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Assessing Computational Thinking Practices and Engagement: Primary Teachers' Reflections on an Unplugged Activity

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Developing computational thinking in early primary education has gained increasing attention, with unplugged methods recognised as particularly effective for young learners. However, teachers' assessment of computational thinking, especially through process-oriented approaches, remains underexplored. The present study investigates how the participating Slovenian primary school teachers assessed computational thinking practices and students' engagement during an unplugged activity based on Bebras Challenge tasks. The results show that the teachers most frequently identified algorithmic thinking, pattern recognition and debugging, while decomposition and abstraction were observed less commonly. The activity received high ratings regarding the students' motivation and engagement, which several of the teachers attributed to the fact that it was conducted outdoors and involved physical movement. Collaboration and communication were also positively evaluated, although some teachers noted that competitiveness occasionally distracted the students. Overall, the findings support the feasibility of using process-oriented observation to assess computational thinking practices in unplugged settings, highlighting the need for targeted professional development to help teachers implement and assess computational thinking meaningfully. These insights contribute to the growing body of research on computational thinking assessment in primary education, underscoring the importance of providing teachers with structured support and context-specific tools.

Keywords: assessment, computational thinking, primary school, STEM education, unplugged

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Vrednotenje veščin računalniškega mišljenja in angažiranosti: refleksije učiteljev razredne stopnje o dejavnosti računalništva brez računalnika

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Razvijanje računalniškega mišljenja v začetnih letih osnovnošolskega izobraževanja dobiva vse večjo pozornost, pri čemer je pristop računalništva brez računalnika posebej učinkovit pri mlajših učencih. Kljub temu ostaja vrednotenje računalniškega mišljenja na strani učiteljev, zlasti z uporabo procesno usmerjenih pristopov, premalo raziskano. V tej študiji analiziramo, kako so sodelujoči slovenski učitelji razredne stopnje vrednotili veščine računalniškega mišljenja in angažiranost učencev pri dejavnosti računalništva brez računalnika, zasnovani na nalogah tekmovanja Bober. Izsledki kažejo, da so učitelji najpogosteje prepoznali algoritmično mišljenje, vzorce ter prepoznavanje in odpravljanje napak, medtem ko sta bila dekompozicija in abstrakcija zaznani redkeje. Dejavnost je prejela visoke ocene glede motivacije in angažiranosti učencev, kar so učitelji pogosto povezovali z izvedbo na prostem in vključevanjem fizičnega gibanja. Sodelovanje in komunikacija sta bila prav tako pozitivno ocenjena, čeprav je nekaj učiteljev opozorilo, da je lahko učence občasno ovirala tekmovalnost. Ugotovitve kažejo, da je pri pristopu računalništva brez računalnika smiselno uporabiti procesno usmerjeno vrednotenje veščin računalniškega mišljenja, hkrati pa poudarjajo potrebo po profesionalnem usposabljanju, ki učiteljem omogoča učinkovito izvajanje in vrednotenje pristopov računalniškega mišljenja. Rezultati naše študije prispevajo k naraščajočemu korpusu raziskav o vrednotenju računalniškega mišljenja v osnovni šoli ter poudarjajo pomen zagotavljanja strukturirane podpore in kontekstno specifičnih orodij za učitelje.

Ključne besede: vrednotenje, računalniško mišljenje, osnovna šola, STEM-izobraževanje, računalništvo brez računalnika

Introduction

Over the past two decades, there has been growing interest in promoting computational thinking (CT) and integrating it into school curricula. This trend reflects the increasing recognition that, in a digitally driven world, students require CT skills to navigate and meet the demands of the twenty-first century (Yadav, Caeli, et al., 2022; Bocconi et al., 2022). Today, CT is widely acknowledged as a key problem-solving skill that can be applied in various disciplines and contexts (Humble & Mozelius, 2023; Rich et al., 2020; Shute et al., 2017; Wu et al., 2024; Yadav, Ocak, et al., 2022).

In the early years of primary education, educators and researchers often use the unplugged approach to introduce and foster CT among students (Bell & Vahrenhold, 2018; del Olmo-Muñoz et al., 2020; Škrobar et al., 2025). However, teachers must know how to assess CT in order to promote it effectively. Although there is widespread agreement on the importance of understanding computational foundations, research on how teachers assess CT in primary education, especially through process-oriented methods, remains limited and underexplored (Sherwood et al., 2024; Ukkonen et al., 2024).

