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Assessment Instruments for Computational Thinking and Coding Skills to Support Quality Education: A Systematic Literature Review

Berlianti Mandasari[1], Sardianto Markos Siahaan[1*], Muhamad Yusup[1]

[1] Master's Program in Physics Education, Universitas Sriwijaya, Palembang, Indonesia.

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Corresponding Author:
Sardianto Markos Siahaan
mr.sardi@unsri.ac.id

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Abstract: This study aims to analyze the need for developing assessment instruments to measure coding skills and Computational Thinking (CT) among physics education students through a Systematic Literature Review (SLR). The literature search was conducted through Scopus and Google Scholar databases using systematic filtering procedures following PRISMA guidelines. The inclusion criteria covered studies addressing coding and/or CT in educational contexts, focusing on assessment instruments, providing full-text access, employing clear research methods, and published between 2022 and May 2026. The selection process identified 13422 initial articles, of which only 14 met all inclusion criteria. The findings reveal that studies specifically focusing on assessment instruments for coding and CT are still limited compared with research emphasizing instructional implementation. Most studies focus on Computational Thinking (9 studies), while only 2 studies discuss coding skills, and 3 studies indirectly examine both aspects. Based on educational levels, the studies are distributed across early childhood education (3), primary education (3), secondary education (1), higher education (2), and non-specific contexts (5). These findings indicate that research at the higher education level, particularly related to physics education, remains limited. Furthermore, no standardized instrument has yet been consistently applied to assess these competencies. However, recent developments in project-based assessment, STEM integration, and digital technology utilization demonstrate promising opportunities for more authentic assessment approaches. Therefore, this study highlights the importance of developing structured, valid, and reliable assessment instruments that not only evaluate learning outcomes but also capture students' thinking processes during learning activities.

Keywords: Assessment Instrument; Coding skills; Computational thinking; Physics education; Systematic literature review

Introduction

The rapid development of digital technology has made 21st-century skills increasingly important, especially coding and computational thinking (Nambiar, 2020). Today, coding is no longer viewed solely as a technical programming skill, but also as a way to develop logical, systematic, and structured problem-solving abilities. Computational thinking is also closely related to creativity, analytical thinking, and other higher-order cognitive skills that are essential in modern learning environments (Israel-Fishelson & Hershkovitz, 2022) In the field of education, coding has gradually been integrated into various disciplines, including science and physics education, where analytical reasoning and computational modeling play an important role in helping students understand complex natural phenomena (Rosandhi & Haryadi, 2024).

Alongside these developments, Palop et al. (2025) explain that computational thinking has emerged as a fundamental cognitive skill in technology driven learning. At the same time, the demand for computational skills continues to grow, as computational thinking and technology-based problem-

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solving are increasingly considered essential competencies for education and future career readiness (Ayanwale & Omeh, 2026). Computational thinking is defined as a way of thinking that involves formulating problems and developing systematic solutions that can be carried out by both humans and machines (Daning & Tedre, 2019). This skill includes key components such as decomposition, pattern recognition, abstraction, and algorithm design (Liao et al., 2022). As a result, computational thinking has become a crucial foundation for solving complex problems across a wide range of disciplines (Arnas et al., 2024).

Coding and computational thinking are closely interconnected and essentially inseparable. Coding serves as the practical implementation of computational thinking, while computational thinking provides the cognitive foundation for designing solutions and structuring programs in a systematic way (Herlambang & Rachmadi, 2024). In other words, Hardiyanti et al. (2025) said that coding acts as a medium for developing computational thinking, while computational thinking, in turn, enhances the quality of the coding process. Previous studies have shown that although the relationship between the two has been widely explored, there is still considerable variation in the learning approaches and assessment methods used (Li et al., 2020). In addition, systematic reviews indicate that assessments of computational thinking are still largely based on simple instruments and have not yet comprehensively integrated coding aspects (Listiaji & Molnár, 2025).

In physics learning, coding plays an important role in helping students visualize abstract concepts, run simulations of physical phenomena, and gain a deeper understanding of mathematical relationships (Caballero & Odden, 2024). The integration of computational approaches in physics education also supports scientific modeling, data analysis, and problem-solving activities that are essential in modern scientific learning environments (Odden & Caballero, 2023). Furthermore, computational thinking is increasingly recognized as an important competency in physics education because it helps students develop analytical reasoning and computational problem-solving skills through technology-based learning activities (Weller et al., 2021).

These competencies are considered essential for supporting computation-based physics learning and preparing students for increasingly digital and data-driven scientific environments (Arnas et al., 2024). However, existing research on computational thinking in physics education has predominantly focused on instructional strategies and learning interventions, while the development of assessment instruments for coding and computational thinking remains limited (Khasanah et al., 2025; Li et al., 2020). Most current assessment approaches still rely on questionnaires and simple tests, which may not adequately capture students' coding performance and computational reasoning in authentic learning contexts (Rahim et al., 2024). Recent studies have also emphasized the importance of developing more authentic and performance-based assessment approaches to evaluate computational thinking skills in educational settings (Tan et al., 2024). These conditions indicate the need for more integrated, valid, and comprehensive assessment instruments to evaluate coding skills and computational thinking in technology-based learning environments.

