

Developing High School Mathematics Teacher Competence Through Computational Thinking Integration Workshop

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Abstract

This community service (CS) aimed to develop the competence of high school mathematics teachers through workshops integrating computational thinking in Barito Kuala Regency. The implementation method of this consisted of preparation, activity implementation and mentoring, and evaluation stages. In the preparation stage, a computational thinking workshop module was developed for mathematics material and distributed to participants during the training activities. Community service with a Participatory Action Research (PAR) approach is oriented towards community empowerment so the community can become an actor of change. Community service activities facilitate bridging mathematics teachers to develop CT in this case. This CS activity was conducted over two face-to-face meetings from August to September 2024. This CS activity was implemented in the Global Islamic Boarding School (GIBS) computer laboratory in Barito Kuala Regency. The participants who attended were 54 high school mathematics teachers from the region. The evaluation instrument used for data collection was a questionnaire filled out by participants via Google Forms. After the workshop, The evaluation showed that most teachers understood that CT was related to problem-solving through a systematic, logical, and algorithm-based approach. The high average score indicated that the training provided successfully introduced and effectively explained the CT concept. The involvement and active participation of teachers were very evident in this activity. Furthermore, an interesting finding was that teachers expressed 89.8% agreement that computational thinking needed to be taught to students. This was because CT could help students think critically and logically and build mental resilience, thereby increasing their readiness for the world of work in the future.

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INTRODUCTION

In today's digital era, technological advances have had a major impact on various fields, including education. Digital technology has changed the way we think, work, and learn. The world of education, especially in mathematics teaching, must adapt to these changes

by implementing new ([Hsu et al., 2018](#)), relevant approaches to support students in developing critical, creative thinking skills and problem-solving abilities effectively. One approach that is increasingly considered important in mathematics learning is computational thinking ([Gadanidis et al., 2017](#)).

Computational thinking is a series of mental processes that involve solving problems in a way computers can understand. This approach involves several main components, such as decomposition (breaking problems into smaller parts), pattern recognition (recognizing similarities between different problems), abstraction (filtering out irrelevant information), and algorithms (developing steps to solve problems) ([Huda & Ikhsan, 2024](#)). Computational thinking is not only for computer scientists but a fundamental skill everyone should have, including students in school ([Barr et al., 2011](#); [Lamprou & Repenning, 2018](#)). Computational thinking pays attention to important patterns or mathematical insights, logical thinking, and being able to design and implement models while considering aspects of robustness, accuracy, and speed of convergence of algorithms and also discusses the basics of computer arithmetic and rounding errors ([Berkaliev et al., 2014](#); [Lan, 2017](#); [Lyon & Magana, 2020](#)). Integrating computational thinking in mathematics learning allows students to understand mathematical concepts better through structured problem-solving.

The importance of implementing computational thinking in mathematics learning is also supported by research showing that this approach can improve students' skills in solving complex problems, critical thinking, High Order Thinking Skills and strengthen the understanding of abstract mathematical concepts ([Chahyadi et al., 2021](#); [Papert, 2020](#); [Syamsy & Sholikhah, 2023](#)). In Indonesia's education context, the need for innovation in mathematics learning is very important, especially with the changes in the curriculum that emphasize mastery of 21st-century competencies, such as critical thinking skills, collaboration, and digital literacy. This places teachers, especially mathematics teachers, in a key position to bring this transformation into the classroom.

Teachers act as facilitators, motivators, and guides in learning, creating an interactive learning environment that supports students' needs. Competencies such as computational thinking enable teachers to teach 21st-century skills, such as problem-solving and logical thinking ([Huda & Ikhsan, 2024](#); [Lyon & Magana, 2020](#)). This increases student engagement, conceptual understanding, and readiness for the digital world. Teachers are the main component in the education process, and the quality of their teaching greatly influences student learning outcomes ([Sutardi & Sugiharsono, 2016](#)). Furthermore, the direction of education policy can be a continuous training program for teachers to support CT integration in schools. In this digital era, teacher competence is no longer limited to mastery of the material but also the ability to integrate technology and modern thinking approaches, such as computational thinking ([Fricticarani et al., 2023](#); [Pringgandinie & Devi, 2022](#); [Sunarno, 2024](#)).