In the following literature review, we examine key aspects of CT, focusing on unplugged approaches to promoting it, and current practices and challenges related to its assessment in the classroom.

Defining CT

The concept of CT has evolved over the decades. Seymour Papert (1980) first mentioned it in relation to children's interaction with computing. Later, Wing (2006) brought widespread attention to the concept, emphasising its importance as a foundational skill for everyone, not just computer scientists. She argued that, alongside reading, writing and arithmetic, CT must be added to every child's analytical ability (Wing, 2006, p. 8). Wing (2017, p. 8) later defined CT as "the thought process involved in formulating a problem and expressing its solution(s) in such a way that a computer – human or machine – can effectively carry it out". She emphasised abstraction as its core component (Wing, 2017).

Despite growing research interest, there is still no consensus on the definition and components of CT (Bocconi et al., 2022). Within the framework of the block-based coding environment Scratch, Brennan and Resnick (2012) identified three essential dimensions of CT: CT concepts, which refer to the core programming constructs children need to understand; CT practices, which involve the problem-solving strategies children use while coding; and

CT perspectives, which encompass the attitudes and mindsets children develop through engaging in programming. In order to address the close relationship between CT and programming, Zhang and Nouri (2019, p. 3) defined CT as "a thought process, through skills that are fundamental in programming, to solve problems regardless of discipline". Shute et al. (2017, p. 151) further highlighted the transferability of CT across disciplines, defining it as "the conceptual foundation required to solve problems effectively and efficiently (i.e., algorithmically, with or without the assistance of computers) with solutions reusable in different contexts".

A recent study by Wu et al. (2024) compared the CT practices of decomposition, pattern recognition, abstraction and algorithm design with traditional problem-solving phases: preparation, analysis, production, verification and reapplication. Their findings suggest that CT stages fulfil similar functions to these established problem-solving steps. Given the potential overlap between metacognition and CT, Yadav, Ocak et al. (2022) concluded that there is an opportunity to exploit the potential of CT as a general problem-solving strategy in the service of broad learning. This perspective is particularly relevant given that research has consistently demonstrated the significant potential of problem-solving for learners (Antunović-Piton & Baranović, 2022; Hodnik & Kolar, 2022; Papadopoulos et al., 2022). Finally, Bers (2020) expanded the understanding of CT beyond problem-solving, framing it as an expressive process that allows for new ways to communicate ideas.

Given the diverse approaches to defining CT, the methods and tools used to promote it vary. Consequently, the integration of CT into educational curricula can take various forms. In the following section, we present the unplugged approach in more detail.

The unplugged approach to computational thinking

Unplugged activities represent pedagogical strategies designed to develop CT without using digital devices. These activities often involve logic games, physical movement, strings, cards or other tangible materials to help learners understand and represent core computational concepts such as algorithms (Brackmann et al., 2017). The origins of unplugged approaches in computer science education date back to the 1960s, when educators sought ways to understand computing without the aid of user-friendly interfaces (Caeli & Yadav, 2020). Despite technological advances, unplugged methods remain relevant due to their focus on cognitive processes rather than tools. Bell and Roberts (2016) emphasised that CT is rooted in human reasoning, rather than in machines. Similarly, Caeli and Yadav (2020) noted that problem-solving is fundamentally a human activity, with technology being a support.

Cortina (2015) argued that one of the key strengths of unplugged activities is their ability to engage learners actively. These activities are often designed to include physical interaction and promote collaboration, encouraging children to work together to solve problems. Furthermore, Weigend et al. (2019) highlighted the fact that unplugged activities can promote student creativity. They emphasised the value of these activities, particularly as an engaging introduction to new topics. Del Olmo-Muñoz et al. (2020) recommended introducing unplugged approaches before transitioning to plugged activities in order to support CT development effectively. They found that combining unplugged activities with subsequent plugged-in tasks enhances skill acquisition and boosts students' motivation, creating a dual benefit. More recently, Liu and Hu (2025) showed that unplugged programming is effective in rural Chinese schools, where students and teachers used simple materials to overcome limited access to technology, resulting in significant gains in the students' CT skills.

Despite these benefits, effectively measuring primary students' progress in CT remains a critical challenge for educators.