In light of this gap, the present study aims to analyze research trends related to assessment instruments for coding skills and computational thinking in educational contexts using a Systematic Literature Review (SLR) approach. This study also seeks to identify research characteristics, gaps, and opportunities for future instrument development at the higher education level, particularly in physics education. It is expected that the findings will provide a conceptual foundation for designing more valid, comprehensive, and contextually appropriate assessment tools in computationally oriented learning environments.

Method

This study adopts a Systematic Literature Review (SLR) approach, carried out in line with the stages recommended by the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) (Page et al., 2021). This approach was chosen to ensure that the review process is systematic, transparent, and reproducible. The literature search was conducted through Scopus and Google Scholar databases using systematic filtering procedures following PRISMA guidelines. Data retrieval was carried out in May 2026, focusing on articles published between 2022 and May 2026. The search used the keywords "coding skills" and "computational thinking skills," focusing on article titles and abstracts to identify literature relevant to the research topic.

Next, the articles identified in the initial stage were screened by removing duplicate records. The preliminary selection was carried out by reviewing titles and abstracts to ensure alignment with the focus of the study, namely the assessment of coding skills and computational thinking The inclusion criteria were as follows: studies discussing coding skills and/or computational thinking in educational contexts; studies related to assessment instruments or evaluation methods; articles published between 2022 and May 2026; full-text articles accessible in English; and studies employing clear research methodologies. The exclusion criteria included: articles focusing solely on instructional strategies without discussing assessment approaches;

studies evaluating curriculum implementation rather than student performance or competency assessment; conference abstracts, editorials, book reviews, and non-peer-reviewed publications; duplicate articles across databases; and studies with insufficient methodological information. Articles that passed the initial screening were then analyzed further through full-text review. At this stage, an in-depth evaluation was conducted to assess the relevance of the topic, methodology, and research objectives. Articles that did not meet all inclusion criteria or matched the exclusion criteria were removed from the review process. The remaining studies were selected as the final articles included in this review.

The selected articles were then organized and presented in a Systematic Literature Review (SLR) results table to identify the need for assessment instruments for measuring coding skills and computational thinking among physics education students. Articles that directly addressed assessment were treated as the primary focus, while other relevant studies were used as supporting literature to help identify these needs. Finally, the article selection process—from identification to inclusion—was illustrated using a PRISMA flow diagram (Page et al., 2021) to document the systematic stages of this literature review.

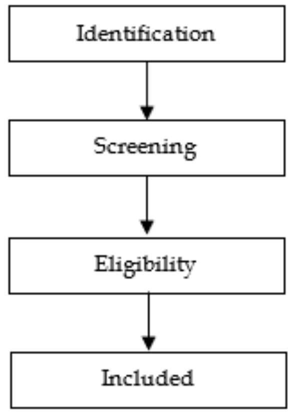

Figure 1. Research flow diagram

Result and Discussion

Result

This study adopts a Systematic Literature Review (SLR) approach, following the PRISMA framework to identify and select articles relevant to the assessment of coding and computational thinking skills. A summary of the article selection process is presented in Table 1.

Table 1. Results of the PRISMA Selection Process

Selection stage	Number of articles	Description
Identification	13422	Search results from various academic databases
Screening	985	After removing duplicates and applying filters for publication year and article type
Eligibility	40	The articles were not fully aligned with the focus on assessment or did not meet the inclusion criteria
Included	14	Met all inclusion criteria and were included in the final analysis

The article selection process in this study followed the PRISMA framework. In the initial identification stage, a total of 13422 articles were retrieved from various academic databases. This number was then refined by removing duplicates and applying filters based on publication year and article type, resulting in 985 remaining articles. The next stage involved screening and full-text eligibility assessment to evaluate the relevance of each article to the research focus. At the eligibility stage, 54 full-text articles were assessed in detail. During this process, 40 articles were excluded because they primarily focused on learning interventions, interdisciplinary applications of computational thinking, conceptual discussions, or the impact of computational thinking on other skills without specifically addressing assessment instruments. In the final stage, 14 articles met all inclusion criteria and were included in the final analysis.

Based on the analysis of the 14 articles that met the inclusion criteria, a further classification was conducted according to their focus on measuring coding and computational thinking (CT) skills. The results, presented in Table 2, reveal a range of approaches in how these assessments are designed and applied.

Table 2. Classification of Articles Based on the Assessment Focus of Coding and Computational Thinking Skills

Aspects	Number of articles
Coding Skills	2
Computational Thinking	9
Combination (Indirect)	3

Most of the articles nine in total focus on assessing computational thinking skills. In contrast, only two studies specifically measure coding skills. Additionally, three articles address both coding and computational thinking, but do so indirectly through an integrated approach. This distribution suggests that computational thinking has received considerably more attention than coding as a standalone skill. This is evident from the larger number of studies focusing on CT, while assessments that specifically target coding skills remain relatively limited. In addition to classifying the studies by their focus, the analysis also examined the distribution of publication years to identify research trends over time. The results are presented in Figure 2.

