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STEM and STEAM Affects Computational Thinking Skill: A Systematic Literature Review

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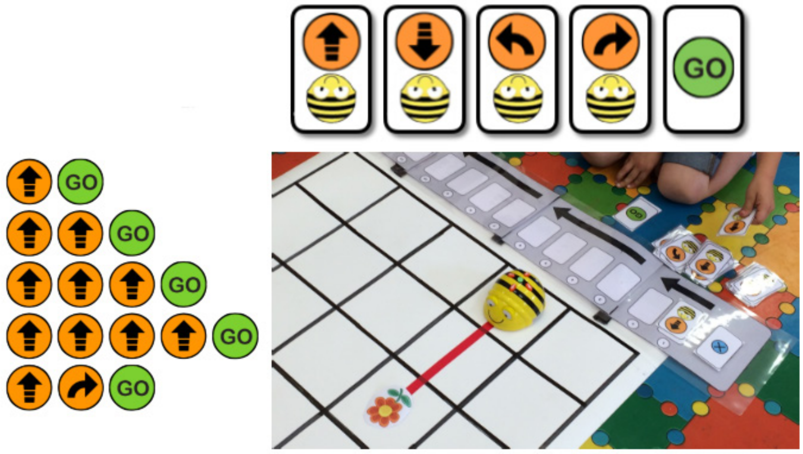
STEM (Science, Technology, Engineering, and Mathematics) and STEAM (Science, Technology, Engineering, Arts, and Mathematics) against CT (Computational Thinking) plays an important role in science learning. This study aims to look at renewable research related to the effect of STEM and STEAM on CT ability. The study was conducted based on 3 stages of the Systematic Literature Review (SLR) method: identification, filtering procedures (pre-processing, abstract screening, and text filtering), and data mapping. Literature review results were obtained from 12 articles with the most distribution in 2020 (n=5), indexed by Scopus Q1 (n=9), applied mixed methods research methods (n=6), and applied to the basic education level (n=6). Then, the most widely used instrument is the Computational thinking test (n=6) on the important dimensions of CT assessment in the form of problem solving, abstraction, algorithmic thinking, critical thinking, creative and cooperative; integrated in project-based activities with a game design model (n=2), producing the most projects in the form of robots (n=4), and overall STEM and STEAM learning activities have a positive impact on CT. Based on the findings, it can be concluded that STEAM activities are able to have more effect than STEM because of the existence of "Art".

Graphical abstract



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1. Introduction

Computational Thinking (CT) is a part of computer science that has historically developed since the 1960s and 1970s [1], and today CT is again in the center of attention in the world of education. The focus on CT is able to prepare future generations of students to become productive citizens in society, and increasingly technologically advanced [2]. The interaction between computer science, artificial intelligence, cognitive, learning, and psychological science, provides a basis in determining various aspects of CT skill evaluation [3]. Computational Thinking can be applied in problem solving to

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better understand the surrounding environment [4], understand digital society, and also cultivate 21st century skills such as creativity and logical thinking [5]. Computer science in CT can assist in the design and verification of algorithms [6], assist in the discovery of problem-solving tools, decide which tools to apply to a particular problem, and recognize how to solve problems in new ways [7]. The presence of STEM in computer science is one of the triggers in the development of CT capabilities [8].

STEM as an approach designed to consider the effectiveness and meaningfulness of CT skills for learners [9]. STEM and CT play an important role in science learning [10]. Computational Thinking is the basis for modern competence in STEM-related fields, encouraging research on how to best prepare students for the 21st century and lifelong learning [11, 12]. Improvements in technology and computing have led to STEM and computing being closely related [13].

The STEM approach is the focus of education today [14], in an effort to create more balanced STEM programs. The presence of "Arts" in STEM, has a positive influence. Previous studies related to STEM have viewed a lack of emphasis on human creative nature [15], so the use of the STEAM approach is considered better than the STEM approach by far eastern countries, such as Japan and South Korea with higher success in international exams, and will contribute to the development of diverse students [16].