Teachers assessing CT

Assessment is the art of concluding evidence about what students know and/or can do (National Research Council, 2001). From this evidence-centred perspective, assessments create opportunities for students to demonstrate observable signs of their knowledge and skills, enabling educators and researchers to gain insight into students' understanding (Weintrop et al., 2021). However, assessing CT poses challenges. The existence of multiple correct solutions and the complexity of CT practices often render traditional assessment methods unsuitable (Yadav et al., 2015). Two key issues are particularly relevant: what to assess and how to assess it. Determining what to assess is complicated by the lack of consensus regarding the definition of CT and its core practices. In terms of how to assess, a variety of methods exist; however, formative assessment, despite its potential to guide learning, is not yet widely implemented in CT research (Ukkonen et al., 2025).

Poulakis and Politis (2021) identified three primary approaches to CT assessment: programming environments, CT-specific instruments and qualitative methods, including portfolios and observations. They noted that most tools target older students and emphasise programming, highlighting the need for age-appropriate methods. Similarly, Tang et al. (2020) categorised assessments into tests, portfolios, interviews and surveys, noting that traditional tests remain dominant. They observed that CT tends to be viewed as a learning outcome rather than a cognitive process. Furthermore, Fields et al. (2019) argued that such traditional approaches inadequately capture the learning process involved in CT, particularly when students engage in hands-on, project-based tasks.

Compared to traditional assessment methods, Ukkonen et al. (2024) promoted a process-oriented view of CT, in which students are assessed through their engagement with the material and their interactions with peers and teachers. Similarly, Sherwood et al. (2024) argued that process-oriented strategies, such as observing students while they work, listening to their discussions during collaboration, and posing reflective questions, are more suitable for young learners. Both studies emphasise that effectively assessing CT through such process-oriented methods requires adequate teacher preparation, particularly through targeted professional development (PD) programmes (Sherwood et al., 2024; Ukkonen et al., 2024). This includes helping teachers to recognise the relevance of CT to their practice and moving beyond generic overviews towards subject-specific integration (Yadav et al., 2017). Through PD programmes, researchers should therefore support teachers with concrete lesson plans and practical methods for assessing classroom implementations (Kónya & Kovács, 2022).

Aim of the study

Recent research highlights growing interest in process-oriented methods for assessing CT, particularly in early primary education. However, despite their growth (e.g., Sherwood et al., 2024; Ukkonen et al., 2025; Ukkonen et al., 2024), these methods remain underexplored in practice. The present study examines how primary teachers with limited prior experience in CT assessed students' engagement and CT practices through observation during a treasure hunt unplugged activity, implemented as part of a PD programme.

The study addresses the following research questions:

1. How do primary teachers assess CT practices in the context of an unplugged activity using observation?
2. What do teachers observe about students' engagement with and response to an unplugged CT activity?

Methods

Participants

The study sample consists of a non-randomised group of 18 teachers (see Table 1) from Slovenia who were participating in the project Innovative Pedagogy 5.0. All of the participating teachers taught either the second or third grade. Ten of the teachers implemented the activity in Grade 2 (with students approximately 8 years old), and eight in Grade 3 (with students approximately 9 years old). Across these implementations, 316 students participated (M = 17.56, SD = 5.12 students per class).

Table 1
Teachers participating in the study.

Teacher (pseudonym)	Grade level	Number of students participating
Ana	3	22
Maja	2	26
Tanja	2	11
Petra	2	15
Nika	3	23
Jasna	3	24
Lea	2	10
Špela	2	14
Urška	3	22
Katja	3	17
Miha	2	9
Mojca	3	15
Nina	3	21
Barbara	2	18
Andreja	2	15
Simona	3	22
Sonja	2	14
Maša	2	18

Instrument

We designed a post-lesson reflection instrument in which we asked the teachers to rate the extent to which the students demonstrated each of the five CT practices (i.e., algorithmic thinking, pattern recognition, debugging, decomposition and abstraction) using a five-point Likert scale (1 = Not at all, 5 = To a very large extent) and to provide written explanations through a targeted open-ended question (i.e., *"Please describe how the students demonstrated the skill of algorithmic thinking during the activity. Provide specific examples or tasks that supported this."*). Formal definitions of the five CT practices (Table 2), adapted from Zeng et al. (2023), were provided to guide the teachers. In the second part of the instrument, the teachers also rated student engagement, motivation, communication and collaboration on the same scale and provided open-ended reflections on the students' experiences.