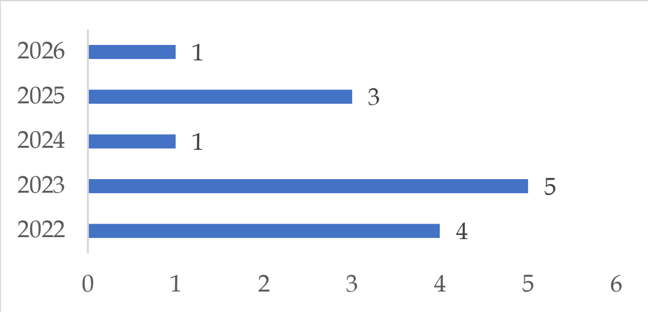

Figure 2. Distribution of publication years

Based on Figure 2, the publication years of the 14 analyzed articles show a relatively recent spread, ranging from 2022 to 2026. A closer look reveals that the highest number of publications appeared in 2023, with a total of five articles. This is followed by 2022 with four articles, 2025 with three articles, and only one article each published in 2024 and 2026.

This pattern suggests that research on the assessment of coding and computational thinking peaked in 2023. After that, the number of publications appears to decline in the following years. However, the continued presence of recent publications indicates that this topic remains relevant and continues to attract attention in educational research. After examining the distribution of articles by publication year, the analysis was extended to explore the educational levels targeted in these studies. The results are presented in Table 3.

The classification results show that the reviewed studies are distributed across different educational levels with varying proportions. At the early childhood level, there are three articles that mainly focus on introducing basic coding and computational thinking (CT). These studies generally emphasize simple approaches, such as the use of ScratchJr and CT assessments tailored to early childhood characteristics. At the primary school level, three articles were also identified, focusing on the assessment of CT skills. These studies involve upper elementary students and include longitudinal research that tracks skill development over time. Meanwhile, at the secondary school level, only one article specifically addresses the combined assessment of computational thinking and mathematical reasoning.

Table 3. Classification of Articles by Educational Level

Educational Level	Number of Articles	Description
Early Childhood	3	Focuses on introducing basic coding and computational thinking, such as through ScratchJr, kindergarten activities, and early childhood CT assessments
Primary School	3	Measures computational thinking among elementary school students, including upper elementary levels and longitudinal studies
Secondary School	1	Examines the combined assessment of computational thinking and mathematical reasoning among high school students
Higher Education (University/Adult Learners)	2	Computational thinking assessment tools designed for adult learners
Non-specific / General	5	Does not explicitly specify an educational level (e.g., frameworks, tools, programming libraries, multimodal assessments, robotics, teacher perceptions).

A similar pattern is also found at the higher education level, where only two article focus on developing computational thinking assessment instruments for adult learners. In contrast, five articles do not explicitly specify an educational level. These studies tend to address more general aspects, such as the development of frameworks, assessment tools, programming libraries, multimodal assessment approaches, the use of robotics, and teachers' perceptions of computational thinking.

To provide a more in-depth overview of the studies that specifically focus on assessing coding skills, an analysis was conducted on the characteristics and key findings of each article. The summary of this analysis is presented in Table 4.

Based on the selection results, two articles specifically address assessment in measuring coding skills. Both were published in 2022 and come from high-reputation, Q1 ranked journals.

The first article by Kalyenci et al. (2022) titled "Test for Assessing Coding Skills in Early Childhood" and published in Education and Information Technologies, focuses on developing a test instrument to measure coding skills in early childhood. The study findings show that the developed instrument demonstrates good validity and reliability. It is also capable of identifying children's basic coding abilities, such as understanding sequencing, simple logical reasoning, and instruction-based problem solving.

Table 4. Analysis of Articles on the Assessment of Coding Skills Measurement

Title	Year	Author	Journal Name	Rank
Test for assessing coding skills in early childhood	2022	Damla Kalyenci, Şermin Metin, Mehmet Başaran	Education and Information Technologies	Q1
The Coding Stages Assessment: development and validation of an instrument for assessing young children's proficiency in the ScratchJr programming language	2022	Laura E. de Ruiter, Marina U. Bers	Computer Science Education	Q1

The second article by Ruiter et al. (2022) titled "The Coding Stages Assessment: Development and Validation of an Instrument for Assessing Young Children's Proficiency in the ScratchJr Programming Language" and published in Computer Science Education, developed a stage-based assessment instrument for evaluating children's use of ScratchJr. The findings show that children's coding abilities can be classified into several structured developmental stages, ranging from using simple commands to more advanced skills involving the combination of coding blocks. The instrument was also found to be valid and effective for assessing children's programming proficiency in a progressive and systematic way.

Overall, both articles highlight the importance of developing assessment instruments that are appropriate for early childhood characteristics. In addition, the findings show that coding skill assessment is still largely dominated by a developmental approach and mainly focused on early learning contexts. After discussing coding skill assessment, the analysis then continues with studies examining the measurement of Computational Thinking (CT). A summary of the analysis results is presented in Table 5.

