Ensuring CT With Three-Dimentional Integrated Assessment

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Abstract. Computational Thinking (CT) is one of the fundamental abilities in the 21st century, while assessment is one of the most important activities in the learning process. Unfortunately, until now there are still a few assessment instruments that ensuring student CT capability, particularly for elementary grade. Based on several previous studies, we conclude the most effective way to design assessments for CT is by Three-Dimensional Integrated Assessment (TDIA) framework. TDIA has two objectives, that is integration between 3 important components in the assessment (direct, open, and process based) and 4 components of CT, that consist of abstraction, decomposition, pattern recognition, and algorithm. The research is done by Development Research. We hope the results will show types of assessment instrument which are expected to accurately measure student CT skills. In addition, also increase CT recognition as knowledge and skills that must be possessed by Science, Technology, Engineering, and Mathematics educators and practitioners.

Keywords: Computational Thinking, Assessment, TDIA

INTRODUCTION ~ The end of millennial era mark by one of most recognize human advancement known as industrial revolution 4.0, that digitalizing many sectors of human life. As a scholar, we must immediately adapt to ensure our student have quality needed in this era. There are many education experts demand that school culture must be change from just memorizing to analyzing. The 4C of 21 Century widely recognize as top skills currently needed in the workplace (Chiasson, 2017). This is where the Computational Thinking (CT) come upfront.

CT was a development from Computer Literacy that started by diSessa (2000) research. While Barr (2011), state that CT is an approach to solving problems in a way that can be implemented with a computer. Another definition of CT according to Royal Society (2012) is the process of recognizing aspects of computation in the world that surrounds us. According to Grover (2013), computational thinking involves solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science.

The pioneer of CT, Wing (2006) state that computational thinking is reformulating a seemingly difficult problem into one we know how to solve, perhaps by reduction, embedding, transformation, or simulation". On her further research, Wing (2011) state, "Computational thinking is the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent".

CT is one of Analytical Thinking (AT) types. It shares similar characteristic as approach to solve a problem with other AT, namely, engineering thinking, scientific thinking, and mathematical thinking. As state by Lee (2011), CT shares elements with mathematical, engineering, and even design thinking, and draws on a rich legacy of related frameworks, it also extends each of those thinking skills in a unique way. The computing paradigm contains echoes of engineering, science, and mathematics, it is distinctively different because of its central focus on information processes (Denning, 2009). The difference is CT mostly done by abstraction so it can be used everywhere and by everyone (Wings, 2008). This process not only prepares students in the field of computer science but also provides students with tools and skills to approach and solve a wide range of problems in different areas of knowledge (Werner, 2012).

CT in short is thinking like computer scientist. CT is a way of approaching everyday situations and solving problems by utilizing concepts that are fundamental to computer science (Flórez, 2017). As a computer scientist, you need to solve the problem logically by using algorithmic also using computing tools to quickly create modeling and data visualization. Information and communication technology (ICT) had 5 informatics pillars that consist of computer engineering, network, data analysis, algorithm and programming, social of computing. The foundation of those 5 pillars are computational thinking (Liem, 2018), as illustrated on figure 1.

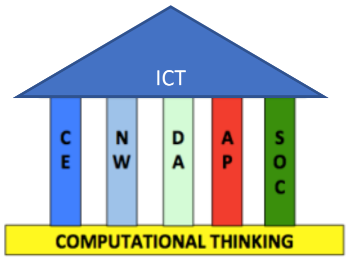

Figure 1. ICT, Informatics, & CT Correlations

CT capability in today's digital age becomes a must-have for learners, considering that life in this era will be heavily influenced by computing, and many will work in areas involving or influenced by computing. Wings (2006) also state "to reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability". Therefore, we conclude that children around 4-9 age are well worth subjected into CT.

Many countries recognize CT as one of the fundamental abilities in the 21st century and embedded into education curriculum core (Edsurge, 2008). Event Singapore has branded CT as the "national ability". At 2018, Indonesia also response this by introducing informatica into core curriculum since elementary grade.

However, based on preliminary investigation, there are 2 noteworthy problem that can hampering student CT capability.

Firstly, in our interview, many still think that CT limited into coding, must have computer, and cannot be applied for children. So, in our previous research, we solidify CT perception to clear this big misconception. Second, there are few evaluation instruments that can assess CT accurately. At second problem, we foresaw 2 challenge to create CT-based assessment instrument, that is, evaluation of problem-solving abilities and measuring the computing capabilities of learners who do not have a foundation informatics skill.

We studied many approaches to construct reliable instrument to measure student CT capacity. Schwarz et al. (2009) use variation of method get learning outcome by using pre-test & post-test with scientific modelling. Brennan (2012) uses 3-Dimensional, first approach with portfolio projects, second with artifact-based interview, and third, with design scenario. Based on these previous studies, assessment instruments for measuring CT capability must have elements (1) Troubleshooting task, (2) Semi-finished project, and (3) CT capability cannot be measured only by summative evaluation. We conclude that the Three-Dimensional Integrated Assessment (TDIA) is the most suitable framework.

TDIA has two objectives, namely integration between 3 important components in the assessment (direct, open, and process based) and 3 components of CT, namely the concepts of computing, practice, and perspective.