Table 2
Descriptions of CT practices

CT Practice	Description
Algorithmic thinking	Planning and/or following structured steps to solve a problem.
Pattern recognition	Identifying patterns or regularities in data or a problem.
Decomposition	Breaking a problem into smaller, more manageable components.
Debugging	Identifying and resolving errors when a solution is incorrect.
Abstraction	Focusing on key information while ignoring irrelevant details in a problem.

Research design

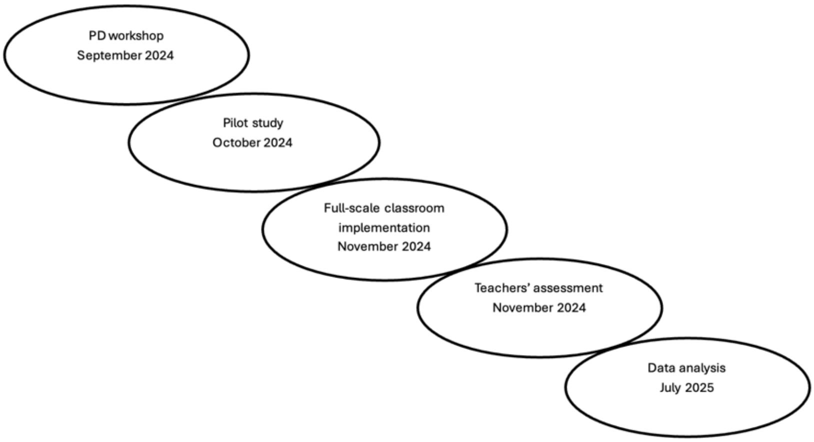
The study employed a mixed-methods research design to examine how the participating teachers reflected on an unplugged CT activity in early primary education. All of the teachers took part in a PD session in late September 2024, where they were introduced to unplugged activities designed to promote CT in early primary education (grades K–3). While the PD session familiarised the teachers with activities intended to promote CT, it did not specifically focus on training them to recognise and assess individual CT practices. The PD session followed the framework of the Teacher Training and Support for Innovative Pedagogy and Creativity Development model (Skrbinjek et al., 2024), which is designed to enhance teachers' professional competencies through a cyclical process involving participation in PD, classroom implementation, evaluation of activities, sharing the new practices with colleagues and self-assessment.

Following the PD workshop in late September 2024 and a pilot study in early October (Škrobar et al., 2025), the teachers implemented the activity in November 2024 as part of STEM subjects. Working in groups, the participating students solved Bebras Challenge tasks arranged as a treasure hunt throughout and around the school. Each location featured a hidden task sheet with four answer options, each linked to a letter. After solving the task, the students recorded the letter corresponding to their chosen answer. Correct answers led to the next location, while incorrect answers led to decoy locations, requiring students to reassess and retry the previous task. After completing all of the tasks, the students used the collected letters to form the final word. The teachers were asked to observe the activity closely; however, no structured observation list was provided at this stage, allowing them to rely on their natural impressions and interpretations of student behaviours. After the lesson, the teachers' impressions and reflections were gathered using the instrument presented in the previous subsection. A total of 22 structured responses were collected, of which 18 met the inclusion criteria (i.e., the assessment was completed and the teacher worked with Grade 2 or Grade 3 students) and were retained for analysis.

In order to analyse the data, a mixed-methods approach was used, combining qualitative and quantitative analyses in line with the nature of the responses. Quantitative responses from the Likert-scale items were analysed in SPSS (version 29.0.2.0) using descriptive statistics, while open-ended responses were analysed using Atlas.ti (version 9.24.0), following a deductive approach with magnitude coding (Saldaña, 2021). The responses were first organised according to the five predefined CT practices and the final question, which focused on the students' experiences. In magnitude coding, categories reflect the frequency of codes and are suitable for qualitative educational studies that also incorporate quantitative evidence of outcomes (Saldaña, 2021). For each CT practice, the responses were coded as either "practice seen in the activity" or "practice seen in the tasks". For the final open-ended question, sentiment analysis was applied within the magnitude coding framework in order to capture positive, negative and neutral perspectives expressed in the text (Saldaña, 2021). Two researchers independently coded the responses within the pre-existing framework. In order to ensure coding consistency, interrater reliability was calculated using Cohen's kappa, with results indicating high agreement ($\kappa = 0.82$). Discrepancies were resolved through discussion.