Table 5. Analysis of Articles on Assessing Computational Thinking Skills

Title	Year	Author	Journal name	Rank
The ct-cube: a framework for the design and the assessment of computational thinking activities	2022	Alberto Piatti Giorgia Adorni Laila El-Hamamsy Lucio Negrini Dorit Assaf Luca Gambarde Francesco Mondada	Computers in human behavior reports	Q1
Assessing computational thinking: development and validation of the algorithmic thinking test for adults	2022	Marc Lafuente Martínez Olivier Lévêque Isabel Benítez Baenac Cécile Hardebolled Jessica Dehler Zufferey	Journal of educational computing research	Q1
Designing formative assessments of early childhood computational thinking	2023	Jody Clarke-Midura Victor R. Lee Jessica F. Shumway Deborah Silvis Joseph S. Kozlowski Rebecca Peterson	Early childhood research quarterly	Q1
Monitoring cognitive development through the assessment of computational thinking pra ctices: a longitudinal intervention on primary school students	2023	Siu-Cheung Kong Yi-Qing Wang	Computers in human behavior	Q1
Using design-based implementation research approach to create computational thinking assessment tools for youth programs in public libraries	2023	Nitzan Koren David Weintro Mega Subramaniam	Library & information science research	Q1
Developing a kindergarten computational thinking assessment using evidence-centered design: the case of algorithmic thinking	2023	Jody Clarke-Midura Deborah Silvis Jessica F. Shumway Victor R. Lee Joseph S. Kozlowski	Assessing computational thinking	book
A principled approach to designing computational thinking concepts and	2023	Satabdi Basu Daisy W. Rutstein Yuning Xu	Assessing Computational Thinking	book

Title	Year	Author	Journal name	Rank
practices assessments for upper elementary grades		Haiwen Wang Linda Shear		
Enhancing computational thinking assessment: a multimodal cognitive diagnostic approach	2025	Sa Yang Sha Zhu Wei Qin	Thinking Skills and Creativity	Q1
Mobile2d-3d-roboticsim: a robotic platform for computational thinking assessment in STEM and STEAM education	2026	José Hugo Barrón Zambrano Marco Aurelio Nuño Maganda Melchor Hernández-Díaz José de Jesús Rangel Magdaleno Yahir Hernández-Mier	SoftwareX	Q2

Based on the analysis results, there are nine publications that discuss the assessment of computational thinking (CT), including both journal articles and books. Each study presents a different approach to designing and implementing CT assessments, depending on its specific context and research objectives.

Piatti et al. (2022), in their article "The CT-cube: A Framework for the Design and the Assessment of Computational Thinking Activities," developed an assessment framework known as the CT-cube. The findings show that computational thinking (CT) assessment can be embedded directly into learning activities. In this way, evaluation is not treated as a separate process, but instead becomes an integral part of the learning experience itself.

Another study by Martínez et al. (2022) titled "Assessing Computational Thinking: Development and Validation of the Algorithmic Thinking Test for Adults" (2022), focuses on the development of a test instrument designed to measure algorithmic thinking skills in adults. The findings indicate that computational thinking (CT) can be assessed more objectively using instruments that have undergone validity and reliability testing.

Next, a study conducted by Clarke-Midura et al. (2023) the article "Designing Formative Assessments of Early Childhood Computational Thinking" emphasizes the importance of formative assessment. The findings show that at the early childhood level, CT assessment is more effective when it is conducted continuously and embedded within everyday learning activities.

Kong et al. (2023), in their article "Monitoring Cognitive Development Through the Assessment of Computational Thinking Practices," use a longitudinal approach. The study shows that computational thinking (CT) assessment can be used to track students' cognitive development gradually over a period of time.

Meanwhile, Koren et al. (2023), in their article "Using Design-Based Implementation Research Approach to Create Computational Thinking Assessment Tools for Youth Programs in Public Libraries," developed assessment tools tailored to non-formal learning contexts. The findings show that CT assessment can be designed flexibly to fit different learning environments, including community-based programs such as public libraries.

Next, Clarke-Midura et al. (2023) in their book "Developing a Kindergarten Computational Thinking Assessment Using Evidence-Centered Design: The Case of Algorithmic Thinking" (2023), developed an assessment instrument based on evidence-centered design. The findings suggest that CT assessment for young children should be designed around clear and well-structured evidence of their skills and abilities.

Another study by dari Basu et al. (2023), titled "A Principled Approach to Designing Computational Thinking Concepts and Practices Assessments for Upper Elementary Grades" (2023), highlights the importance of balancing both concepts and practices in CT assessment. The findings show that both aspects need to be assessed together in order to provide a more complete picture of students' abilities.

Yang et al. (2025), in their article "Enhancing Computational Thinking Assessment: A Multimodal Cognitive Diagnostic Approach," introduce a multimodal assessment approach. The findings indicate that using multiple types of data can improve the accuracy of diagnosing students' computational thinking (CT) abilities.

Finally, Barrón-Zambrano et al. (2026), in their article "Mobile2D-3D-RoboticSim: A Robotic Platform for Computational Thinking Assessment in STEM and STEAM Education," developed a robotics-based platform as an assessment tool. The findings show that interactive technologies can serve as an effective way to measure computational thinking (CT) skills in more applied and hands-on learning contexts.

Overall, these studies show that computational thinking assessment has developed through a wide range of approaches, including test-based instruments, formative assessment, conceptual frameworks, and the use of technologies such as multimedia and robotics. However, this diversity also indicates that there is still no fully standardized approach to CT assessment. As a result, the measurement of computational thinking continues to evolve and adapt to different learning contexts.

In addition to studies that separately focus on coding skills and computational thinking (CT), several recent studies have begun to integrate both within a single assessment framework. Therefore, a specific analysis was conducted on articles that evaluate coding and CT in an integrated manner. A summary of this analysis is presented in Table 6.

