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Exercising the Students Computational Thinking Ability using Bebras Challenge

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Abstract. In this paper, we present our observation regarding the student's computational thinking skill in the region of Sumatera Utara, Indonesia. The observation is based on the result of Bebras Indonesia 2019, a computer-based countrywide test on computational thinking aimed at students in primary school, middle school, and high school. We collected the data in a specific targeted region (the province of Sumatera Utara), collects additional data from the participant's school, and analyse the data. Our objective is to find a pattern between the schools' approach, if any, regarding topics related to computation thinking to the ability of students to actually solve the problem based on their score in the test.

1. Introduction

Computational thinking (CT) is the ability to solve a problem by using abstraction and automation. Such skill is considered necessary to prepare students to embrace the digital age. The ability to think and express a task in a manner to be executable by digital agent is important for modern students. However, depending on the country, the implementation of CT education in primary and secondary education level is still undeveloped. There are various factors that contributed to this condition such as curriculum availability, school's capability to provide necessary tools, and teachers knowledge on CT and their ability to perform education on the subject. Moreover, limited internet access in most high school in Indonesia, although may introduce a new problem [1], may support the introduction of CT to the students.

In Indonesia, education in CT has not yet been widely implemented. Current nation-wide curriculum published by the minister of education and culture does not contain any course on computer education. However, schools are allowed to perform their own computer-related education either as part of the curriculum or as an after-class activity. Acknowledging this condition as a problem for computer education, some practitioner in computer study in University decided to hold Bebras Challenge in Indonesia. The idea of this project is not only to measure the ability of students to think computationally, but also to promote the concept of computational thinking in Indonesia. The project has been running since 2016 and has been established as an annual event.

As part of the organizer, we took this opportunity to use this event to observe the development of computational skill in our region. We use the test result from Bebras Challenge 2019, observe the participating schools, and try to find the relation between school's approach in computer education and the ability of their students to perform computational thinking. Our objective is to have a thorough knowledge regarding the state of computational thinking in our region and to have a rough recommendation to collaborating schools/institution to develop their own CT education.



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2. CT in Primary and Secondary Education Level

The idea of implementing CT in early phase of education has been an issue. Integrating computational thinking into primary and secondary education curriculum has met a few challenges. One major issue in introducing CT in primary education is to how to implement CT skills such as algorithmic thinking into existing pedagogies [2]. However, there are a few studies that successfully attempted to introduce a curriculum that include study on CT or infuse the concept into existing courses in primary and secondary education [3]–[5]. Nevertheless, these studies were experimental and have yet to be implemented universally. Aside from the curriculum, the inability of most teachers to define the concept of computational thinking correctly also contributes to the lack of CT education in primary school. Some studies performed a survey regarding this matter and found out that some teachers were incapable to define CT skills accurately [6], [7]. Additionally, these surveys also show that due to the lack of knowledge of CT, teachers and schools do not have a proper resource to perform education on CT.

There are several studies focused on finding a solution to overcome these issues. Some studies introduced and evaluated new and innovative methods to perform education in computational thinking. Alegre et al. developed a method to introduce computational thinking through programming course [5]. Students were introduced to basic programming with a simplified variant of Haskell using CodeWorld [8]. The study uses a highly modified programming curriculum that focuses on teaching computational thinking and not the programming itself. Based on result from 325 students, the study concluded that this method can be performed in CT education. There are also other approaches that tried to introduce CT in the form of games. Apostolellis et al. developed a board game named RaBiT EscAPE intended to challenge children from age 6-10 to perform a problem-solving ability by playing the game [9]. Repenning et al. developed AgentCubes Online, a 3D based application that allows users to modeling and programming in 3D [10]. The motivation of this study is based on the popularity game Minecraft which increase the familiarity of student to navigate through a virtual 3D world. Malizia et al. developed TAPASPlay, a virtual reality turn-based games where the players combine swords and shield to fight each other [11]. Combining an effective formula, however, requires player to perform design-debug-run stages by analyzing the outcome of the battle. Morisson et al. developed Computational Thinking Bins, a box that contains a set of activity related to computational thinking for middle and high school (secondary) students [12]. Additionally, various toys and technology companies have also developed products to support the study of computational thinking such as Lego Mindstorm [13], App Inventor [14], and SCRATCH [15]. Most of these tools are already available in the market and has been used by several educational institution.

3. CT in Sumatera Utara

In this paper, we present the result of our observation on the state of CT education in our region, Sumatera Utara, Indonesia. The study is based on the result of Bebras Challenge 2019 in this region. We have collected the result of 98 participating students from 10 schools throughout the region. Additionally, we also performed an interview with the teachers from participating schools regarding the availability of CT education in their institution. Due to confidentiality issues, we will not use the real identity of the students nor the schools.