We follow up one of conclusion from Zhong (2015) research that a single task was inadequate, we suggested that a combination of tasks could be more appropriate in the educational practice". Therefore, we construct 3 pair of instruments consist of with 6 different tasks. In addition, we collaborate with bebras organization experts for CT material, and finally, to successfully integrated CT into classroom, we also must consider the level of motivation, interest and enthusiasm of learners (Yadav, 2011). We hope, the research results can increase CT recognition as the fundamental 21 Century skills, and provide ground framework of instructional design to measure student CT capability as an educator response to face digital era, particularly in Indonesia.

METHOD

Product development is done by Development Research Method with Akker (1999) procedure scheme. It consists of 4 phases, which are, (1) Preliminary Investigation, (2) Theoretical Embedding, (3) Empirical Testing, and (4) Documentation, analysis, and reflection on process and outcomes. On Phase 3 (Empirical Testing), we conduct formative evaluation for assessment instrument (figure 2). To construct instrument, we used the infamous Dick & Carrey (2001) method.

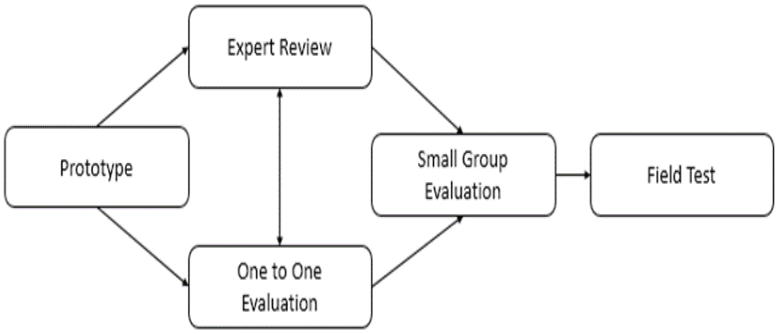

Figure 2. Formative Evaluation

Research site and subject

Research site are Purwakarta District, West Java Province, Indonesia. Research subject for small group evaluation are 8 (4 Male, 4 Female) student of Lab school Kampus Purwakarta grade 6, while for field test are 40 (18 Male, 22 Female) participant.

RESULTS

Based on TDIA principle, we construct 3 pair of instruments that have an element of directionally, openness, and process. Each pair consist of 2 tasks, pair 1 are the closed forward tasks and closed reverse tasks (Task 1 & 2), Pair 2 are semi-open forward tasks and semi-open reverse tasks (task 3 & 4), and Pair 3 are open task with and without process report (task 5 &6). Each task has varied CT elements and was validated by informatics and assessment experts, as seen in table 1.

Small Group Evaluation

The result of Small Group Evaluation (SGE) shown at table 2, 3, & 4. We note there are slightly different score between forward task and reverse task, but it not significant enough to determine which one of this instrument types that most effective to ensure CT. In the other hand, there are significant differences between closed task, semi-open task, dan open task. Closed task scored higher than other types and open task has higher score than semi-open task. Lastly, task 5 scored higher than task 6 and positively correlated.

1) Field Test

At this point, the field stage is still on progress. We currently await data results from this stage to elaborate further findings.

Table 1. Instrument Validation

Task Types	Task Number	Informatics Elements	CVR	Interpretation
Closed Forward	1	Network	0.71	Pass
Closed Reverse	2	Network	0.57	Pass
Semi-open Forward	3	Algorithm & Programming	0.86	Pass
Semi-open Reverse	4	Algorithm & Programming	0.86	Pass
Open with process	5	Computer system	1.00	Pass
Open without process	6	Computer system	0.57	Pass

Table 2. Direct Dimension SGE Results

Pair		N	Mean	SD	T	Sig
Pair 1	Task 1	8	3.91	1.793	-1.102	0.281
	Task 3	8	4.02	1.783		
Pair 2	Task 2	8	3.01	2.106	-0.221	0.824
	Task 4	8	2.92	1.987		

Table 3. Openness Dimension SGE Results

Groups		N	Mean	SD	T	Sig
G 1	Task 1	8	3.91	1.793	7.185	0.001
	Task 4	8	2.92	1.783		
G 2	Task 1	8	3.91	2.106	2.384	0.011
	Task 5&6	8	3.52	0.787		
G 4	Task 4	8	2.92	1.783	-6.678	0.000
	Task 5&6	8	3.52	0.787		

Table 4. Process Dimension SGE Results

Pair		N	Mean	SD	T	Sig
Pair 3	Task 5	8	3.11	2.793	-1.702	0.081
	Task 6	8	3.00	2.883		

DISCUSSION

Result show that closed task has the highest score than any other task. This possess same trait from Hikmawan (2019) findings. The closed task shows the higher score than any other task because it causes little pressure for the participant to solve the problem.

Researcher commonly believe that reverse task is most effective approach for CT assessment, but the result shown there are no significance different between reverse and forward task. It may be just a preconception and bias in researchers (Zhong, 2015).

For the openness dimension in task 5 and 6, the result shown that it was positively correlated. Which is mean that process report element may possibly provide technical support for participant. The students' thoughts in the process of finishing tasks could help teachers find students' thinking barriers especial in the computational practices.

CONCLUSION

Result from SGE stage mainly use to revise instrument to increase the ease-of-use aspect. We can only conclude after we finish analyze data from the field stage which are currently on progress. However, early findings show promises that our hypothesis are correct.

Just 1 type of task are not enough to ensure student CT capability. For example, the closed task is most easy to construct and also easy to finish. They were easy to carry out in practices but we stressed that it can be accurately enough to conclude that student have good CT. It must be followed up by task that demand student to do abstraction, decomposition, pattern recognize, and made an algorithm to solve problem, which based on our findings, it can be provide by open task with process report

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