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Unplugged Coding Activity (UCA) for Kids: Enhancing Digital Literacy through Creative Color Grids

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ABSTRACT

This community service activity aims to introduce the basic concepts of computational thinking (CT) through unplugged coding methods for 4th, 5th, and 6th-grade students at SD Ulil Albab, Bangkalan. This program was a collaboration between lecturers from Informatics Education, Informatics Engineering study program, University of Trunojoyo Madura, and also international students from Palacky University, the Czech Republic. The main method used was unplugged coding activity (UCA). UCA is an activity of coloring row-column grids to form specific objects. Students are given instructions in English to color the boxes according to color codes that represent certain objects. The involvement of international students in delivering coding instructions in different languages can motivate students to complete the color coding on the image enthusiastically. This activity trained students in logic, problem-solving, and basic foreign language recognition while introducing computational thinking concepts without digital devices. The measurable outcomes showed that over 90% of students completed the assigned patterns according to instructions. Feedback from teachers indicated improved student engagement and confidence in understanding basic programming logic. These results demonstrate that unplugged coding can effectively foster problem-solving skills and computational thinking in elementary students.

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INTRODUCTION

The development of information technology in the era of society 5.0 requires mastery of digital literacy from an early age. Digital literacy includes the ability to understand, use, and create technology wisely, including skills in computational thinking (Wing, 2006). The Indonesian government, through its Coding and Artificial Intelligence Curriculum (KKA) policy, has encouraged the integration of programming and artificial intelligence skills at the elementary school level (Kemendikbudristek, 2023). This shows that coding is no longer an additional skill, but a fundamental and important part of the 21st-century competencies that the younger generation must possess (Pratama & Hartanto, 2022).

The 21st-century skill framework, better known as the 6Cs, consists of critical thinking, creativity, collaboration, communication, citizenship, and character, which are important to introduce to students from elementary school onwards. Early digital literacy serves as a concrete step to build algorithmic reasoning, media ethics, and cross-cultural collaboration, which are also needed in the Society 5.0 era. Recent research data confirms that effective digital-based learning needs to instill cognitive and social-emotional skills starting in elementary school (OECD, 2023a; OECD, 2023b). In Indonesia, the direction of the Coding and Artificial Intelligence (KKA) policy strengthens the integration of computational and digital skills, so that digital literacy is not just a companion but a reinforcement of the 6Cs in elementary school (Kemendikbudristek, 2025).

Computational thinking (CT) has thus become a core component of digital literacy, bridging logical reasoning, creativity, and problem-solving skills that underpin all digital-age learning. While numerous studies have confirmed that CT can be developed through early exposure to coding, there remains a challenge in ensuring equitable access, particularly in schools with limited technological resources. Research findings show that introducing computational thinking through unplugged coding activities at an early age/elementary school level has been proven to improve problem-solving and technological learning readiness, while also helping teachers bridge device limitations (Zeng, 2023; Camacho & Rocabert, 2023; Liu et al., 2024). In addition, global children's organizations emphasize the urgency of equal access and digital literacy for children to prevent a 6C competency gap in the future (UNICEF, 2025).

Affordable, simple, and enjoyable coding learning strategies are essential to address these issues at the elementary school level. One such strategy is through the use of unplugged coding activities (UCA). UCA is a programming learning method that does not use computers or digital devices but utilizes simple media such as paper, pencils, grid boards, or instruction cards (Bell et al., 2009). This approach has been proven effective in introducing the concepts of algorithms, patterns, logic, and computational thinking to children (Dagienė & Sentance, 2016). In addition, unplugged coding provides an inclusive alternative for schools with limited technological facilities (Nouri et al., 2020).

However, previous studies on UCA have mainly focused on its impact on computational thinking and problem-solving, with limited exploration of how UCA can simultaneously strengthen English literacy and foster international collaboration in the learning process. This community service activity develops material in the form of color-based row-column grid activities. Students will be given instructions to color the boxes according to color codes that represent the colors of the same object. The level of difficulty and complexity of the image and the number of colors are adjusted to the class level. Fourth graders use a few simple colors, fifth graders use more colors, and sixth graders create more complex patterns.