The STEM approach was created to educate more conscious young people with the high-tech skills needed to expand job opportunities in the digital age. The STEAM approach offers students more than high-tech skills. Complex systems and solutions are conceptualized and designed with dominant analytical skills but ultimately a desire to be transitioned into implemented and deployed capabilities that deliver business/mission value that requires more creative skills [17]. Currently, research related to STEM and STEAM has come to the conclusion that these two initiatives are the best way for students to gain knowledge, creatively, and solve problems across disciplines, both in the classroom and outside the classroom [18-20].

However, it seems that the prospects offered by CT are limitless, raising critical questions about how CT is operationalized in empirical studies. What has been taught, learned, and assessed? Such as the changing dimensions of CT skills assessment, varied learning models, the importance of using STEM and STEAM in learning to assess students' CT skills, projects used in STEM and STEAM learning to develop students' CT skills, as well as considerations for choosing STEM and STEAM to improve CT skills. Based on the explanation above, the research focus that will be discussed is:

1. Instruments and dimensions used in assessing CT
2. Integrated learning model in STE(A)M learning activities to improve CT ability
3. Projects used in STE(A)M learning activities to improve CT skills
4. Assess the influence of STE(A)M learning activities to improve CT ability

2. Results and Discussion

2.1 Article Distribution

The distribution of articles is grouped by, year of publication, journal name and journal category, type of research (quantitative, qualitative, mixed methods, or development), place of research, level of education of research participants. Based on the publication year variable, it was found that articles published according to the theme were published in the last 7 years (2016 - 2022). This is intended to reveal research trends related to STEM interventions on CT ability.

The mapping results can be seen in Table 1. The results show that the largest distribution of articles was found in 2020 (n=5) [35, 37, 39, 42, 10], 2021 (n=2) [41, 43], 2022 (n=3) [36, 40, 44], 2018 (n=1) [34], 2016 (n=1) [38].

Based on the variables of the place of study, the mapping results of Table 1 show that the dominant study was carried out in the Turkish region (n=3) [34, 41, 42], then China region (n=2) [36, 10] and the United States region (n=2) [38, 39], as well as Spanish territory (n=1) [35], Lithuanian region (n=1) [37], Taiwan region (n=1) [44], Malaysian territory (n=1) [43]; region of Thailand (n=1) [40].

Based on the variables of participants' education levels, the mapping in Table 1, shows that STEM and STEAM studies that affect CT are generally carried out for elementary school students (n=6) [10, 35-39], then junior high school students (n=5) [34, 37, 38, 41, 42]; college students (n=3) [43, 44, 40], high school seniors (n=1) [37], and kindergarten students [37].

2.2 Instrument Type Used and CT Dimensions

Table 2 shows that CT analysis was performed using research instruments. Based on the Systematic Literature Review (SLR) the instruments used are; (1) Computational thinking test (n=7) [10, 34-36, 40, 43, 44], contain test questions developed based on the assessment aspects you want to measure, then the analysis is carried out based on the results of the pre-test and post-test; (2) computational thinking scala (n=4) [37, 39, 41, 42], containing assessment categories based on likert scale and ordinal scale; (3) Computational thinking rubric [38], which contains ordinal scales.

Table 2 shows that, troubleshooting (n=7) [10, 34, 36, 38, 41-43] as the most dimensional in CT assessment in STEM and STEAM, is an important predictor in CT skills [45], as well as the dimensions of creativity, and critical thinking (n=3) [41-43], where these three dimensions are important skills in equipping students to face future life and career success [46]. Then the dimension of algorithmic thinking (n=7); [37-42]. Algorithms are at the core of computational thinking, which refers to a series of problem-solving processes that help children to think logically [47, 48]. Developing algorithmic thinking becomes an important skill needed in implementing STEM [49]. Dimensions of communication and collaboration (n=2) [37, 41], this dimension is able to support the collective ability to understand "SWOT (Students Ways of Thinking)/ student way of thinking" and produce a coherent perspective to be interoperable in a STEM context [50].

Cooperative dimension (n=3) [41-43] is a group-based strategy system [51] where students work together and communicate with each other to achieve common goals, and can improve teacher-student and student-student relationships [52]. Dimensions of abstraction (n=3) [37, 39, 40] in the form of the ability to consider important aspects (Rijke et al., 2018), through a simplification process to obtain the essence of something interesting [53]. Dimensions of systems thinking (n=2) [34, 39], which is also an aspect in the evaluation of CT. This system thinking and abstract thinking is a skill in computer engineering (hardware and software) [54].

