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Analysis of Content Validity on Mathematical Computational Thinking Skill Test for Junior High School Student Using Aiken Method

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Abstract

Computational thinking skills are a relevant approach to future problem-solving. Therefore, these skills need to be integrated into mathematics learning in schools. This research is part of developing mathematical computational thinking skill tests for junior high school students. In this segment, the study aims to analyze the content validity of the mathematical computational thinking skill test. The main stages in this research are define, design, and develop. Expert validation data were collected using Google Form sheets. The analysis technique used is the content validity technique with the V Aiken method. The results of the study revealed that the results of content validation through the assessment of 7 experts, developed a test specification containing 20 items that measure mathematical computational thinking skills with a coefficient (V) in the interval (0.770 – 0.920) with an average of 0.866 or very good category. The test instrument is valid for measuring decomposition indicators, pattern recognition, abstraction, algorithmic thinking, and evaluation indicators. Each indicator is measured by 4 items with a coefficient of V decomposition indicator of 0.868, pattern recognition 0.883, abstraction 0.865, algorithmic thinking 0.833, and evaluation 0.883. The study concludes that the indicators of decomposition, pattern recognition, abstraction, algorithmic thinking, and evaluation indicators are valid in measuring mathematical computational thinking skills.

***Keywords**: mathematical computational thinking skill, content validity, Aiken method, research and development*

INTRODUCTION

The rapid rate of technological growth is marked by artificial intelligence (AI) and the internet of things (IoT) as the backbone of the movement and connectivity of humans and machines. The education system has integrated Information and Communication

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Technologies (ICT) in the implementation of learning. According to Suryani (2010), mastery of ICT is very helpful in improving the quality of student learning in schools. The use of ICT in learning helps students become active learners. That is, students will know what information they need, why they need it, and how they can get that information. The utilization of ICT can create dynamic and collaborative learning to increase interactivity and communication. In addition, using ICT can not only support cognitive development but can also increase students' learning motivation.

Integrating education with learning technology in schools supports the improvement of various skills needed to support future generations facing various problems. Computational thinking skills are among the essential skills to be developed in the learning process. According to Denning and Tedre (2019), those computational methods that originated in the history of mathematics are intended to help development, trade, and scientists in various fields. This is because computational thinking involves problem-solving procedures that can be applied to various aspects of life. Integrating computing in various aspects of life provides many benefits and conveniences for humans. At the same time, it brings new challenges for future generations in competing in a globalized world.

Computational thinking is very relevant because it is a means to develop problem-solving skills and students' creativity integrated with technological developments. Computational thinking includes a problem-solving process that involves a collection of cognitive and metacognitive activities using a computational approach (Wei, Chee, Looi, and Sumintono, 2020).

Computational thinking "represents a universally applicable attitude, and skill set for everyone." Computational thinking is not devoted to computer scientists but is a style of thinking that everyone in the computing era needs to learn and so should add to the analytical abilities of every child. Computational thinking methods can provide problem-solving strategies in various fields in the future (Wing, 2006).

Furthermore, Denning stated that computational thinking is a mental orientation to formulate problems as conversion from several inputs to outputs, use mathematics to develop algorithms, perform conversions, abstraction, and check how well a solution can be applied to different problems (Denning, 2009).

From the explanation above, it can be seen the importance of computational thinking skills is mastered by students. However, students' computational thinking ability is still relatively low. The reality in the field shows that computational thinking skills in mathematics learning have not been trained optimally. Research (Kamil, Imami, and Abadi, 2021; Satrio, 2020; Supiarmo, Mardhiyatirrahmah, and Turmudi, 2021) found that abstraction and problem-solving abilities based on algorithms with mathematical rules were still below average. The students' computational thinking has just reached the stage of decomposition and pattern recognition, and students have not been able to use abstractions for the given mathematical problems.