The uniqueness of this program lies in its international collaboration with students from Palacky

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University, the Czech Republic, who provide instruction in English. In this way, students not only learn coding concepts and computational thinking, but also gain exposure to contextual English literacy. The hope is that teachers can obtain alternative learning models for teaching KKA without technology, students can learn coding in a fun way, and their creative and digital literacy skills will improve. Therefore, this UCA community service activity has high benefits in the form of international collaboration and foreign language literacy integration, as well as direct benefits for teachers, students, and elementary schools in facing the demands of implementing the Coding and Artificial Intelligence Curriculum.

METHOD

Participant, Place, and Time of Community Service

The selected participants during the implementation phase of the UCA were elementary school students from SD IT Ulil Albab. This school is one of the Islamic private schools in Madura Island, especially in Bangkalan regency, East Java. Three classes were selected. Grade 4 consisted of two study groups (20 students), grade 5 consisted of two study groups (20 students), and grade 6 consisted of one study group (23 students). Thus, the total number of participants was 63 students. All participants took part in face-to-face activities in the classroom with their accompanying teachers. The role of the teachers was to facilitate the class and ensure the orderliness of the activities. Meanwhile, the implementation team (lecturers from the Informatics Education and Informatics Engineering study program of Trunojoyo University, Madura, and international students from Palacky University) was responsible for planning the UCA concept, preparing materials, delivering instructions, observing, and reflecting.

The activity was carried out at SD IT Ulil Albab, Bangkalan, in a regular classroom that was adapted as an unplugged coding practice room. Each UCA session lasted approximately 60 minutes, divided into three segments: (1) a 5-minute briefing, (2) 35–40 minutes of guided practice, and (3) 10–15 minutes of reflection and evaluation. Each grade level participated in two sessions per week over two weeks, resulting in a total of approximately 4 hours of learning engagement per grade. The schedule was coordinated with the school to ensure alignment with students' cognitive capacity and to avoid disrupting regular academic activities.

Implementation Steps

In this community service activity, the implementation steps were planned to consist of a briefing, instruction delivery, structured practice, evaluation, and feedback. The first stage was the briefing. The activity began with a brief briefing of approximately 5 minutes to explain the learning objectives and classroom rules. The classroom teacher is responsible for guiding students to ensure a conducive and orderly environment, while the implementation team, consisting of collaboration between UTM lecturers and international students from Palacky University, conveys the learning objectives and rules of the learning process. Students are divided into small groups of 3 to 4 people to facilitate collaboration and discussion. This stage is important to prepare the procedural mindset before entering into simple algorithmic practice (Lye & Koh, 2014).

The second stage is giving instructions. International students explain in English how to color the grid according to the colors of the objects that will be mentioned. The colors are taken from examples of

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objects or things around the students. These colors are then used as codes on the grid squares. These color codes are, for example, apple for red, grass for green, and sky for blue. Students then color the squares on the grid according to the color codes. Meanwhile, the lecturer assists students who have difficulty understanding the information. Instructions are given in the form of row-column coordinates on a prepared colored grid. This approach presents a concrete representation of the algorithm, a sequence of steps that students can follow without tools, and is in line with the principles of computational thinking (CT) at the elementary level (Wing, 2006; Bell et al., 2009).

The third stage is structured practice. These activities are carried out in stages according to class level. Grade 4 works on 2–3 color patterns to introduce coordinates and basic sequences. Grade 5 works on 4–5 color patterns to repeat patterns and precision. Grade 6 works on >6 color patterns with the aim of more detailed object composition and prediction of the final shape. This tiered differentiation is designed to challenge students in decomposition, pattern recognition, simple abstraction, and step design. These four aspects are known as the core aspects of CT (Lye & Koh, 2014; Camacho & Rocabert, 2023).