Table 1. Article distribution.

Study	Year Publishing	Journal Publisher		Methods	Research Location	Level of Education
		Scopus Index	Journal Name			
Bati et al. (2018) [34]	2018	Q2	Cogent Education	Mix Methods	Turkish	Junior High School
Cervera et al. (2020) [35]	2020	Q2	Education Sciences	Mix Methods	Spanish	Primary school
Chiang et al. (2022) [36]	2022	Q1	Journal of Science Education and Technology	Mix Methods	China	Primary school
Juskeviciene et al. (2020) [37]	2020	Q1	Computer Applications in Engineering Education	Qualitative	Lithuania	Kindergarten, Primary school, Junior & Senior High School
Leonard et al. (2016) [38]	2016	Q1	Journal of Science Education and Technology	Mix Methods	United States	Primary school
Newton et al. (2020) [39]	2020	Q1	Journal of Research on Technology in Education	Mix Methods	United States	Primary school
Pewkam & Chamrat (2022) [40]	2022	Q1	Informatics in Education	Mix Methods	Thailand	College Students
Sen et al. (2021) [41]	2021	Q1	Thinking Skills and Creativity	Qualitative	Turkish	Junior High School
Sirakaya et al. (2020) [42]	2020	Q1	Journal of Science Education and Technology	Quantitave	Turkish	Junior High School
Sun et al. (2020) [10]	2020	Q1	Journal of Computer Assisted Learning	Quantitave	China	Primary school
Tan et al. (2021) [43]	2021	Q2	Eurasia Journal of Mathematics, Science and Technology Education	Quantitave	Malaysia	College Students
Tsai et al. (2022) [44]	2022	Q1	International Journal of Technology and Design Education	Development	Taiwan	College Students

Table 2. Instrument and CT dimensions.

Study	Instrument	CT Dimensions
Bati et al. (2018) [34]	Computational thinking test	Data and information skills, modeling and simulation skills, computational problem-solving skills, system management skills
Cervera et al. (2020) [35]	Computational thinking test	Direction and basic sequence, loop-time repeated, loop-repeated
Chiang et al. (2022) [36]	Computational thinking test	Problem solving that implements ideas and methods in the computer field
Juskeviciene et al. (2020) [37]	Computational thinking scala	Data and representative analysis, computational artifacts, parsing, abstraction, algorithms, communication and collaboration, computers and communities, evaluation
Leonard et al. (2016) [38]	Computational thinking rubic	Formulating problems, abstractions, logical thinking, algorithmic, analyzing and applying solutions, generalization and transfer of problems, the use of cultural game plops
Newton et al. (2020) [39]	Computational thinking scala for robotic activity	Sequencing, causal interference, conditional reasoning, systems thinking
	Computational thinking scala for game design	Abstraction, algorithmic thinking, learning transfer
Pewkam & Chamrat (2022) [40]	Computational thinking test	Decomposition, pattern recognition, abstraction, algorithmic
Sen et al. (2021) [41]	Computational thinking scala	Collaboration, problem solving, creativity, critical thinking, and algorithmic, cooperative thinking
Sirakaya et al. (2020) [42]	Computational thinking scala	Problem solving, creativity, critical thinking, and algorithmic, cooperative thinking
Sun et al. (2020) [10]	Computational thinking test	Spatial ability, reasoning ability, and problem-solving ability
Tan et al. (2021) [43]	Computational thinking test	Problem solving, creativity, critical thinking, algorithmic thinking, and cooperative
Tsai et al. (2022) [44]	Computational thinking test	Sequence of loops, events, parallelism, conditionals, operators, and data

Then other assessment dimensions used in CT assessment based on the needs of researchers are such as; data and information skills [34][37][44], modeling and simulation skills, systems thinking skills [34, 39], learning transfer [39], modeling and simulation skills [34], spatial ability [10], reasoning [10, 39], causal sequencing and interfence [39], computational and deciphering artifacts [37], loop sequences, loop-time repetitive/event, loop-repeated/ parallelism [35, 44], conditionals and operators [44], generalizations, problem transfer, as well as the use of cultural game plops [38], decomposition, pattern recognition [40].