Some experts who have provided operational definitions of various indicators or stages of computational thinking include (Barr and Stephenson, 2011; Csizmadia et al., 2015; Curzon, Dorling, Ng, Selby, and Woollard, 2014; Lee et al., 2011). Previous experts proposed the stages of computational thinking are very varied, and the sequence is also very different. Our research tries to build a distinction with previous research by synthesizing and constructing, as well as restructuring the indicators into five main indicators of computational thinking, namely: (1) Decomposition means the act of solving the system into smaller components so that a complex problem is easier to solve, understand, and large systems are easier to design, (2) Pattern recognition, is to identify patterns, see if a problem has similarities and differences that have been solved, (3) Abstraction is the process of reducing objects by eliminating details into a representation, (4) Algorithmic thinking is to develop a sequence and rule framework of a similar problem repeatedly, and (5) Evaluation is an action to ensure that the solution, either algorithm, system, or process is the right thing.

The reality at school shows that there is no available mathematical computational thinking ability (MTCA) test instrument relevant to mathematics learning materials. Besides, the teacher's ability to design a mathematical computational thinking ability test is still very diverse. Thus, a valid and consistent test instrument is needed to measure computational thinking skills. Therefore, this study aimed to develop a test instrument for mathematical computational thinking skills through an assessment of validity by experts.

METHOD

The method used in this research is research and development (R&D). The development model is a modification of the 4D model of Thiagarajan et al. (Kadir, Fatma, and Rizki Heryani Oktavianti, 2018). The item development procedure is adapted from the research (Kadir and Sappaile, 2019). There are three main stages in developing this test instrument: define, design, and develop. The development of items in the research only reached the develop stage using expert validation.

The item development procedure includes: 1) determining test variables, 2) analyzing and synthesizing theory, 3) developing indicators, 4) determining test objectives, 5) compiling a specification of test instruments, 6) determining the form of the test and the length of the test, 7) writing item questions, 8) perform theoretical validation through expert testing, 9) revise item questions based on expert advice. The development design is presented in Figure 1.