Table 6. Analysis of Articles on Combined Assessment of Coding Skills and Computational Thinking

Title	Year	Author	Journal name	Rank
Evaluation of creative project production performance in mathematical logic and computational thinking skills among gifted high school students	2025	Gülnur Özbek ökhan Karaaslan Ecem Karabulut	Acta psychologica	Q1
Teachers' understanding of assessing computational thinking	2025	Aino Ukkonen Katarina Pajchel Louise Misfud	Computer science education	Q1
Computational thinking measurement of cs university students	2024	Raquel Hijón-Neira Celeste Pizarro John French Daniel Palacios-Alonso Emre Çoban	Applied sciences	Q2

Based on the analysis presented in Table 6, three articles were identified that specifically address assessment approaches integrating coding skills and computational thinking (CT). Two of these articles were published in 2025 in Q1-ranked journals, while an additional study from 2024 was published in a Q2 journal. Although ranked slightly lower, it still makes an important contribution, particularly in the development of more structured assessment instruments.

The first article by Özbek et al. (2025), titled "Evaluation of Creative Project Production Performance in Mathematical Logic and Computational Thinking Skills among Gifted High School Students" and published in Acta Psychologica, uses a performance-based assessment approach. Students were evaluated through creative project work with indicators including mathematical logic skills, computational thinking, and creativity in problem-solving. The findings show that project-based assessment can effectively capture the connection between coding-related abilities and CT, particularly in complex tasks that require the integration of multiple skills.

The second article by Ukkonen et al. (2025), titled "Teachers' Understanding of Assessing Computational Thinking" and published in Computer Science Education, examines assessment from the teachers' perspective. Rather than directly measuring students' abilities, the study explores how teachers understand the concept and implementation of assessing computational thinking (CT) and coding. The findings reveal that teachers' understanding varies considerably, which leads to inconsistencies in assessment practices in the classroom.

Meanwhile, the third article by Hijón-Neira et al. (2024), titled "Computational Thinking Measurement of CS University Students" and published in Applied Sciences, presents a more standardized approach through the development of an assessment instrument. The study by Hijón-Neira et al. (2024), represents a different form of integration at the assessment instrument level, where computational thinking and coding skills are measured together using a structured evaluation tool. The proposed method, UniCTCheck, combines two main components: a web-based application called CTScore and a psychometric scale known as CTProg. These tools are designed to assess seven core components of computational thinking alongside six programming concepts. The findings indicate that this approach enables a more systematic measurement of differences in student abilities, taking into account factors such as gender, educational level, and institution.

Overall, the three articles show that assessment of coding skills and computational thinking is carried out through three main approaches: (1) performance-based assessment through projects, (2) indirect assessment based on teachers' perspectives, and (3) standardized instrument-based assessment.

These findings suggest that, although there have been efforts to integrate computational thinking and coding, the approaches used are still quite diverse and highly context-dependent. As a result, there is not yet a fully consistent or unified standard for assessing these skills.

Discussion

The results of this systematic literature review show a significant narrowing from the initial number of articles to those that are truly relevant to the assessment of coding skills and computational thinking (CT). Out of 13,422 articles identified, only 14 met the inclusion criteria. This finding suggests that research specifically focused on assessment aspects is still relatively limited compared to studies that emphasize instructional implementation. This phenomenon aligns with the findings of Su et al. (2023), who state that research on computational thinking (CT) is still largely dominated by pedagogical interventions, as well as (Tang et al., 2020), who emphasize that the development of CT assessment instruments remains fragmented and lacks consistency.

The distribution of research focus shows a clear dominance of computational thinking over coding skills. This reflects a broader paradigm shift from purely technical abilities toward higher-order cognitive skills. In science education, several studies highlight the important role of computational thinking (CT) in solving complex problems, such as Student's Computational Thinking Ability in Solving Trigonometry Problems and Computational Thinking Skills to Solve Kinematics Problems (Rabiudin et al., 2023). In addition, CT also contributes to developing scientific thinking dispositions through approaches such as simulation and collaborative modeling (Noviani et al., 2026). These findings reinforce the idea that CT has evolved into a cross-disciplinary competency. However, other studies also show that the measurement of CT has begun to develop more systematically through standardized instruments, as noted by Álvarez et al. (2024). This suggests that the development of CT assessment is not entirely lagging behind, but is instead still in a stage of consolidation.

The publication trend that peaked in 2023 indicates a growing interest in computational thinking (CT), particularly in the context of its integration into STEM curricula. However, the subsequent decline in publications suggests that the research field is still exploratory in nature and has not yet developed in a consistent or sustained way. This aligns with the findings of Khasanah et al. (2025), which show a strong dominance of research focusing on instructional implementation. On the other hand, Grover (2021) emphasizes that the main challenge in developing computational thinking (CT) assessment lies in the complexity of the construct itself, making standardization difficult.

Nevertheless, several longitudinal studies, such as Kong et al. (2023), demonstrate that CT skills can be measured quantitatively and tend to develop gradually over time. This suggests there is potential for building more stable and consistent approaches to CT assessment in the future.