The insertion of STEM and STEAM in schools confirms that problem solving, abstraction, and algorithmic thinking are important dimensions required in CT assessment. Meanwhile, critical, creative and cooperative thinking are skills that emerge in STEM activities, and are important dimensions in CT assessment that cannot be avoided. Based on this, there are 6 important dimensions suggested in assessing CT in integrated STEM and STEAM learning activities: (1) problem solving, (2) algorithmic thinking, (3) algorithmic thinking, (4) critical thinking, (5) creative, and (6) cooperative. Apart from that, Problem Solving, Critical Thinking, Creativity, and Cooperatives are part of the 4C skills which are very important to be implemented by teachers in schools to increase students' understanding of concepts [69, 70, 74].

2.3 Integrated STEM and STEAM Education

Integrated STEM or STEAM education is an effort in connecting Science, Technology, Engineering, (Art), and Mathematics in developing curricula and implementing learning through STEM and STEAM integrated learning methods/ models [55, 56]. Managing and implementing integrated STEM learning, aiming to improve the effectiveness of students' learning and improve various thinking abilities [57].

Table 3 shows that STEM is integrated with several models/methods that influence Computational Thinking (CT) capabilities. STEM integrated in game design (n=2) [38, 39]. STEM integrated Project Based Learning (PjBL) model [44], is a model that is often integrated in STEM education along with Problem Based Learning (PBL) models. Then STEM or STEAM integrated Time Teaching Program [34]. Then STEM or STEAM integrated 3 types of models that are applied in developing robots, the ER (Education Robotics) model [35], the 6E model (Engage, Explore, Explain, Engineer, Enrich, Evaluate) [36], and the EDP (Engineering Design Process) Model with 9 learning stages; (1) identify need or problem, (2) research need or problem, (3) develop possible solutions, (4) select the best possible solution, (5) construct a prototype, (6) test and evaluate the solution, (7) communicate the solutions, (8) redesign, and (9) complection [41]; and Computing Science Teacher Training [40]. Even STEM or STEAM is integrated into 6 models with different terms, the result of the activity remains the same, namely producing a project that is used in learning [72]. Learning by applying the right model can reduce misconceptions in learning [71].

2.4 Project STEM and STEAM Education

This STEM learning experience is considered capable of improving students' engineering design skills [36]. Authentic, interdisciplinary, research, and problem-based integrated STEM projects are ideal for encouraging critical thinking and creativity, developing teamwork, and presenting challenges (problem solving) [58], which are an important part of the CT dimension.

Table 4 shows that integrated STEM projects were applied to the field of mathematics (n=2) [35, 39]; science (n=5) in thematic subjects [36], electricity [43], and three did not list subjects but were analyzed by project [37, 41, 44]; the field of geography (n=1) on the concept of time [34], and chemistry [40]. The application of STEM in chemistry can have a positive effect on students' metacognitive abilities [73].

Computational Thinking skills are often associated with STEM and STEAM [59],and take advantage of the role of project activities in it. Robotics is one of the long-term projects that can have a positive influence on improving CT capabilities. However, at the same time it is also a challenge that students must face in the technological environment [60].

Table 4 also shows that, for the most part, the resulting project is a robot (n=5) [35, 39, 41, 38, 40], by utilizing the scratch programming language, which is an early tool in programming used to create educational and entertainment content, create mathematical and scientific projects, and simulate and visualize experiments [61]. The robot was also designed using LEGO mindsorm education EV3 [41][38]; and LEGO WeDo 1.0 which forms 4 mini-projects: (1) flying bird, to spread herbs, (2) crocodile expedition, to search for useful herbal plants, (3) Robotic arm, to take herbs, (4) herbal delivery vehicles [62]. The analysis illustrates that in the aim of implementing STE(A)M to improve CT, robotics projects are more recommended. This is because apart from being the focus of various research, CT is also closely related to the computer environment so it is more useful. The authors suggest using computer-based projects to maximize the improvement of various dimensions of Computational Thinking skills.