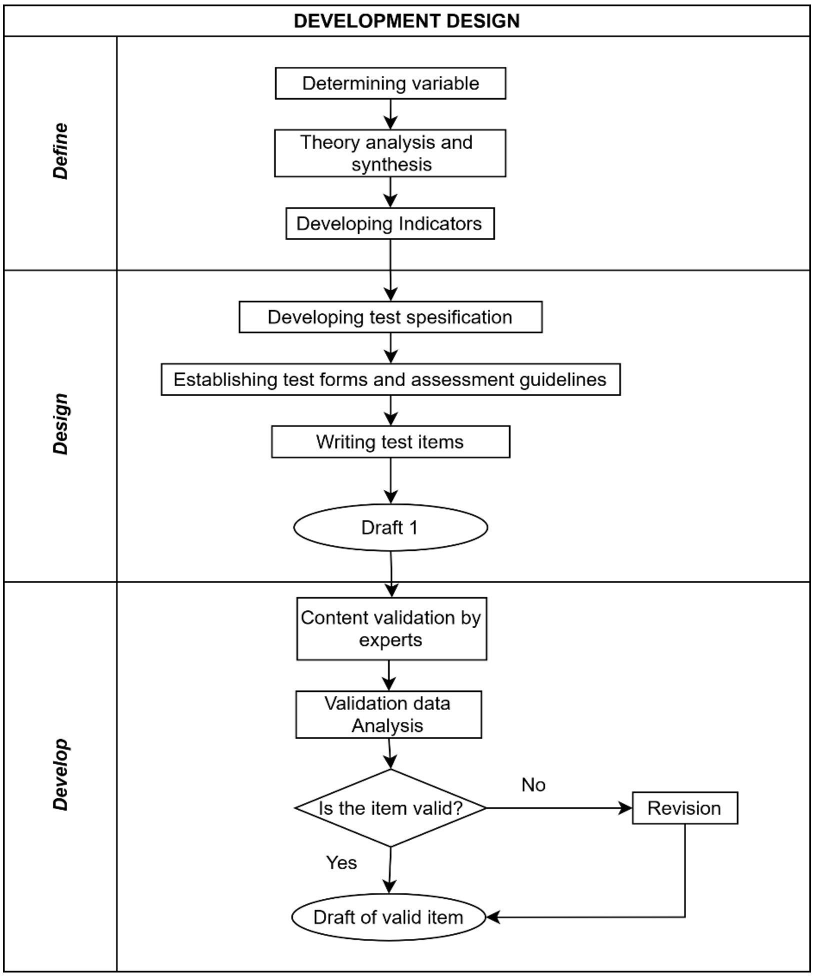


Figure 1. Development Design

The mathematical computational thinking ability test of junior high school students was developed in the form of 20 items of multiple-choice questions. The items were built to measure decomposition indicators, pattern recognition, abstraction, algorithmic thinking, and evaluation indicators. Furthermore, the draft instrument was assessed qualitatively and quantitatively on a scale (1-4) by seven experts, namely five mathematics education lecturers and two junior high school mathematics teachers. Aspects that become material for expert assessment include: 1) the relevance of the item with indicators of mathematical computational thinking ability, 2) clarity of the subject matter, 3) the logic of all answer options, 4) the standardization of the language used, 5) the functioning of the description/picture/table in the item question.

The collection of expert validation data was carried out online using a Google Form sheet due to the covid-19 pandemic. The validation sheet contains a prototype of mathematical computational thinking skills consisting of conceptual and operational definitions, examples of assessments, and multiple-choice question cards. The question card consists of components: competence, indicators, question number, answer key, assessment column, and suggestions column for improvement. The data from the quantitative assessment were then analyzed using the Aiken's V formula, while the suggestions from the experts were analyzed qualitatively to improve the test item. The item is said to be valid if the index value V 0.76 or p-value <0.05.

RESULTS AND DISCUSSION

The research results are presented according to the stages of development of the computational mathematical thinking skill test, which are described as follows.

Define

The analysis and theoretical synthesis results are the basis for constructing a construct in the form of a conceptual and operational definition. The conceptual definition described by the construct is "Mathematical computational thinking skill is a thinking process that involves formulating complex problems into smaller parts so that the solution can be represented as logical patterns, abstractions, and efficient and effective algorithms." Furthermore, the operational definition described from the conceptual definition is "Mathematical computational thinking skill is a thinking process that involves formulating complex problems into smaller parts which are reflected in scores that measure indicators of problem decomposition, pattern recognition, abstraction, algorithmic thinking, and evaluation." A description of each indicator is presented in table 1.

Table 1. Mathematical Computational Thinking Skill (MCTS) Indicator

Indicator	Definition
Decomposition	Decomposition means the act of breaking a system into smaller components. With decomposition, a complex problem can be more easily solved and understood.
Pattern recognition	Pattern recognition is an activity related to identifying patterns, similarities, and connections. It is done by looking at whether a problem has anything in common with the problems that have been resolved and identifying the differences.
Abstraction	Abstraction is the process of reducing an object to its essence so that only the essential elements are represented. Abstraction in computational thinking aims to model relevant aspects of complex problems.
Algorithmic thinking	Algorithmic thinking is the skill of thinking in terms of sequences and rules to solve problems or understand situations.
Evaluation	Evaluation is an action to ensure that the obtained solution, algorithm, system, or process is the right one.

Computational thinking and mathematics are problem-solving methodologies, which involve decomposition to break down problems into smaller steps, designing algorithms, and modeling, namely translating objects into mathematical equations (Liu and Wang, 2010). Based on table 1, there are five indicators used to measure MCTA in this study. The results of defining the MCTA indicators are somewhat different from the results of the Widyatma research, where the MCTA indicators used only include decomposition, pattern recognition, abstraction, and algorithmic thinking (Satrio, 2020). There is also Anita's research on MCTA indicators, namely decomposition, generalization, abstraction, algorithmic thinking, and debugging (Amelia, 2020). Furthermore, Kallia et al. identified three aspects to consider computational thinking in mathematics education, namely problem solving, cognitive processing, and transposition (Kallia, van Borkulo, Drijvers, Barendsen, and Tolboom, 2021).

Design

At the MCTS test's design stage, we compiled problem situation contexts based on indicators and sub-indicators. The context of the problem in this research consists of 4:

Situation 1: Kongres pelajar, Situation 2: Pulau Bahari, Situation 3: Tarsius, and Situation 4: Kotak buah sawo. Each situation context has five questions with different indicators, so the total number of items is 20. The table of MCTS test specifications can be seen in table 2.