During the practice, lecturers conducted formative observations using observation sheets. The indicators recorded included: (a) ability to follow coded instructions, (b) accuracy of coloring the target pattern or accuracy of coordinates and accuracy of coloring, (c) problem-solving strategies when errors occurred, such as backtracking or clarification of instructions, and (d) participation and collaboration in groups. At the end of the session, a checkpoint of the results was conducted to validate the conformity with the target pattern and to provide quick feedback to groups that needed improvement (del Olmo-Muñoz et al., 2020).

The fourth stage involved guided monitoring, evaluation, and documentation (10–15 minutes). Lecturers and international students asked brief reflective questions about difficulties, strategies, and improvements. Students and teachers also filled out feedback questionnaires. Documentation was collected through photographs and notes for reporting purposes. Qualitative data from feedback and reflections were analyzed using thematic content analysis, which included three stages: (1) open coding to identify key ideas from student and teacher responses, (2) categorization of recurring themes related to engagement, understanding, and challenge, and (3) interpretation to link these themes with observed CT indicators. Triangulation between observation notes, artifacts, and reflections ensured data validity and reliability.

Cascade Model Activity Flow

The flow of these community service activities was organized using a cascade model. This model aims to ensure the needs of the school, material design, implementation, and continuous evaluation. The following is a detailed explanation of the stages of the planned community service activities at SDIT Ulil Albab.

- Needs Analysis

  The community service team coordinated with the school to discuss class profiles, teacher readiness, and facilities to support CT community service material literacy. The community service team then identified realistic digital and CT literacy goals in the elementary school context, as well as the gap between the curriculum targets and classroom practices.

- Conceptualization of Community Service Activities

  The community service team conducted focus group discussions (FGD) to develop learning

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objectives, decomposition, patterns, abstractions, step sequences, grid formats, and a list of color codes that are consistent across classes. At this stage, observation sheets, questionnaires, and documentation guidelines were also prepared (Lye & Koh, 2014). Lecturers and international students conducted simulations on the grid worksheet material for three levels of complexity, in coordinate format, and internal trials to validate the clarity of instructions and cognitive load. The rubric for assessing the accuracy of coordinates, consistency, and patterns/colors was finalized (Bell et al., 2009; del Olmo-Muñoz et al., 2020).

- Implementation

  The implementation of UCA at the classroom level is carried out simultaneously according to the service schedule. International students deliver instructions in English, teachers facilitate and monitor orderliness, the team records observations, and conducts checkpoints on the work results of each group.

- Evaluation & Feedback

  A rapid review of observation notes, artifacts, and reflection forms was conducted after each session. Thematic findings from these data were used to refine the instructional design, adjust session duration, and improve the clarity of coding patterns. This continuous feedback cycle ensured the quality, contextual fit, and sustainability of the program for the participating school (Camacho & Rocabert, 2023).

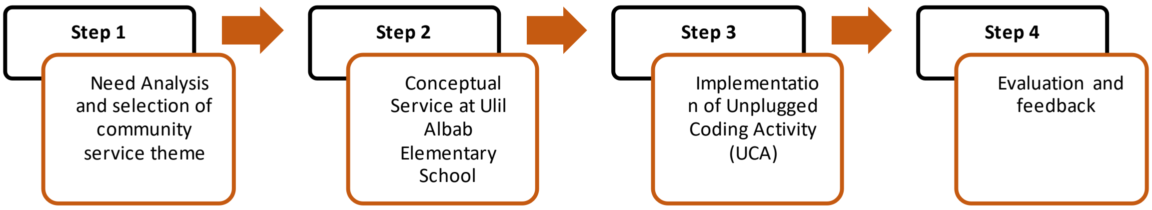

FIGURE 1. Steps of Community Service Activity

RESULT AND DISCUSSION

The community service activities carried out by lecturers at the University of Trunojoyo Madura are a collaborative program between lecturers from the Informatics Engineering and Informatics Education study programs and students from Palacky University, the Czech Republic. This program was implemented at SD IT Ulil Albab, Bangkalan, East Java. The theme of the community service activity was "Unplugged Coding Activity (UCA) for Kids" through the use of creative color grid media. The implementation of this program went well and received positive responses from students and teachers. The community service sample used students from grades 4, 5, and 6. This activity provided a learning experience for students that was enjoyable and meaningful. Documentation of the community service activity is presented in Table 1.