Table 3. Integrated Model in STEM and STEAM

Study	Integrated Model
Bati et al. (2018) [34]	Time Teaching Program (TTP)
Cervera et al. (2020) [35]	ER (Education Robotics)
Chiang et al. (2022) [36]	6E Model
Leonard et al. (2016) [38]	Game Design
Newton et al. (2020) [39]	Game Design
Pewkam & Chamrat (2022) [40]	Computing Science Teacher Training (CSTT)
Sen et al. (2021) [41]	Model Engineering Design Process (EDP)
Tsai et al. (2022) [44]	Project Based Learning

Other projects utilized in STEM interventions to improve CT are learning tools (n=3), which consist of: An hourglass hourglass, a luna calendar designed based on a lunar phase model, and a mars calendar designed based on a phase model of the planet mars [34]; prototype of a security alaram system made from arduino uno, red LED, 100 ohm meters (brownish black, brown), Bel, Sensor, cable link with placeboard [37]; and electrical games [43]. Another project is a game controller (n=1) designed using arduino microcontroller boards and using the scratch programming language. The games produced are: (1) Energy Shooter. Players use sliding sensors to move their archer left and right, (2) Pokémon Energy Competition. Players use sliding sensors to control Pikachu or Eevee, (3) Keep Eating Energy. Players use sliding sensors to move a bird character up and down, (4) Energy Battle. Each player controls a soldier, (5) Wind, water, and sugar-apple. Players use sliding sensors to move the wind power or hydropower character up and down, (6) Fiery and Golden Eyes:

An Energy-Saving War, (7) Star of Energy. Each player controls a Super Mario character using their sliding sensor to move, collect coins, and avoid obstacles, (8) Energy War. The gameplay of this two-player game is similar to that of Fleabag vs. Mutt [44].

Table 4. Subject, project, and tools/software used.

Study	Subject	Project	Tools/Software
Bati et al. (2018) [34]	Science	Hourglass	Hourglass
		Lunar calendar	Lunar phase model
		Mars calendar	Phase model of the planet mars
Cervera et al. (2020) [35]	Mathematics	Bee-Bot Education Robot	Scratch
Chiang et al. (2022) [36]	Thematic	LEGO Robot	LEGO WeDo1.0
Juskeviciene et al. (2020) [37]	Physics	Prototype security alaram system	Arduino Uno, red LED, 100 ohm meter (brownish black, brown), Bell, Sensor, cable link with placeboard
Leonard et al. (2016) [38]		Robots	Lego Mindstorms Education EV3
Newton et al. (2020) [39]	Mathematics	LEGO Robots	Technology application with scratch programming language
Pewkam & Chamrat (2022) [40]	Chemistry, Mathematics, Arts	Robots	Microcontroller
Sen et al. (2021) [41]		LEGO Robots	Lego Mindstorms Education EV3
Tan et al. (2021) [43]	Physics	Electrical games	
Tsai et al. (2022) [44]		Game controller	Scratch and Arduino microcontroller boards

2.5 Influence of STEM and STEAM to Computatioanal Thinking

Table 5 and Table 6 present an evaluation of the effects of STEM education and STEAM education on Computational Thinking Skills, and their causal elements. STEM and STEAM is an inseparable approach to science because of the interconnection between the learning of science, technology, engineering, art, and mathematics. The results of studies from several articles show that both STEM and STEAM education have a positive effect on the ability of Computational thinking targets (students and pretrial teachers). Science attitudes (n=3), in the category of learning attitudes [36] STEM attitudes, STEM learning styles [42], self-confidence [10], are able to provide a significant correlation to students' Computational thinking [63]. Robotic activities (n=3), such as engineering learning and programming [36], basic programming activities [39], robot making activities [41], and game-design projects [44], will provide opportunities for students to engage in computational thinking [18]. Group activities (n=2) [36][39], mentoring activities [35], and activities that apply the Team Teaching Process (TTP) [34], in learning that have a significant effect on CT ability. Then the online training and monitoring of project activities carried out for teachers had a positive effect on CT abilities [40].