From an educational level perspective, the analysis shows that CT assessment has been developed more extensively at the early stages (early childhood and primary school), while it remains quite limited at the secondary and higher education levels. This suggests that research has mainly focused on introducing CT rather than evaluating advanced-level skills. However, studies in more advanced learning contexts, such as The Analysis of Implementation Project-Based Learning Model and Computational Thinking Skills to Solve Kinematics Problems by Ridlo et al. (2022), show that CT plays an important role in solving complex problems. This gap indicates that the need for assessment at higher levels has not yet been matched by the development of adequate instruments.

From a methodological perspective, coding assessment tends to rely on structured instruments based on developmental stages, particularly in early childhood education. In contrast, computational thinking (CT) assessment shows a wider variety of approaches, ranging from formative and longitudinal assessments to technology-based methods. This aligns with the study by Sulsilah et al. (2023), which emphasizes the importance of validity and reliability in measuring CT.In addition, technological advancements have encouraged the emergence of digital-based assessments, such as the use of multimedia (Roslina et al., 2026), and robotics (Muzakiah et al., 2024). Li et al. (2020) further highlight that technology-based approaches can provide richer data for measuring CT, although they still face challenges related to standardization and large-scale implementation.

In addition, learning approaches such as problem-based learning, STEM education, and programming integration have been shown to be effective in improving computational thinking (CT) skills (Pangsuma et al., 2025). However, these improvements are generally measured through performance outcomes or learning results, rather than through dedicated assessment instruments. This indicates that CT is still largely evaluated indirectly and within specific learning contexts.

Another important finding is that research directly integrating coding and computational thinking (CT) assessment remains limited. Most studies still treat them separately or only combine them indirectly through project-based approaches or teacher perceptions. The study Teachers' Understanding of Assessing Computational Thinking shows that teachers' understanding of CT assessment varies, which leads to inconsistent classroom practices. On the other hand, performance-based approaches such as those in Evaluation of Creative Project Production Performance suggest that integrating coding and CT is more effectively assessed through complex tasks. In fact, earlier work by Weintrop et al. (2016) indicates that integration of coding and CT in both instruction and assessment has already begun, although it is still not widely developed or standardized.

Furthermore, studies such as those conducted by Rahim et al. (2024) and Taupik et al. (2023), show that the measurement of computational thinking (CT) varies widely across research, both in terms of indicators, methods, and contexts. This variation reinforces the finding that there is still no consistent or standardized assessment framework. However, approaches such as project-based assessment (Brennan & Resnick) have been recognized as a valid alternative for measuring CT, particularly in practice-oriented learning environments.

Overall, this study shows that although computational thinking (CT) has rapidly grown as an essential 21st-century skill in education, its assessment is still facing several challenges. There is a clear imbalance between the large number of studies focused on instructional implementation and the relatively limited research on assessment, indicating a significant gap in the field.At the same time, the existence of some validated instruments and the increasing use of technology-based approaches suggest that the field is gradually moving toward a more consolidated stage. However, further development is still needed to build more comprehensive assessment models—ones that do not only focus on final outcomes, but also capture students' thinking processes in a systematic, valid, and context-sensitive way. This study reinforces the idea that integrating coding and CT within assessment remains both a key challenge and a strategic opportunity for future research.

Conclusion

This study reviewed 14 articles related to the assessment of coding skills and computational thinking (CT) published between 2022 and May 2026. The findings indicate that most studies focus on computational thinking assessment, while research specifically addressing coding skill assessment remains limited. In terms of educational levels, the studies are mainly concentrated in early childhood and primary education, whereas research at the higher education level is still relatively limited. In addition, the reviewed studies demonstrate that CT and coding assessments are implemented through diverse approaches, including test-based instruments, performance-based assessment, formative assessment, and technology-supported assessment tools. However, no standardized assessment framework has yet been consistently applied across different educational contexts. Based on these findings, future research is recommended to develop more comprehensive and standardized assessment instruments, particularly at the higher education level and within STEM-related learning environments. Further studies may also explore the integration of coding and computational thinking assessment in specific disciplinary contexts, including physics education.

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References

Álvarez, M. C., Ocampo, L. M., & Cardona Torres, S. A. (2024). Instrumentos de evaluación del pensamiento computacional: una revisión sistemática. *TecnoLógicas*, *27*(59), e2950. https://doi.org/10.22430/22565337.2950

Arnas, Y., Lamtiar, S., Kurniawati, Z., & Dinamis, F. (2024). Analisis Pemecahan Masalah Fluida Dinamis dengan Metode Computational Thinking pada Program Studi Teknik Mekanikal Bandar Udara. *Jurnal Ilmiah Ilmu Pendidikan*, *7*(6). https://doi.org/10.54371/jiip.v7i6.4475

Ayanwale, M. A., & Omeh, C. B. (2026). AI-supported problem-based learning for enhancing computational thinking skills in STEM education. *Computers in Human Behavior: Artificial Humans*, *7*, 100263. https://doi.org/10.1016/j.chbah.2026.100263

Basu, S., Rutstein, D., Xu, Y., Wang, H., & Shear, L. (2023). A principled approach to designing computational thinking concepts and practices assessments for upper elementary grades. *Computer Science Education*, *31*, 1–30. https://doi.org/10.1080/08993408.2020.1866939

Caballero, M., & Odden, T. O. (2024). Computing in physics education. *Nature Physics*, *20*, 339–341. https://doi.org/10.1038/s41567-023-02371-2