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TABLE 1. Documentation of community service implementation

Date	Activity	Photo
September 17, 2025	focus group discussion (FGD) of UTM lecturers with Palacky University students	
September 29, 2025	classroom activity in 4th grade	
September 29, 2025	classroom activity in 5th grade	
September 29, 2025	classroom activity in 6th grade	

The Unplugged Coding Activity (UCA) implementation consisted of three main stages: (1) an introduction and briefing on learning objectives, (2) group-based grid coloring guided by international students using English instructions, and (3) reflection and discussion. Students worked in small groups to follow English-coded instructions by international students from Palacky University. They were given row and column grid worksheets as shown in Figure 2. The number of rows and columns for 4th, 5th, and 6th-grade students differed. The next step was for the international students to give instructions in English about the coordinates to be colored. An example of an instruction was to color column D, row 5. Each color code represented a specific color of an object from the surrounding environment. “Wood” represented brown, “sky” represented blue, ‘lemon’ represented yellow, and “grass” represented green. This concise, gamified approach promoted both contextual learning and basic algorithmic reasoning, helping students connect computational concepts to their everyday experiences.

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FIGURE 2. Row and Column Grid

The complexity of activities was adapted to each grade level based on the cognitive development and computational thinking abilities of the students. Fourth graders receive relatively simple images, such as ducks and rockets. There are fewer grid boxes, and the patterns are easier to recognize. This is in line with Piaget's concrete operational stage in Babullah (2022), where children of this age still need clear visual representations and simple instructions to understand the concept of coordinates. Simple images help them practice basic skills such as counting rows and columns, recognizing simple patterns, and connecting colors with objects in their surroundings. The expected final result for fourth-grade students is the duck and rocket shapes shown in Figure 3.

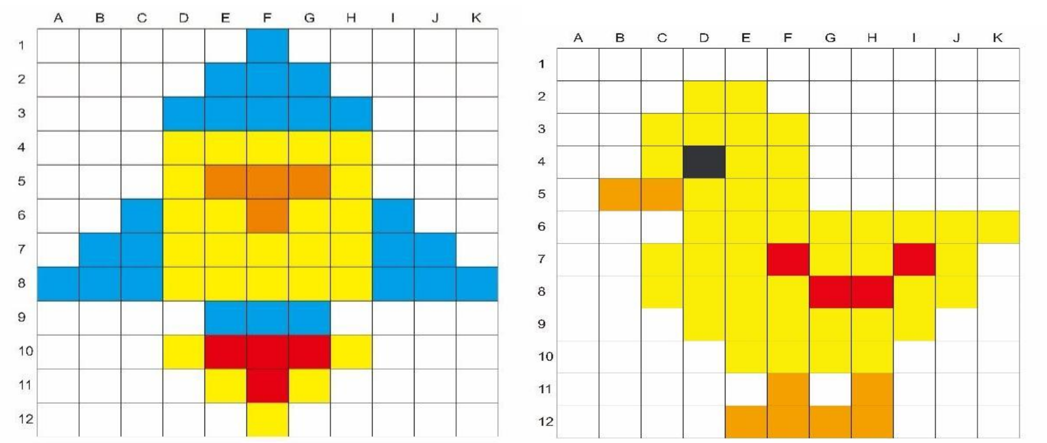

FIGURE 3. Results of drawings by 4th-grade students

Unlike fourth graders, fifth graders are introduced to more detailed and complex images. The objects chosen are also more complex, such as a picture of a duck with five colors and a picture of a boat with five colors (Figure 4). The number of grids used is greater, with more varied colors, in order to assess the students' accuracy in following instructions. Theoretically, at this stage, children begin to transition towards formal operational thinking skills, enabling them to understand more complex patterns and work with longer instructions. Assigning tasks of medium difficulty aims to challenge students to think systematically, while also training their memory and consistency in completing algorithmic instructions (Marinda, 2020).