However, the reality of the research [37] proves that there are project activities in the class in the form of assignment, idea modeling, poster making, spreadsheets, and presentations, lacking interconnection to CT skills in the dimensions of computational artifacts, abstraction parsing, and algorithms. This certainly provides an opening for further research, where algorithmics are one of the important dimensions in CT and have a positive effect on some studies, but this study has a different effect.

Table 5. The Effect of STEM Education on Computational Thinking and Reason

Study	Effect	Explanation
Chiang et al. (2022) [36]	Positive	Engineering learning and programming Good confidence in learning The existence of activities that train students' thinking in group activities
Leonard et al. (2016) [38]	Positive	Digital game design activities showcasing venue and culture
Newton et al. (2020) [39]	Positive	Basic programming activities Group work activities in planning, implementing, modifying, and revising
Pewkam & Chamrat (2022) [40]	Positive	Online training of effective project activities Monitoring performance progress Maximum pretrial teacher engagement and participation Effective use of online platforms
Sen et al. (2021) [41]	Positive	Robot manufacturing activities
Sirakaya et al. (2020) [42]	Positive	STEM attitudes and STEM thinking styles
Sun et al. (2020) [10]	Positive	Student learning attitudes
Tsai et al. (2022) [44]	Positive	Game-design project

Table 6. The Effect of STEAM Education on Computational Thinking and Reason

Study	Effect	Explanation
Bati et al. (2018) [34]	Positive	Learning activities by applying TTP
Cervera et al. (2020) [35]	Positive	Mentoring experiences in learning
Juskeviciene et al. (2020) [37]	Positive	Project activities in the classroom have an interconnection to CT skills (data & representative analysis, communication and collaboration, computers and society, evaluation)
	Negative	Project activities in the classroom have no interconnection to CT skills (computational artifacts, abstraction parsing, algorithms)
Tan et al. (2021) [43]	Positive	There is an influence of intervention (electrical games)

Nevertheless, STEM, STEAM and CT remain one of the things that should concern us today, because of the importance of the role of technology in the learning process and both things are very supportive of technology. Technology gives rise to the creative aspects of humans in the field of art [64]. When viewed between STEM and STEAM, both have differences in terms of "Art", which in fact art is an important thing that we need in STEM and CT activities. Art itself is known as the pedagogy of meaningful social-emotional learning [47]. Art plays a role as an aspect of communication and culture [65], where this will be an attraction and the most important part in Indonesian learning with a very diverse culture. The strong appeal of this art is able to combine perceptual, physical, cognitive, belief, and emotional processes to stimulate imagination, cognitive, and affective [66]. In the affective realm, art encourages students to express their thoughts and emotions visually in order to increase creativity, confidence, and self-awareness [67, 68]. In addition, art is able to maintain the balance of the brain. The study of [36] shows that unbalanced areas of the brain are capable of giving rise to cognitive dissonance. Based on this, the author recommends applying STEAM in the learning process to improve CT in students.

3. Material and Methods

Systematic Literature Review (SLR) is the method used in this study. The aim is to identify, interpret, and produce synthetics that highlight a relevant publication related to the study area [21]. Figure 1 presents the stages of identification, interpretation, and production of qualified studies.

3.1 Identification

The focus of the article search is influenced by the research question, and a search is carried out on articles containing the keywords "STEM Computational Thinking" and "STEAM Comptational Thinking". There are no other terms in STEM, STEAM, and Computational Thinking (CT), so only 2 keywords are used in search. Based on the search terms, execution is carried out through several databases of major indexers for educational disciplines with high quality: Scopus, Education Resources Information Center (ERIC), Science Direct. Article execution is restricted to research of the last 10 years (2014 – 2023), and international articles. The Scopus index works on 4650 titles, ERIC works on 1341 titles, and science direct works on 5197 titles.

Further analysis was carried out on: article titles, abstracts, and keywords on the study. This dimension represents an important part of the scientific work that describes the central theme of an article [22]. The deadline for the article identification stage, which is November 24, 2022, produced 87 documents: Scopus (n1/3. 28), ERIC (n1/3.43), and Science Direct (n1/3. 16), given that this study belongs to the category of renewable research, so few articles were found based on narrow keywords, as there is no variation in keywords used by various STEM-related studies, STEAM, and Computational Thinking.

