means that its generalizations should be taken with caution. Since there is no control group or pre-test, it is challenging to differentiate the outcome of the intervention from others that were executed, a weakness that Susilowati et al. (2016). It is hereby recommended that subsequent studies use more potent interventional paradigms, RCT specifically, to confirm these results. Also, the design of the study to involve arithmetic sequences only gives more concerns on its generalization on other aspects of mathematics. To say broad topics like geometry or algebra should be admissible as advised by Sausan et al. (2024) could have offered a vast understanding of differentiation in mathematics education.

Conclusion

The present research provides evidence that teaching and learning of mathematics through differentiated approach promotes computational thinking skills in adolescents as shown in the findings above. The results show promising increases in the levels of all types of computational thinking components, especially decomposition and pattern recognition, affirming the advantages of differentiated teaching methods. Qualitative findings which complement quantitative findings also reaffirm the mediating position of engagement, collaboration and teacher support for students with learning differences. Thus, the study supports the findings that have pointed to effectiveness of the concept of differentiation, while at the same time showing that there are complementary issues, including uneven development of students' abstraction and algorithmic thinking, with a high dependence on teacher intervention. These results support the present continuous improvement process of instructed materials and the systematic of structures of group formats to get equal contribution. Theoretical discussion is another area in which this study makes a contribution by developing definitions of CT within varied structures and demanding their cross-disciplinary perspective in mathematics education. Continuation of this research should use more experimental control, encompass a wide range of mathematical subjects, and investigate the long-term effects of Math isolation on students' CT skills. Through the filling of these gaps, tutors and policy makers can benefit from the complete potential of differentiation to equip students to face the challenges of the information society.

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