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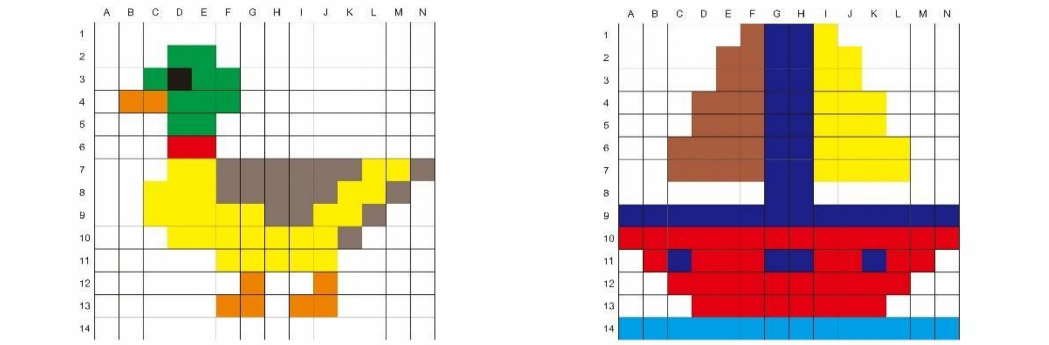

FIGURE 4. Results of drawings by 5th-grade students

As for sixth graders, the images provided are more complex. Images of trains and parrots with six color variations were chosen for sixth graders. The grid size is larger, and the patterns require a more abstract understanding of the relationships between the parts of the image. The results of the sixth-grade students' drawings can be seen in Figure 5. This challenge is tailored to the characteristics of sixth-grade students, who are beginning to think more maturely in formal operational terms. Thus, the image design for sixth graders not only trains basic grid coordination skills but also integrates long instructions, pattern comparison, and anticipation of the final form of the image, as well as training pattern prediction, problem solving, and more abstract visual representation skills (Nuryati & Darsinah, 2021).

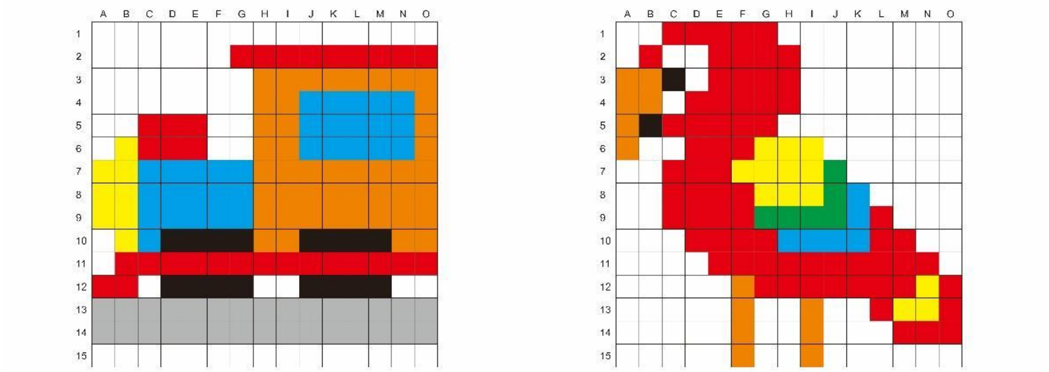

FIGURE 5. The result of drawings by 6th-grade students

These differences in difficulty levels for different grade levels in the UCA activity are designed gradually to match children's cognitive development. This strategy is in line with Vygotsky's scaffolding theory in Muntasir and Akbar (2023), which emphasizes the importance of providing challenges in line with the zone of proximal development (ZPD). In other words, each grade level is given images that are slightly more challenging than their current abilities, so that students are motivated to learn actively and progressively develop computational thinking skills (Lee, et al. 2024).