Figure 1

Overview of the research procedure



Results

Teachers' assessment of computational thinking practices

The teachers observed the students throughout the activity and completed the assessment instrument at the end of the lesson.

Table 3

Teachers' ratings of students' use of computational thinking practices

CT practice	*N*	Mean	Std. dev.	Median	IQR
Algorithmic thinking	18	3.83	1.10	4	2
Decomposition	18	3.33	1.24	3	2.25
Pattern recognition	18	3.83	1.10	4	2
Debugging	18	3.67	1.14	4	1.25
Abstraction	18	3.22	1.11	3	1.25

As shown in Table 3, the teachers most often recognised algorithmic thinking and pattern recognition in the activity (both $M = 3.83$, $SD = 1.10$), followed closely by debugging ($M = 3.67$, $SD = 1.14$). In contrast, decomposition ($M = 3.33$, $SD = 1.24$) and abstraction ($M = 3.22$, $SD = 1.11$) received comparatively lower scores. These quantitative ratings were further supported by the teachers' qualitative reflections, which provide insights into their assessment of the students' use of each CT practice during the activity. In the following paragraphs, we present the results from the open-ended questions.

The teachers most frequently identified algorithmic thinking in following the sequence of steps during the treasure hunt, where completing one task revealed the location of the next task ($N = 10$). As Mojca explained, *"Regarding the sequence of steps, the activity was designed so that once the students completed one task, it led them to the next. They had to follow the planned steps precisely until the final challenge."* Two other teachers observed algorithmic thinking when the students had to return to a previous location if they arrived at the wrong destination, requiring them to re-evaluate and follow the correct sequence of steps, which indicates debugging as part of algorithmic thinking. Furthermore, two teachers noted that algorithmic thinking was encouraged at a specific station involving a task where the students had to place stickers on an image of an aquarium in a fixed order. Four teachers did not respond to this item.

Four teachers explicitly observed decomposition within the structure of the activity itself. For example, Špela noted: *"To solve the activity, the students had to break it down into steps –read the instructions, identify the correct answer and follow the guidance provided – which led them to the next challenge."* Several of these responses resembled those describing algorithmic thinking, indicating that some of the teachers may have interpreted the two practices in overlapping ways. Nine teachers referred to specific tasks that required decomposition, with the aforementioned aquarium sticker task and the clothing preparation task mentioned most frequently. Tanja explained, *"The students had to break down the tasks at different locations into smaller steps in logical order; for example, the aquarium activity, the clothing task and the table setting."* Five teachers did not respond to this item.

Pattern recognition was most frequently observed in the students' interaction with specific tasks ($N = 8$). The most frequently mentioned example was the bracelet task, in which the students had to identify which of several circular arrangements matched the original linear sequence of coloured shapes. Seven teachers noted that the structure of the overall activity also reinforced pattern recognition. Most of them explained that the students moved from one station to the next by following a recurring pattern: each correctly solved task revealed the location of the next task. Others highlighted more strategic uses of pattern recognition. Andreja observed that "*the students recognised patterns by reflecting on where they had already been and what they had already checked; they used these patterns to infer the location of the next station*." Similarly, Miha noted that "*the students recognised recurring features while testing different solutions, which helped them determine the correct answer*". Three teachers did not respond to this item.

Debugging was most frequently observed when the students had to return to a previous station after solving a task incorrectly ($N = 13$). As Mojca described, "*Tasks offered four possible answers. Only one was correct, while the other three led to dead ends. When the students arrived at a location without a new challenge, they realised their solution was incorrect. They then had to return to the original task and try again. On the second attempt, they usually read the problem more carefully and approached the solution with greater focus.*" Two teachers also recognised debugging in the process of solving tasks themselves. Simona mentioned that it occurred "*while solving tasks*", without further elaboration. At the same time, Maša noted that "*the students developed debugging skills by selecting from possible answers, excluding less likely options, and trying out alternatives.*" Three teachers did not respond to this item.