Table 2. Mathematical Computational Thinking Skill (MCTS) Test Specification

Indicator	Sub-Indicator	Item
Decomposition	Breaking down data and problems becomes simpler so that they are easy to solve.	1, 6, 11, 16
Pattern recognition	Identify the general pattern of similarities/differences found in the given problem.	2, 7, 12, 17
Abstraction	Finding important objects to create models/representations in solving problems.	3, 8, 13, 18
Algorithmic thinking	Arrange the correct sequence of steps to get a solution to a problem.	4, 9, 14, 19
Evaluation	Analyze errors in the solution and process of solving a problem.	5, 10, 15, 20

A table of specifications is needed to design a test that does not deviate from the core aspect to be measured (Arikunto, 2021). The results of defining MCTA indicators in table 2 reveal five indicators used to measure KBKM. The designed test contains a description of the problem context, where each problem context has five questions with five different indicators. The context in problem-solving is vital as a starting point for students to explore mathematical ideas in familiar situations with their actual experiences (Widjaja, 2013).

Develop

The results of the development of the mathematical computational thinking skill test are shown by content validity based on expert judgment using the Aiken method. The results of the content validity analysis are presented in table 3.

Based on the results of the analysis in table 3, it is found that all items on the MCTA test have a content validity value of ≥ 0.76 ($p < 0.05$), this is in accordance with the criteria proposed by Aiken that if the validity coefficient is 0.76 for the validity assessment with seven raters and four scale means the item is valid (Lewis. R. Aiken, 1985).

Table 3. Results of Content Validity Calculation Analysis with the Aiken Method

Indicator	Item	Validity (V)	*P-value* ($p < 0,05$)	Conclusion
Decomposition	1 (D1)	0,84	0,000	Valid
	6 (D2)	0,87	0,000	Valid
	11 (D3)	0,92	0,000	Valid
	16 (D4)	0,84	0,000	Valid
Pattern recognition	2 (P1)	0,87	0,000	Valid
	7 (P2)	0,89	0,000	Valid
	12 (P3)	0,92	0,000	Valid
	17 (P4)	0,85	0,000	Valid
Abstraction	3 (A1)	0,89	0,000	Valid
	8 (A2)	0,87	0,000	Valid
	13 (A3)	0,85	0,000	Valid
	18 (A4)	0,85	0,000	Valid
Algorithmic thinking	4 (BA1)	0,86	0,000	Valid
	9 (BA2)	0,77	0,002	Valid
	14 (BA3)	0,90	0,000	Valid
	19 (BA4)	0,80	0,000	Valid
Evaluation	5 (E1)	0,87	0,001	Valid
	10 (E2)	0,91	0,000	Valid
	15 (E3)	0,90	0,000	Valid
	20 (E4)	0,85	0,000	Valid

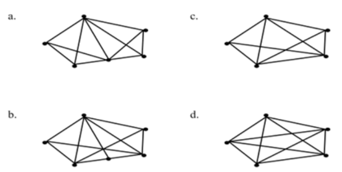
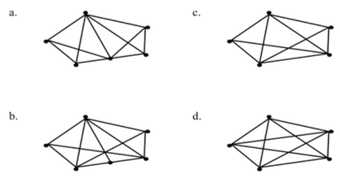
Furthermore, the qualitative assessment results were obtained from experts' advice. The results of the revision of items based on the validator's suggestions for the MCTA test are shown in table 4.

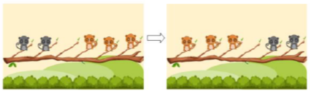
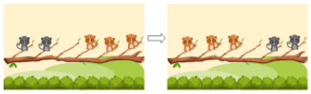
Content validity shows that an instrument can measure certain specific objectives that are parallel to the material or content of the lesson given. The level of content validity of an instrument is assessed by people with expertise in the relevant field. It is necessary to examine the instrument's table of the specification to ensure that the instrument's items already represent all the material that should be mastered proportionally (Zein and Darto, 2012).

Lopez et al. emphasized the importance of using multiple methods to triangulate and validate data. In their research, they collaborated with nine experts to evaluate the content validity of their survey questionnaire on perceptions of computational thinking and art history and obtained an acceptable Aiken V content validity index (Sáez-López, Román-González, and Vázquez-Cano, 2016). Furthermore, Korkmaz et al. developed a computational thinking scale of 29 items to test students' computational thinking skills. They analyzed the construct validity of this scale using exploratory factor analysis, confirmatory factor analysis, and item specificity analysis via independent sample t-tests among students with different performance levels. The study shows that the scale developed is a valid and reliable measuring tool to measure students' computational thinking ability (Korkmaz, Çakir, and Özden, 2017).