The benefits of this activity are not only to practice grid-based instruction following skills but also to foster computational thinking skills. Children learn to recognize patterns, understand sequences, and practice simple logic in determining coordinate positions. By following instructions systematically, students practice basic algorithm concepts without the need for computers. This is in line with the objectives of computer science education in elementary schools, which is to provide a basic understanding of computational concepts through methods appropriate for the age of the children (Yuliantin, 2025). In addition, this grid coloring activity also serves as a means to develop students' cognitive, affective, and psychomotor aspects. In the cognitive aspect, students are trained to think

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logically, recognize patterns, and understand the relationship between row and column positions. In the affective aspect, this activity encourages children to work together in groups, practice patience, and be thorough in understanding and completing the instructions given. Meanwhile, in terms of psychomotor skills, students hone their fine motor skills through coloring activities by accurately filling in the empty grid boxes provided.

According to the results of observations and interviews with students and teachers who participated in this activity, it indicates a strong engagement and intrinsic motivation among students. Younger students enjoyed the puzzle-like nature of the activity, while older ones expressed pride upon completing complex patterns. This sense of accomplishment enhanced persistence and confidence, key traits for sustained learning motivation (Araya, 2023).

Based on interviews with four teachers, they generally stated that this method provides a simple, fun, and easy-to-integrate alternative for digital literacy learning. Teachers assessed that the use of color grids helps students understand the basic concepts of algorithms and programming logic without having to rely on digital devices. This is in line with the research by Fauziyah et al. (2025), which confirms that unplugged coding activities can stimulate computational thinking in children by utilizing activities based on everyday life.

The first teacher emphasized that the color grid activity fosters orderly thinking in students. Students are more focused when asked to arrange color patterns according to the instructions for each step. This shows the strengthening of the algorithmic aspect, namely the ability to follow a sequence of instructions consistently. The second teacher added that this activity also trains accuracy and concentration, because students need to pay attention to the details of the instructions and adjust them to the position of the boxes on the grid. Thus, this activity not only supports early digital skills but also basic cognitive skills such as working memory and problem-solving (Jumrah, 2019).

Meanwhile, the third teacher discussed the collaborative aspect of the UCA activity. International collaboration with Palacky University students proved to provide a different learning experience. Although the students were not yet familiar with English, simple object and color-based instructions made it easier for them to color. This also trained contextual learning and the students' courage in accepting foreign languages. In addition, the teacher also observed that many students discussed among themselves when they encountered difficulties in coloring according to the pattern. Discussions among peers helped students find solutions, while also fostering mutual respect and cooperation. This reinforces Nuriyanti's (2022) finding that UCA can develop students' social and communication skills in addition to computational thinking skills. The fourth teacher emphasized the relevance of the activity to thematic learning in elementary school. The color grid can be adapted to various subjects, such as mathematics to introduce coordinates or cultural arts to train creativity through color combinations.

From the students' perspective, interviews with 13 randomly selected students revealed a high level of enthusiasm. Most students stated that the color grid activity felt like playing while learning. They enjoyed arranging color patterns because it resembled a puzzle game. Some students admitted to feeling proud when they completed complex patterns, as they saw the concrete results of their thinking efforts. This sense of accomplishment fostered intrinsic motivation to try new challenges.

Interestingly, some students associated the color grid experience with their daily activities. One student said that arranging the color grid was similar to the Lego game he often played at home. This shows a transfer of experience that supports the construction of new knowledge. Another student said that he felt he was learning “computer language” even without digital devices, which illustrates the emergence of early awareness of digital literacy. By integrating color elements from the surrounding

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environment, the Unplugged Coding for Kids activity successfully bridged abstract computer science concepts into enjoyable, concrete experiences. This is in line with 21st-century learning principles that emphasize the connection between learning and real life, while honing students' critical, creative, collaborative, and communicative thinking skills.