The teachers frequently observed abstraction in the students' task engagement ($N = 10$). The most frequently mentioned tasks required the students to focus on essential features while ignoring irrelevant details, such as selecting an image that matched a given set of criteria or identifying a specific house based on a limited number of visual elements. Some of the teachers provided more general reflections but still included tasks. Jasna noted: "*The students had to focus on essential information that was critical for solving the task and ignore everything else.*" Two teachers described the use of the abstraction in the activity more broadly. Nika wrote: "*The students tried to solve tasks quickly and efficiently. They filtered out irrelevant information, chose a reader, thought aloud, coordinated with each other… and identified the most likely solution.*" In comparison, Lea reflected on attention: "*When they reached a location where they had made a mistake, they knew they had to look more carefully at the previous station and pay closer attention.*" Six teachers did not respond to this item.

Overall, the quantitative data show that teachers identified algorithmic thinking, pattern recognition and debugging more frequently than decomposition and abstraction. These findings are supported by the qualitative responses, where decomposition and abstraction were the most frequently left unanswered. The teachers primarily identified algorithmic thinking and debugging in the overall structure of the activity, while pattern recognition was observed both in the structure and in specific tasks. In contrast, decomposition and abstraction were mentioned primarily in relation to individual tasks, rather than the overall activity.

Students’ experience of the activity

In addition to assessing CT practices, the teachers also assessed the students’ overall experience of the activity, focusing on motivation, engagement, collaboration and communication.

Table 4

Teachers’ ratings of students’ experience of the activity

Dimension	*N*	Mean	Std. dev.	Median	IQR
Engagement	18	4.61	0.92	5	0
Motivation	18	4.89	0.47	5	0
Communication	18	4.39	0.92	5	1
Collaboration	18	4.50	0.79	5	1

As shown in Table 4, motivation received the highest mean rating (M = 4.89, SD = 0.47), followed by engagement (M = 4.61, SD = 0.92). Collaboration (M = 4.50, SD = 0.79) and communication (M = 4.39, SD = 0.92) received slightly lower ratings. As in the previous subsection, the teachers’ open-ended responses provided additional insights into the students’ experiences during the activity.

We received thirteen positive reflections, four mixed assessments and one negative response. The teachers frequently described the students as “*enthusiastic*”, noted that the activity was “*fun*” and commented that the students enjoyed it. For instance, Špela reported: “*They said this was the best math lesson so far and asked when we would do it again. They were delighted.*” Jasna similarly noted that “*the students were highly motivated to work. Ultimately, they expressed a desire to do similar tasks more often.*” Petra added that the activity was novel and enjoyable for the students: “*They found it fun and did not feel like they were learning. They want to work this way more often.*”

Several teachers (N = 6) emphasised that the students’ motivation increased because the activity took place outdoors. As Tanja explained, “*Most of the students said it was fun. Since we had a sunny day, we conducted the activity outside, which the students especially enjoyed.*”

Three teachers also highlighted the fact that the students were motivated because the activity involved physical movement. Miha noted that the students were “*excited about the activity because it was new and involved a lot of movement*”. Two teachers added that the element of mystery and searching for clues also motivated many of the students. For example, Barbara shared that her students asked: “*When will we be detectives again?*”

Three teachers expressed general satisfaction with the activity, but also noted that some of the students treated it as a competition, which occasionally led to students being less focused and rushing. Lea commented: "*The students were very committed to solving the tasks; they found them difficult but interesting. However, I repeatedly told them that time was unimportant, and they rushed because they wanted to be the first.*"

Only one teacher provided a negative reflection. Sonja explained: "*My students are poor readers and did not attempt to solve the problems. Instead, they looked at the possible answers and guessed their way to the next station and final solution.*"

In summary, both the quantitative ratings and the qualitative reflections indicate that most of the students responded positively to the activity. High ratings of motivation and engagement were reported, with outdoor implementation, physical movement and mystery as contributing factors. A few of the teachers raised concerns about the students rushing due to competitive behaviour, and one reported difficulty due to the students' poor reading skills. However, the overall feedback suggests that the activity was well received and offered an enjoyable learning experience for most of the participants.

Discussion

In the present study, we examined how primary school teachers assessed CT practices and students' experiences of the activity following their observation of a treasure hunt. The next section presents the findings related to the two research questions.