Clarke-Midura, J., Lee, V. R., Shumway, J. F., Silvis, D., Kozlowski, J. S., & Peterson, R. (2023). Designing formative assessments of early childhood computational thinking. *Early Childhood Research*

Quarterly, *65*, 68–80. https://doi.org/10.1016/j.ecresq.2023.05.013

Hardiyanti, W. D., Prayitno, Martha Christianti, Aprilia Rambe, & Ulfiyani. (2025). Coding Games to Stimulate Computational Thinking Ability in Early Childhood. *Journal for Lesson and Learning Studies*, *8*(2), 243–256. https://doi.org/10.23887/jlls.v8i2.92569

Herlambang, A. D., & Rachmadi, A. (2024). Computational Thinking Skills Theorization in the Vocational High School Computer Programming Subject Context. *Elinvo (Electronics, Informatics, and Vocational Education)*, *9*(1), 64–75. https://doi.org/10.21831/elinvo.v9i1.64501

Hijón-Neira, R., Pizarro, C., French, J., Palacios-Alonso, D., & Çoban, E. (2024). Computational Thinking Measurement of CS University Students. *Applied Sciences (Switzerland)*, *14*(12). https://doi.org/10.3390/app14125261

Israel-Fishelson, R., & Hershkovitz, A. (2022). Studying interrelations of computational thinking and creativity: A scoping review (2011–2020). *Computers & Education*, *176*, 104353. https://doi.org/10.1016/j.compedu.2021.104353

Kalyenci, D., Metin, Ş., & Başaran, M. (2022). Test for assessing coding skills in early childhood. *Education and Information Technologies*, *27*(4), 4685–4708. https://doi.org/10.1007/s10639-021-10803-w

Khasanah, U., Supahar, S., Fitria, T., Prasasti, N. H., & Malik, E. (2025). A Systematic Literature Review: Implementation of Computational Thinking in Physics Learning in Indonesia. *Jurnal Penelitian Pendidikan IPA*, *11*(3), 97–105. https://doi.org/10.29303/jppipa.v11i3.6675

Kong, S.-C., & Wang, Y.-Q. (2023). Monitoring cognitive development through the assessment of computational thinking practices: A longitudinal intervention on primary school students. *Computers in Human Behavior*, *145*. https://doi.org/10.1016/j.chb.2023.107749

Koren, N., Subramaniam, M., & Weintrop, D. (2023). Using design-based implementation research approach to create computational thinking assessment tools for youth programs in public libraries. *Library & Information Science Research*. https://doi.org/10.1016/j.lisr.2023.101240

Li, Y., Schoenfeld, A. H., diSessa, A. A., Graesser, A. C., Benson, L. C., English, L. D., & Duschl, R. A. (2020). On Computational Thinking and STEM Education. *Journal for STEM Education Research, 3*(3), 147–166. https://doi.org/10.1007/s41979-020-00044-w

Liao, C. H., Chiang, C. T., Chen, I. C., & Parker, K. R. (2022). Exploring the relationship between computational thinking and learning satisfaction for non-STEM college students. *International Journal of Educational Technology in Higher Education*, *19*(1). https://doi.org/10.1186/s41239-022-00347-5

Listiaji, P., & Molnár, G. (2025). Integrating computational thinking into teacher education: A systematic literature review. *International Journal of Educational Research*, *133*. https://doi.org/10.1016/j.ijer.2025.102682

Martínez, M. L., Lévêque, O., Benítez Baena, I., Hardebolle, C., & Dehler Zufferey, J. (2022). Assessing Computational Thinking: Development and Validation of the Algorithmic Thinking Test for Adults. *Journal of Educational Computing Research*, *60*(6). https://doi.org/10.31124/advance.16685314

Muzakiah, M., Irwandi, I., Yusibani, E., Sari, I. M., Omar, R., & Oktavia, R. (2024). Effectiveness of Block Programming and Quarky Robots to Improve Computational Abilities Thinking through the STEMC Approach. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 10593–10599. https://doi.org/10.29303/jppipa.v10i12.8965

Nambiar, R. (2020). Coding as an Essential Skill in the Twenty-First Century. *Education in the Asia-Pacific Region*, *55*. https://doi.org/10.1007/978-981-15-7018-6_29

Noviani, E. P. F., Daeng, F. F., Wijaya, A., & Herwinarso. (2026). Promoting Quality Education through Physics Simulations and Collaborative Modeling-Based Learning: Students' Computational Thinking Dispositions in High School Physics. *Jurnal Penelitian Pendidikan IPA*, *12*(3), 67–73. https://doi.org/10.29303/jppipa.v12i3.13724

Odden, T. O., & Caballero, M. (2023). *Physics Computational Literacy: What, Why, and How?* (pp. 1–28). https://doi.org/10.1063/9780735425477_019

Özbek, G., Karaaslan, G., & Karabulut, E. (2025). Evaluation of creative project production performance in mathematical logic and computational thinking skills among gifted high school students. *Acta Psychologica*, *260*. https://doi.org/10.1016/j.actpsy.2025.105328

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. In *The BMJ* (Vol. 372). BMJ Publishing Group. https://doi.org/10.1136/bmj.n71

Palop, B., Díaz, I., Rodríguez-Muñiz, L. J., & Santaengracia, J. J. (2025). Redefining computational thinking: A holistic framework and its implications for K-12 education. *Education and*