However, not all students immediately understood the instructions at the initial stage. Some of them admitted to having difficulty following long or repetitive patterns. The teacher then helped by giving instructions in stages and using simple examples first. With this scaffolding approach, students who initially experienced obstacles were finally able to complete the patterns well. This shows the importance of the teacher's role as a facilitator who accompanies children in internalizing algorithmic concepts.

In addition to cognitive aspects, this activity also has implications for student character development. For example, one student said that he learned to be patient when he had to correct mistakes in color arrangement. The patience and perseverance trained through this activity are important soft skills that are relevant to lifelong learning. Another student said that he enjoyed working with his friends, reaffirming the importance of collaboration in creative project-based learning.

From the teachers' perspective, several challenges remain. One of them is the limited time in class, as color grid activities often require more time than conventional methods. However, teachers realize that the time investment is worth the benefits gained by students, especially in developing logical and systematic thinking. Another challenge is the need for variety in patterns so that students do not get bored. Therefore, teachers strive to design patterns that gradually become more complex and relate them to the lesson themes being studied.

Compared to digital-based learning, color grid activities have advantages in terms of accessibility. Teachers mentioned that this method is considered an innovation in introducing programming logic concepts without computers, while also strengthening creative learning in elementary schools, because not all schools have adequate computers or tablets, making the unplugged approach more realistic to implement in elementary schools. This is consistent with the results of research by Fauziyah (2025) that unplugged methods are effective alternatives where technological access is limited.

Comparatively, similar outreach programs such as “CS Unplugged” (Bell et al., 2009) and “CT4Kids” (Zeng, 2023) primarily emphasize algorithmic and problem-solving skills. The present program adds novelty through its integration of English literacy and international collaboration, extending CT learning into a multicultural and linguistic context. This dual focus not only promotes computational thinking but also prepares students for global digital citizenship, which is an essential competence in the Society 5.0 era.

Overall, the Unplugged Coding for Kids program effectively enhances elementary students’ computational thinking, creativity, and collaborative skills through engaging, low-tech activities. Although there are still technical and pedagogical challenges, the benefits gained are far greater and support the goal of community service in introducing digital literacy from an early age. Thus, it can be emphasized that Unplugged Coding for Kids is not just an alternative activity but a contextual, enjoyable, and inclusive educational strategy to prepare the younger generation for the digital age.

CONCLUSION

Based on qualitative data from observations, student artefacts, and brief reflections from teachers and students on the Unplugged Coding Activity (UCA) training at SD IT Ulil Albab, Bangkalan, was carried out well and received positive responses. Each grade level showed consistent positive progress. Fourth

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graders completed simple patterns, fifth graders completed intermediate patterns with more color variations, and sixth graders completed complex patterns that required abstract predictive thinking. The UCA activity proved to train computational thinking, specifically in pattern recognition, coordinates, and simple algorithms, while also developing the cognitive, affective, and psychomotor domains (accuracy, cooperation, patience, and fine motor skills through coloring). The UCA method is also practical, easy to integrate into thematic learning, and relevant for elementary schools with limited digital devices. The collaboration between UTM lecturers, Palacky University students, and local teachers enriches a fun and contextual learning experience.

Overall, color grid-based UCA is an innovative and inclusive strategy for introducing basic digital literacy in elementary schools and has the potential to be replicated with adjustments to the complexity of tasks according to students' cognitive development. However, several limitations were identified during implementation, including limited class time that constrained activity completion and the need for greater pattern variety to maintain student engagement. Recognizing these limitations provides a more balanced perspective and offers valuable insights for program refinement.

For future use, it is necessary to develop UCA media to be more innovative yet simple, such as story puzzles. Story puzzles can consist of three interconnected episodes. Several errors need to be inserted into the puzzles so that students can practice finding and fixing bugs. Addressing the identified limitations while expanding the creative aspects of UCA will further strengthen its potential as a scalable and sustainable model for computational thinking education in elementary schools.

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