Addressing teachers' assessment of computational thinking practices (RQ1)

Regarding CT practices, the teachers most frequently assessed evidence of algorithmic thinking, pattern recognition and debugging during the activity, while decomposition and abstraction were noted less often. These findings align with those of Rich et al. (2020), who found that, following a PD session presenting four CT practices, eight primary teachers most frequently incorporated debugging and patterns in their classroom implementations, while abstraction and decomposition were less commonly framed, prompted or reflected upon by teachers. In the following paragraphs, we examine each practice in greater detail.

The teachers in our study frequently identified algorithmic thinking. Primary teachers tend to be familiar with algorithms, which are often introduced through everyday tasks such as sequencing routines or designing simple, step-by-step instructions (Rich et al., 2021). Notably, the teachers in our study often described decomposition in a manner closely aligned with algorithmic thinking when assessing the activity. This alignment in teacher responses suggests an understanding consistent with Wu et al. (2024), who argue that decomposition represents the initial phase of problem solving, identifying sub-problems, while algorithmic thinking constitutes the final phase, involving the formulation or execution of step-by-step procedures to reach a solution. Four teachers in the present study explicitly described this sequential relationship, where decomposition involved breaking down the task and was directly followed by algorithmic processes to solve it. Furthermore, two teachers presented algorithmic thinking in terms of debugging algorithms. This conflation of algorithmic thinking with decomposition and debugging highlights the overlapping nature of CT practices (Ukkonen et al., 2024). It also underscores the need for greater conceptual clarity in defining the practices.

Decomposition appeared to be less evident to the teachers than algorithmic thinking when assessing the activity. Most of them recognised decomposition in tasks such as setting the table. Humble and Mozelius (2023) also noted that some teachers perceived decomposition as challenging, suggesting that while it may be conceptually easier to grasp, it remains unfamiliar to many students and more challenging to apply in practice. Similarly, Norwegian teachers have called for more precise guidance on assessing decomposition (Ukkonen et al., 2025). In contrast, teachers from the Midwestern United States appeared more successful in recognising and assessing decomposition in classroom contexts (Ukkonen et al., 2024).

Debugging emerged as the most coherently described CT practice in the teachers' reflections. The majority of the teachers explained that when the students selected an incorrect answer, they were required to return to the previous station and attempt the task again. This observation aligns with the findings of Humble and Mozelius (2023), who noted that debugging is likely the most accessible component of CT to implement with young learners. Teachers in their study emphasised that debugging could help students develop patience as they search for and resolve errors, a point similarly noted by several teachers in our study. Brennan and Resnick (2012) likewise observed that outcomes in programming rarely unfold as expected, making it essential for children to develop strategies to anticipate and manage problems. They described trial and error as one of the approaches to debugging. Although a few of the teachers in our study mentioned this method, it was often framed negatively, suggesting that teachers preferred more deliberate forms of debugging in which students actively identify and correct errors through reasoning rather than guesswork.

Pattern recognition was similarly prominent, with the teachers frequently identifying it in both the individual tasks and the overall structure of the activity. The patterns within the tasks appeared straightforward to identify, while solving an activity based on patterns seems to represent a more advanced application of this practice, one that few teachers noted in the activity. In contrast to our results, Ukkonen et al. (2024) found that teachers experienced difficulties in assessing pattern recognition. This discrepancy may be due to the specific structure of the tasks in our activity, which likely made instances of pattern recognition more salient than in the lessons observed in the aforementioned study.

Wing (2017) argued that abstraction is the highest-level and most important CT practice, as computer science fundamentally involves abstraction processes. However, it appears to be one of the hardest practices to assess (Ukkonen et al., 2024). Abstraction does not easily align with concrete classroom tasks, which may explain why teachers often find it challenging to recognise and assess in practice. For example, Rich et al. (2020) found that teachers made fewer connections to abstraction when integrating CT into mathematics and science instruction than other practices. In our study, abstraction was most often recognised in individual tasks, with only two teachers connecting it to the overall activity. In those examples, the teachers equated abstraction with speed and attention. This conflation suggests that the two teachers interpreted abstraction through observable student behaviours rather than through the students' mental processes of focusing on the main ideas of the problem or activity.