3.2 Screening

Based on the articles that have been identified, further screening is carried out by re-analyzing articles based on research questions, to ensure that the selected documents meet the following criteria: (1) studies include target engagement towards learning interventions, (2) studies describe STEM and STEAM interventions against CT (Computational Thinking) skills. The inclusion criteria describe the purpose of our review, to provide more complete information on how studies analyze CT abilities based on learning activities with STEM and STEAM, how interverence is applied in learning, and how it affects CT ability. The inclusion criteria are set as "core", as they are an important condition of documents that can answer research questions. This inclusion criterion is known as delimeation [23]. Delimation is carried out in two sequential stages of screening: pre-processing, and full-text filtering.

The pre-processing stage, restricted to the set of documents on peer-reviewed journal articles, which is at the core of academic publishing. The filter is adapted to the exception of document types in the form of, conference proceedings articles (e.g. [24]), due to the quality of the variables (e.g. [25]), papers (e.g. Bell & Bell, 2018), books (e.g. [26]), articles that are not indexed by Scopus (e.g. [27-29]), and Indonesian researcher articles. The bias of this stage is very minimal because all statements related to articles are facts such as proceedings, books, and papers, which are listed directly in the article, while the category of indexed articles is checked in https://www.scimagojr.com. We exclude 52 articles: Scopus (n1/3. 10), ERIC (n1/3. 33), and Science Direct (n1/3. 9), so there are 35 articles left: Scopus (n1/3. 18), ERIC (n1/3. 10), and Science Direct (n1/3. 7), which are then re-filtered at the full-text screening stage.

Full text filtering stage. This stage is the last process to produce articles that have met the inclusion criteria and are able to answer research questions. The filter at this stage is adapted to the exclusion of article results integrating STEM and CT in a learning plan [30][31][32], did not analyze STEAM interventions against CT (Valovicova et al, 2020), and looked at the effect of CT application on STEM careers [33]. We exclude 23 articles; Scopus (n1/3. 12) ERIC (n1/3. 5), Science Direct (n1/3. 6), so there are 12 articles left: Scopus (n1/3. 6) ERIC (n1/3. 5), Science Direct (n1/3. 1), which already meets the inclusion criteria and can answer research questions.

3.3 Data Mapping

After the articles are obtained from the identification results, the collection of information needed to answer research questions is carried out. This stage became an important stage in the SLR, conducting an in-depth analysis of 12 articles. The important variables in the analysis are: (1) author, (2) article title, (3) year of publication (see table 1), (4) journal name and journal category, (5) type of research (quantitative, qualitative, mixed methods, or development), (6) place of research, (7) level of education of research participants, (8) integrated model / method, (9) CT instruments and dimensions used, (10) projects used in research, (11) subjects / topics, (12) the influence of interventions and reasons.