3.1. Bebras Challenge 2019

Bebras Challenge 2019 is a worldwide event that invites student from primary and secondary levels. In Indonesia, the event is held by Bebras Indonesia [16] and the test is organized by local Bebras committee cooperating with participating Universities. The latest challenge was held on 11th - 15th of November 2019. There were 6673 students participated in this event: 1384 from elementary school, 2826 from junior high school, and 2463 from high school. The Bebras Challenge will be performed using a computer-based test. For junior high school and high school, the test consist of 15 question and the test duration is 45 minutes. The type of the question is varied based on the problems it represents.

In Sumatera Utara, there are two regional organizers involved in the event: Bebras Biro USU and Bebras Biro ITDel. In this paper, we only collected the data from Bebras Biro USU which consist of 53 students from 4 junior high schools and 44 students from 5 high schools. Table 1 below shows the overall information based on the result from Bebras Biro USU. Additionally, we compare the result with the data from all regional in Indonesia.

Table 1. Overall Data of Bebras Challenge 2019.

	Junior High School		High School	
	All Region	Sumatera Utara	All Region	Sumatera Utara
Mean	30.89	35.13	26.91	28.51
Standard Deviation	22.18	27.02	19.67	20.13
Highest Score	100	100	100	85
Lowest Score	0	0	0	1.67

3.2. Junior High School

The table below shows the data from high school level.

High School ID	Quantity	Highest Rank (Reg/All)	Lowest Rank (Reg/All)	Min. Score	Max. Score	Average (Total)	Standard Deviation	Average (Top 3)
JS1	5	1	6	68,89	100	88,11	11,75	95
JS2	19	5	46	8,06	78,89	43,96	20,19	68,51
JS3	8	7	42	9,72	65	34,13	22,14	59,16
JS4	21	20	53	0	40,56	14,92	11,72	33,33

Based on the result, JS1 has the highest scores amongst other school. In fact, 4 of the students from JS1 managed to get the top 4 of the regional rank. Based on our interview with the teacher, students from JS1 are in fact have basic knowledge on programming. There is no course on computer in their curriculum, however, there are an extracurricular on computer which include computer programming introduction. Moreover, the score is added into student's performance report. The rest of the schools do not have similar approach. There is an after-school student activity focus on the use of computer software but there is no course on computer programming.

3.3. High School

The table below shows the data from high school level.

Table 2. Data Based on Origin.

High School ID	Quantity	Highest Rank (Reg/All)	Lowest Rank (Reg/All)	Min. Score	Max. Score	Average (Total)	Standard Deviation	Average (Top 3)
HS1	5	1	16	33,33	85	52,66	19,70	65
HS2	7	2	28	18,33	70	37,62	18,53	57,22
HS3	16	3	43	8,33	68,33	32,70	19,31	21,66
HS4	8	17	47	1,67	60,71	11,45	9,37	21,66
HS5	8	18	38	11,67	31,67	20,41	7,15	28,89
HS6	3	32	45	1,67	16,67	11,67	7,07	11,67

Based on the data above, it is obvious that HS1, HS2, and HS3 are the top 3 of the 6 schools participated in the challenge. Based on our observation, students from HS1 and HS2 have programming knowledge compared to the others. Computer programming is one of the subjects taught in the

classroom. HS3 also have computer related course as part of their curriculum. This course focuses on the use basic computer knowledge and utilization (hardware, software, internet, and office) instead of computer programming.

The other 3 high schools do not have a course in computer technology. However, there is a computer club extracurricular that focus on the use of computer. This club is managed and organized by students and does not have a regulated curriculum by the school (although teacher's supervision is present).

4. Conclusion

In this paper, we investigated the relation between school's activity and the result of their students in Bebras Challenge 2019. Based on our study, we can conclude there is an evidence that students with computer programming experience have an advantage in performing computational thinking. In fact, the two schools that perform computer programming as part of their curriculum were able to have their students on the top of the test ranking list. There are also evidence that basic knowledge of using computer may contribute to the score. Students from schools that have a consistent after-class activity on information technology were able to perform better at the challenge.

While we believe that the evidence is strong enough to support our theory, there are a lot of other factor that we have yet to observe in our research such as academic performance and personal backgrounds (hobby, experience). Moreover, some students may suffer from lack of computer-based test experience, which is, based previous study [17], may affect significantly with their performance in the test. Yet, this work can be used as evidence that applying computer course as one of the subjects in school may affect student's computational skill. As the organizer of Bebras Challenge in Sumatera Utara, we are consistently educating the teacher regarding the concept of computational thinking. Currently, the team are currently collaborating with the teacher and local ministry of education to develop a curriculum on computer and information technology in classroom.

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