An assessment instrument is needed to develop students' computational thinking skills. A good instrument not only aims to measure students' abilities but can also be useful for evaluating and assessing curriculum effectiveness. Therefore, measures that enable educators to assess student learning must be created, tested, and validated (Grover, 2017).

Table 4. Results of Item Revision

Item Number	Revision	Item before revision	Item revision Result
3	Changed the item redaction so students could understand the questions well and changed option (a) to make it more relevant.	**BUTIR SOAL** Susunlah rumusan pola jumlah meja (U_m) dan jumlah kursi (U_k) pada pengaturan tempat duduk kongres pelajar tersebut! a. $U_m = 4m$ $U_k = 2 + 6k$ b. $U_m = 2 + 2m$ $U_k = 8 + 4k$ c. $U_m = 2 + 2m$ $U_k = 4 + 8k$ d. $U_m = 3 + m$ $U_k = 8 + 4k$	**BUTIR SOAL** Jika banyaknya meja adalah U_m dan banyaknya kursi adalah U_k. Model matematis yang menunjukkan pola banyaknya meja dan kursi pada situasi 1 adalah… a. $U_m = 4m$ $U_k = 4 + 8k$ b. $U_m = 2 + 2m$ $U_k = 8 + 4k$ c. $U_m = 2 + 2m$ $U_k = 4 + 8k$ d. $U_m = 3 + m$ $U_k = 8 + 4k$
7	Changed the item redaction and year description on the item to 2022.	**BUTIR SOAL** Jika jumlah pemukiman dan jalan di Pulau Bahari merupakan suatu pola, identifikasilah ilustrasi yang menunjukkan peta pulau bahari pada tahun 2021! *Keterangan: titik = kota, garis = jalan* 	**BUTIR SOAL** Jika titik adalah pemukiman dan garis adalah jalan. Ilustrasi yang menunjukkan pola denah tata kota pulau bahari pada tahun 2022 adalah…. 
10	Changed the item redaction so that questions can be understood well and in accordance with the context of the problem and changed the form of answer choices into one sentence	**BUTIR SOAL** Jika pembangunan pemukiman dan jalan dilakukan secara konsisten, diprediksi pada tahun 2045 akan ada 9 pemukiman nelayan dan 27 jalan penghubung di Pulau bahari. Apakah Anda setuju dengan prediksi tersebut? Jika tidak, tentukan berapa jumlah pemukiman dan jalan penghubung yang seharusnya! (Pemukiman / Jalan) a. Ya, terdapat 9 pemukiman nelayan. / Ya, terdapat 27 jalan penghubung. b. Tidak, seharusnya terdapat 8 pemukiman nelayan. / Tidak, seharusnya terdapat 28 jalan penghubung. c. Tidak, seharusnya terdapat 10 pemukiman nelayan. / Tidak, seharusnya terdapat 30 jalan penghubung. d. Tidak, seharusnya terdapat 10 pemukiman nelayan. / Tidak, seharusnya terdapat 36 jalan penghubung.	**BUTIR SOAL** Jika pembangunan pemukiman dan jalan dilakukan secara konsisten, diprediksi pada tahun 2045 akan ada 9 pemukiman dan 27 jalan penghubung di Pulau bahari. Apakah Anda setuju dengan prediksi tersebut? Tentukan berapa jumlah pemukiman dan jalan penghubung yang seharusnya! a. Ya, terdapat 9 pemukiman dan 27 jalan penghubung. b. Tidak, seharusnya terdapat 8 pemukiman dan 28 jalan penghubung. c. Tidak, seharusnya terdapat 10 pemukiman dan 30 jalan penghubung. d. Tidak, seharusnya terdapat 10 pemukiman dan 36 jalan penghubung.