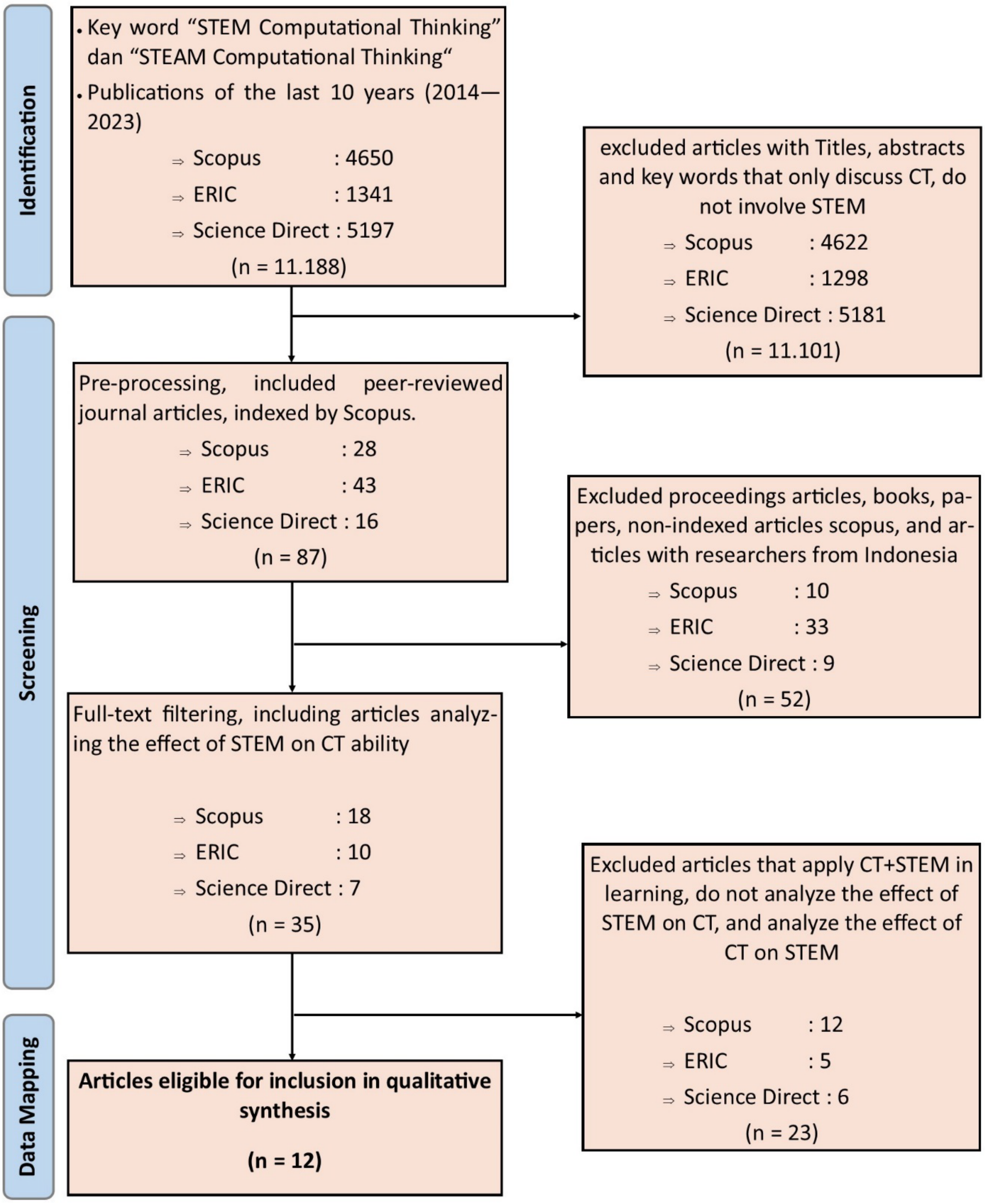

Fig. 1. Flow chart of the search and filtering process of articles worth analyzing.

4. Conclusions

STEM and STEAM activities in learning are considered to be able to influence CT ability. However, CT is considered an ability with infinite dimensions, due to the various developments made in its assessment. This is a gap in the study to see trends in the dimensions of CT assessment, the tendency to use approaches between STEM and STEAM, the tendency of projects used, and learning models that play a role in integrated STEM and STEAM.

Most CT assessments through STEM and STEAM activities in learning are carried out on the dimensions of problem solving, abstraction, algorithmic, critical thinking, creativ, cooperative, and systems thinking, with the instruments used can be computational thinking tests or computational thinking scala. In the goal of implementing

STEM and STEAM to improve CT, almost all interventions are predominantly based on design activities and projects though, integrated with models and methods as diverse as the Time Teaching Program (TTP), ER (Education Robotics), model 6E, game design, Computing Science Teacher Training (CSTT), Engineering Design Process (EDP) model, and Project Based Learning (PjBL). In addition, STEM and STEAM activities as a whole have a positive effect on CT however, the application of STEM and STEAM is preferred because the role of art in technology-related desin is an important factor for beauty.

Author Contributions

The first author contributed with the formulation of ideas, writing, selection, revision and support in this research. The contributions of the second and third were to guide, review and collaborate in writing the discussion. The fourth author helped correct the wording and provided information on the research methods used. The contributions of the fifth and sixth author contributed to the writing and final.

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