The competencies in question include understanding computational thinking and the ability to apply it in the context of mathematics learning. Computational thinking provides a new way for teachers to teach students how to solve mathematical problems more structured and analytically ([Yanti & Syazali, 2016](#)). This provides a deeper understanding of mathematical concepts and trains students to think logically and systematically.

However, based on initial observations and interviews with the Senior High School Mathematics MGMP in Barito Kuala Regency, many mathematics teachers still face obstacles in understanding and implementing computational thinking in their teaching. It is known that the challenges of implementing computational thinking include inadequate school infrastructure (unstable connections, devices that are not supportive, limited WiFi

coverage), practical problems in implementing CT taking up teaching time, and teachers feeling less confident due to limited knowledge or technological capabilities. Most have not received special training that equips them with the skills and knowledge to integrate computational thinking into mathematics learning ([Telaumbanua et al., 2024](#)). Training and professional development for teachers are very important in improving their competencies related to integrating technology and computational thinking in teaching ([Purba et al., 2022](#); [Sari et al., 2020](#); [Sukmawati et al., 2022](#)). Similar activities have also been carried out before. For example, computational thinking training on subjects for madrasah teachers at Selaparang Lombok Islamic Boarding School ([Supatmiwati et al., 2023](#)) and computational thinking training for improving Telkom Schools Teacher Competence as Part of the Gerakan PANDAI (Indonesian Digital Era Teachers) ([Arzaki et al., 2023](#)). This service offers something new that focuses on developing mathematics teacher competencies through CT integration carried out in Barito Kuala Regency.

Therefore, this community service activity is designed to solve the problems mathematics teachers face in Barito Kuala Regency. A workshop that focuses on integrating computational thinking in mathematics learning is expected to improve the competence of these teachers so that they can teach with a more innovative and relevant approach to current developments. Thus, this community service aims to develop the Competence of High School Mathematics Teachers through Computational Thinking Integration Workshops in Barito Kuala Regency.

METHODS

Community service with a Participatory Action Research (PAR) approach is oriented toward community empowerment ([Afandi et al., 2022](#)). Empowerment must always meet the community's needs and solve problems that exist in it. In addition, PAR is also oriented towards the development and mobilization of knowledge in the community so that the community can become an actor of change. The community is the main agent of socio-religious change, so lecturers and students implementing community service are the other parties facilitating the change process. The presence of lecturers and students as facilitators who participatory empower community members. In this case, it is a facilitator to bridge high school mathematics teachers to develop CT. The implementation method of CS consists of several stages, as described below.

Preparation Stage

At this preparation stage, the community service team conducted an initial survey and coordinated with partners regarding the community service implementation plan. After initial communication with partners, the community service team made a statement of willingness to cooperate with the partners, which the Head of the MGMP Mathematics signed for High Schools in Barito Kuala Regency. At this stage, the community service team prepared teaching materials relevant to developing a computational thinking workshop module for mathematics materials. The workshop activities will use the module as a presentation and discussion material. This activity was socialized by the management of the MGMP Mathematics for High Schools in Barito Kuala Regency to its targeted members.

Implementation of Activities

This activity was carried out in the Global Islamic Boarding School (GIBS) computer laboratory, Barito Kuala Regency. Participants who attended were 54 high school mathematics teachers in Barito Kuala Regency. This activity was carried out from August to September 2024. The community service team comprised 12 people, eight lecturers, and four students. The workshop was held for two days and included theory and practice

sessions. In the theory session, participants will be given basic knowledge about computational thinking and examples of its application in mathematics. In the practice session, participants will do direct practice. Participants get direct experience in creating programs in Scratch. Instructors assist them during the practice session. The Community Service Team assists participants so that if there are difficulties, they can be resolved quickly. Teachers learn to operate the Scratch interface and compose scripts relevant to mathematics learning.

Evaluation Stage

After the workshop, an evaluation was conducted through a questionnaire to measure the usefulness of computational thinking to be applied directly in classroom learning. The evaluation included distributing an evaluation questionnaire on implementing training activities to participants. Participants completed the evaluation questionnaire via Google Form ([Purba et al., 2024](#)). Several strategic steps can facilitate teacher participation in the CS program to ensure active involvement and sustainability of training outcomes. The training practicum module is provided online, so it can be used as a digital learning resource to support teacher competencies development independently. Furthermore, the CS team offers advanced training to deepen the skills learned and introduce the latest innovations in related fields based on feedback provided by teachers based on the questionnaire results.