Item Number	Revision	Item before revision	Item revision Result
14	Changed the item redaction so that students could more easily understand the questions.	**BUTIR SOAL** Fitri membuat suatu kode untuk memudahkan penulisan langkah atau lompatan yang tarsius lakukan. Kode **C**: tarsius cokelat melompati tarsius lain ke batang pohon yang kosong. Kode **H**: tarsius hitam melompati tarsius lain ke batang pohon yang kosong. Kode **c**: tarsius cokelat melangkah ke kiri. Kode **h**: tarsius hitam melangkah ke kanan. Jika di pohon lain terdapat kelompok tarsius dengan jumlah yang berbeda. Selidikilah kode yang Fitri harus tulis untuk menukar tempat sehingga dua tarsius hitam berada di batang pohon bagian kanan dan tiga tarsius cokelat berada di batang pohon bagian kiri!  a. h – C – c – h – H – c – C – h – h – C – h b. h – C – c – H – H – c – C – C – h – H – c c. h – C – c – H – c – C – C – H – h – c – h d. h – C – c – H – H – C – c – C – h – c – h	**BUTIR SOAL** Fitri membuat suatu kode untuk memudahkan penulisan langkah atau lompatan yang tarsius lakukan. Kode **C**: tarsius cokelat melompati tarsius lain ke batang pohon yang kosong. Kode **H**: tarsius hitam melompati tarsius lain ke batang pohon yang kosong. Kode **c**: tarsius cokelat melangkah ke kiri. Kode **h**: tarsius hitam melangkah ke kanan. Jika di pohon lain terdapat kelompok tarsius dengan jumlah yang berbeda. Selidikilah kode yang Fitri harus tulis untuk menukar tempat sehingga dua tarsius hitam berada di batang pohon bagian kanan dan tiga tarsius cokelat berada di batang pohon bagian kiri!  a. h – C – c – h – H – c – C – h – h – C – h b. h – C – c – H – H – c – C – C – h – H – c c. h – C – c – H – c – C – C – H – h – c – h d. h – C – c – H – H – C – c – C – h – c – h
20	Changed the item redaction and the main questions on the questions to match the indicators to be measured, namely the evaluation indicators.	**BUTIR SOAL** Agus menunjukkan tabel dan ilustrasi situasi 4 kepada teman-temannya. Ia menanyakan prediksi waktu semua sawo dalam kotak akan membusuk. **Bima** berpendapat, *"semua sawo dalam kotak akan busuk setelah minggu ke-tujuh."* **Fikri** berpendapat, *"semua sawo dalam kotak akan busuk setelah minggu ke-sembilan."* Tentukan pendapat siapa yang tepat terkait waktu yang dibutuhkan untuk semua sawo di kotak menjadi busuk! a. Pendapat Bima. b. Pendapat Fikri. c. Tidak keduanya, karena waktu yang tepat adalah setelah minggu ke-delapan. d. Tidak keduanya, karena waktu yang tepat adalah setelah minggu ke-sepuluh.	**BUTIR SOAL** Agus menunjukkan masalah pada situasi 4 dan menanyakan kepada Bima prediksi waktu semua sawo dalam kotak akan membusuk. **Bima** berpendapat, *"Semua sawo dalam kotak akan busuk setelah minggu ke-tujuh."* Apakah prediksi Bima terkait waktu yang dibutuhkan untuk semua sawo di kotak menjadi busuk bernilai benar? a. Ya, prediksi Bima bernilai benar. b. Tidak, karena waktu yang tepat adalah setelah minggu ke-delapan. c. Tidak, karena waktu yang tepat adalah setelah minggu ke-sembilan. d. Tidak, karena waktu yang tepat adalah setelah minggu ke-sepuluh.

CONCLUSION

This research resulted in a product, namely a mathematical computational thinking skill test for junior high school students, which was developed using a 3-D development model with the stages of defining, designing, and developing. The mathematical computational thinking skill that has been developed theoretically has a relatively good quality (0.76) with a V-Aiken index > (0.77-0.92). The test instrument is valid for measuring decomposition indicators with a V coefficient of 0.868, pattern recognition of 0.883, abstraction of 0.865, algorithm thinking of 0.833, and evaluation of 0.883. This research concludes that the developed mathematical computational thinking skill test meets the criteria for content validity. This study is an important issue to support digital literacy in the future. Therefore, it is recommended that a mathematical computational thinking skill test instrument be developed on more diverse mathematics materials and other levels of education.

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