Overall, our findings suggest that the teachers were relatively successful in observing and assessing CT practices through the students' behaviours, which aligns with the process-oriented approach to CT assessment described by Sherwood et al. (2024) and Ukkonen et al. (2024). In our PD session, we introduced teachers to unplugged activities but did not focus explicitly on assessment. To further support teachers in developing assessment skills, Ukkonen et al. (2025) suggest that targeted PD can help alleviate teachers' challenges when assessing CT. Similarly, Sherwood et al. (2024) reported that PD programmes targeting assessment skills enhanced teachers' confidence and understanding in evaluating students' use of CT.

Reflecting on the students' experience of the activity (RQ2)

The results show that the unplugged treasure hunt activity was motivating and fostered active engagement among the students. Unplugged methods are widely considered suitable for young learners, particularly those who are just beginning to develop CT skills (Looi et al., 2018). Research also indicates that students in early primary education, especially girls, find unplugged activities more motivating than plugged ones (del Olmo-Muñoz et al., 2020). Cortina (2015) argued that a significant factor contributing to the widespread adoption of unplugged methods in CT is their ability to engage children physically. These activities often incorporate movement, aligning with learning theories that advocate learning through movement, which encourages students to break away from typical classroom routines (Weigend et al., 2019). Several teachers in our study also highlighted the fact that the students were both motivated and engaged because the activity took place outside the classroom and involved physical movement.

The teachers also gave high ratings to the students' collaboration and communication during the activity. Cortina (2015) emphasised that unplugged activities foster group work, encouraging children to collaborate in solving problems. Similarly, Weigend et al. (2019) argued that unplugged activities provide a foundation for cooperation and teamwork, thereby supporting the development of communication skills. While prior studies support the use of unplugged methods to foster engagement and collaboration, our findings suggest a potential drawback: a few of the teachers observed that the students' competitiveness occasionally undermined their focus, resulting in rushed problem-solving. Our observation that competitiveness sometimes disrupts students' focus highlights the need to design collaborative tasks that ensure fairness and maintain attention on learning outcomes.

Overall, our findings affirm the value of unplugged methods for promoting motivation, engagement, communication and collaboration, while also underscoring the need for thoughtful activity design to mitigate potential challenges.

Conclusion

In the present study, we explored how Slovenian primary school teachers recognised CT practices and evaluated student engagement during an unplugged treasure hunt learning activity. Our findings advance the limited body of work on process-oriented methods for assessing CT in early primary education. The results show that the participating teachers most frequently identified algorithmic thinking, pattern recognition and debugging, while abstraction and decomposition were less visible. This pattern suggests that abstraction and decomposition may be inherently more challenging to detect. The teachers also tended to conflate algorithmic thinking with decomposition and debugging, which is not surprising given the overlapping nature of CT practices (Ukkonen et al., 2024). The high ratings of the students' engagement, motivation, collaboration and communication, together with the teachers' qualitative reflections, indicate that physical activity, group-based activities and outdoor learning environments can effectively foster these aspects.

While these findings provide valuable insights, several limitations should be acknowledged. First, the study relied on the teachers' self-reported reflections without a structured observation protocol, which restricts the depth and validity of the findings. Self-reported reflections are inherently subjective and may overstate student engagement, motivation, collaboration and communication. Although triangulated with quantitative data, the qualitative insights are influenced by the participants' reporting styles and the researchers' interpretations. Second, given that the results are primarily descriptive and were not triangulated with classroom observations or student outcomes, and considering the narrow sample from a single national context within the project Innovative Pedagogy 5.0, the generalisability of the findings is limited.

Future research should address these limitations by developing systematic strategies to support teacher monitoring of CT practices, such as observation rubrics, annotated exemplars and video-based reflection. There is also potential to design hybrid assessment approaches that integrate teacher perceptions with tangible student artefacts, allowing for triangulation between observed behaviour and demonstrated problem-solving outputs. Given our finding that teachers conflate different practices, it is essential to ensure that teachers have a conceptual clarity of CT practices. However, instead of treating this overlap as a limitation, future work should focus on examining the shared properties among CT practices and investigating their similarities and distinctions more closely.

To conclude, based on the results of the present study, we recommend the inclusion of more unplugged activities in early primary curricula and call for PD programmes that strengthen teachers' practical and conceptual understanding of CT practices and their assessment.

Ethical statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Ethics Committee of the Institute of Contemporary Technologies, University of Maribor.

Disclosure statement

The authors declare no relevant financial or non-financial interests and report no conflicts of interest.

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