Data Collection and Analysis Techniques

Data were collected through the following methods: (1) qualitative through informal interviews with teachers to discover their views on applying computational thinking in learning. The interviews were conducted with only a few teachers due to time and resource constraints. This allowed for a deeper focus on relevant teacher perspectives, providing more specific and detailed insights into CT implementation in teaching, (2) quantitative through the results of filling out the Google form questionnaire ([Purba et al., 2024](#)). Data analysis techniques used descriptive methods to describe changes in teacher competency before and after the workshop.

RESULTS AND DISCUSSION

This community service activity was carried out face-to-face using lecture, question and answer, demonstration, and discussion methods. In this activity, participants listened to the explanation and gained direct experience in creating programs in Scratch. Instructors supported them during the practice session, which allowed them to apply the knowledge they had learned realistically. This was intended so that participants understood the concepts and functionality of the available features and could also understand the procedure for creating programs in Scratch that were integrated with mathematics material. This activity began with an opening by the host. Continued with remarks from the Community Service Team and Head of the Senior High School Mathematics MGMP in Barito Kuala Regency and officially opened the workshop activity. Furthermore, the core activity of this training was the presentation of material and an introduction to the integration of Computational Thinking to develop mathematics teachers' competence in Barito Kuala Regency. The material was opened with a basic presentation of Computational Thinking, Computer Programming and Mathematics, and Scratch. Scratch provides computational thinking and problem-solving skills, creative teaching and learning, self-expression and collaboration, and equity in computing (Fagerlund et al., 2021; Martínez-Murciano & Pérez-Jorge, 2024). The following is a presentation of the workshop material shown in Figure 1.



Figure 1 Presentation of material

Figure 1 shows a resource person providing material, followed by hands-on practice by participants guided by an instructor. This allows participants to ask questions if they experience any obstacles or difficulties. Furthermore, discussions and hands-on practice are conducted on applying Scratch, which integrates computational thinking with mathematical material. Figure 2 shows participants participating in the training while doing hands-on practice in front of their laptops.

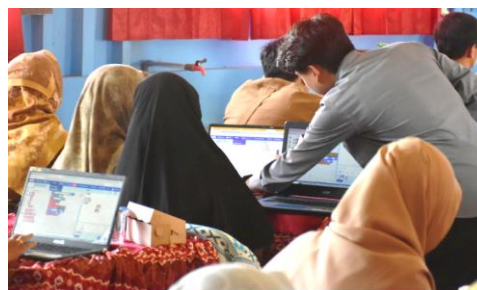


Figure 2 Teachers practice using scratch

After the practical session, participants also get hands-on experience in creating programs using Scratch. Accompanied by instructors, they can apply the knowledge they have learned practically, thus increasing their confidence in teaching and using technology in the classroom. Participants receive feedback from instructors and their peers, which can help them refine the programs they have created. This process contributes to improving the quality of teaching materials that will be used in class. Furthermore, discussion and question-and-answer sessions are important parts of this activity, as shown in Figure 3.



Figure 3 Teachers are actively involved in the workshop

This session created a collaborative atmosphere that encouraged participants to share their experiences and challenges actively. This interaction is very valuable in deepening their understanding of the application of computational thinking in the classroom.

In addition, participants were also asked to fill out a questionnaire to evaluate their understanding and experience during the workshop, which provided an overview of the overall impact of the activity. At the end of the program, participants shared reflections on the benefits they gained. They planned concrete steps to implement computational thinking and Scratch in the teaching process in their respective classes. Computational thinking provides a new way for teachers to teach students how to solve mathematical problems more structured and analytically (Yanti & Syazali, 2016). Next, Figure 4 presents the analysis results of the questionnaires teachers filled out about integrating CT in learning.