Information Technologies, *30*(10), 13385–13410. https://doi.org/10.1007/s10639-024-13297-4

Pangsuma, N. S., Purwianingsih, W., & Kusumastuti, M. N. (2025). Empowering Computational Thinking through PBL-SSI: Tackling Conservation Threats Effectively. *Jurnal Penelitian Pendidikan IPA*, *11*(5), 725–732. https://doi.org/10.29303/jppipa.v11i5.10359

Piatti, A., Adorni, G., El-Hamamsy, L., Negrini, L., Assaf, D., Gambardella, L., & Mondada, F. (2022). The CT-cube: A framework for the design and the assessment of computational thinking activities. *Computers in Human Behavior Reports*, *5*. https://doi.org/10.1016/j.chbr.2021.100166

Rabiudin, R., Afifi, E. H. N., Hastuti, T. W., & Nisa, D. C. (2023). Computational Thinking Skills to Solve Kinematics Problems at High Cognitive Level Cases. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 10955–10964. https://doi.org/10.29303/jppipa.v9i12.5775

Rahim, F. R., Widodo, A., Suhandi, A., & Ha, M. (2024). Systematic Review of Educational Level and Evaluation Tools for Computational Thinking Skill. *Jurnal Penelitian Pendidikan IPA*, *10*(2), 54–61. https://doi.org/10.29303/jppipa.v10i2.5209

Ridlo, Z. R., Supeno, S., Wahyuni, S., Mahardika, I. K., Wicaksono, I., & Ulfa, E. M. (2022). Analysis of Implementation Project-Based Learning Model of Teaching Integrated with Computer Programming in Improving Computational Thinking Skills in a Classical Mechanics Course. *Jurnal Penelitian Pendidikan IPA*, *8*(4), 2029–2035. https://doi.org/10.29303/jppipa.v8i4.1789

Rosandhi, U., & Haryadi, R. (2024). The Ability of Computational Thinking in Physics Learning. *Jurnal Materi Dan Pembelajaran Fisika*, *14*(2), 2024. https://doi.org/10.20961/jmpf.v14i2.79

Roslina, Nurwahidin, M., Herpratiwi, & Fitri, D. M. (2026). The Effectiveness of Android Based Interactive Learning Media in Improving Students Computational Thinking on Heat Material. *Jurnal Penelitian Pendidikan IPA*, *12*(3), 714–721. https://doi.org/10.29303/jppipa.v12i3.14547

Ruiter, L. E. de, & Bers, M. U. (2022). The Coding Stages Assessment: development and validation of an instrument for assessing young children's proficiency in the ScratchJr programming language. *Computer Science Education*, *32*(4), 388–417. https://doi.org/10.1080/08993408.2021.1956216

Su, J., & Yang, W. (2023). A systematic review of integrating computational thinking in early childhood education. *Computers and Education Open*, *4*. https://doi.org/10.1016/j.caeo.2023.100122

Sulsilah, H., Hidayat, A., & Ramalis, T. R. (2023). Analysis of Computational Thinking Instrument for High School Student Using Rasch Model. *Jurnal Penelitian Pendidikan IPA*, *9*(3), 1445–1450. https://doi.org/10.29303/jppipa.v9i3.2771

Tan, B., Jin, H.-Y., & Cutumisu, M. (2024). The applications of machine learning in computational thinking assessments: a scoping review. *Computer Science Education*, *34*(2), 193–221. https://doi.org/10.1080/08993408.2023.2245687

Tang, X., Yin, Y., Lin, Q., Hadad, R., & Zhai, X. (2020). Assessing computational thinking: A systematic review of empirical studies. *Computers & Education*, *148*, 103798. https://doi.org/10.1016/j.compedu.2019.103798

Taupik, R. P., & Fitria, Y. (2023). Learning Motivation and Computational Thinking Ability of Elementary School Students in Learning Science. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 7665–7671. https://doi.org/10.29303/jppipa.v9i9.4826

Ukkonen, A., Pajchel, K., & Mifsud, L. (2025). Teachers' understanding of assessing computational thinking. *Computer Science Education*, *35*(4), 794–819. https://doi.org/10.1080/08993408.2024.2365566

Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L., & Wilensky, U. (2016). Defining Computational Thinking for Mathematics and Science Classrooms. *Journal of Science Education and Technology*, *25*(1), 127–147. https://doi.org/10.1007/s10956-015-9581-5

Weller, D. P., Bott, T. E., Caballero, M. D., & Irving, P. W. (2021). Developing a learning goal framework for computational thinking in computationally integrated physics classrooms. *Cornell University*. Retrieved from http://arxiv.org/abs/2105.07981

Yang, S., Zhu, S., & Qin, W. (2025). Enhancing computational thinking assessment: A multimodal cognitive diagnostic approach. *Thinking Skills and Creativity*, *56*. https://doi.org/10.1016/j.tsc.2025.101752

Zambrano, J. H. B., Nuño-Maganda, M. A., Hernández-Díaz, M., Rangel-Magdaleno, J. de J., & Hernández-Mier, Y. (2026). Mobile2D-3D-RoboticSim: A robotic platform for computational thinking assessment in STEM and STEAM education. *SoftwareX*, *33*. https://doi.org/10.1016/j.softx.2025.102473