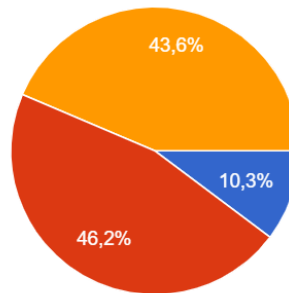


Figure 4 Teacher's choice that computational thinking needs to be taught to students

Based on Figure 4, teachers stated that CT needs to be taught to students by integrating it into other subjects as much as 46.2%. Nearly half of the teachers believe CT should be integrated into existing subjects. This perspective stems from the interdisciplinary nature of CT, which emphasizes problem-solving, data analysis, and logical thinking. Teachers stated that CT needs to be taught to students as a separate study and integrated into other subjects, learning as much as 43.6%. Many teachers advocate for a combined approach, where CT is both a standalone subject and integrated into other subjects. Teaching CT separately allows for deeper exploration of core computational concepts like algorithms and coding, while integration ensures students can apply these skills in real-world contexts. As much as 10.3% of teachers stated that CT needs to be taught to students as a separate study without needing to be integrated into other subjects. Concerns about losing depth might drive this view if CT is merely integrated into other lessons. Teachers with this perspective may believe that a focused curriculum is necessary to cover the technical aspects of CT comprehensively.

In another statement, 51.3% of teachers strongly agreed that developing CT skills is as important as developing other basic skills, such as reading, writing, and arithmetic. The statement that CT needs to be an elective subject for students who are interested but there should be no coercion in learning CT principles for students who tend not to be interested had a variety of responses from teachers: 2.6% disagree and less agree; 25.6% neutral; 46.2% agree, and 23.1% strongly agree.

Future jobs require more skilled workers using CT skills by utilizing computers agreed upon by teachers. As many as 33.3% and 53.8% strongly agree. Teachers need to facilitate learning activities oriented towards the involvement of CT skills, for example, by giving problem-solving-oriented tasks and discussing the potential for computer involvement with the CT approach in problem-solving, with the agreement of as much as 48.7% strongly agreeing as many as 33.3%.

Teachers agree that computational thinking can improve students' critical thinking skills, especially when facing challenges in the digital era. Furthermore, teachers can plan the implementation of CT in mathematics teaching through various strategies involving computational thinking skills such as decomposition, pattern recognition, abstraction, and

algorithms ([Huda & Ikhsan, 2024](#); [Sung et al., 2017](#)). In addition, teachers can also use software such as GeoGebra, Scratch, and interactive media to visualize mathematical concepts. They believe that mastery of CT will strengthen students' ability to solve problems more effectively and in a structured manner. However, infrastructure and teaching time challenges are major obstacles to implementing computational thinking in schools. Many teachers believe that existing technological facilities are inadequate and that the teaching process using computational thinking requires more time than traditional methods.

After this workshop, most teachers already understood that CT is related to problem-solving through a systematic, logical, and algorithm-based approach. The high average score indicates that the training provided successfully introduced and explained the concept of CT well.

The involvement and active participation of the teachers were very visible. They were present to listen to the material and actively interacted through discussion and Q&A sessions. The teachers shared their experiences, challenges, and innovative ideas related to applying computational thinking in teaching. In addition, they participated in practical activities, where they practiced using Scratch to create simple programs. Their activeness in collaborating with instructors and fellow participants showed a high enthusiasm for learning and applying new concepts in their teaching. This involvement enriched their learning experience and created an environment that supported the exchange of ideas and continuous professional development ([Borko et al., 2010](#)).

CONCLUSION

By implementing this workshop, it is expected that several positive impacts can be achieved, including (1) improving teacher competence so that they are able to integrate computational thinking in their teaching, (2) improving the Quality of Mathematics Learning, which will ultimately have an impact on improving student learning outcomes, (3) establishing an innovative teacher community, so that an innovative and sustainable teaching culture is created. This is reflected in the activeness of teachers in participating in the direct practice of the Scratch material provided. An interesting finding was obtained: teachers showed 89.8% agreement that computational thinking (CT) needs to be taught to students.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

All authors have made significant contributions to this study. DPS conceptualized the study, designed the methodology, manuscript writing, and final editing, and supervised the implementation. RAS, HSP, and AIM were responsible for data collection, analysis, and interpretation. MHA and NABS contributed to the development of workshop materials and teacher training sessions. RP and NW played a key role in coordinating with participating schools and stakeholders. NNA and MA assisted in implementing workshops at school and data processing. All authors reviewed and approved the final version of the manuscript.

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