EXPLORING STUDENTS' METACOGNITIVE REGULATION SKILLS AND MATHEMATICS ACHIEVEMENT IN IMPLEMENTATION OF 21ST CENTURY LEARNING IN MALAYSIA

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Abstract

21st-century learning is integral to the transformation of the curriculum in Malaysia with the transition from School Integrated Curriculum (SIC) to School Standard Curriculum (SSC) introduced around 2014. During this time, the implementation of 21st-century learning was acceptable and very rewarding. However, the impact of implementation on students' skills, abilities, potentials and achievements should be looked at to ensure that the new curriculum is stable and practical to continue. There is a need to discuss the level of metacognitive regulation skills and students' achievement in line with the introduction and implementation of 21st-century learning in the context of the Malaysian curriculum. Therefore, this research was conducted to examine whether the implementation of 21st-century learning has an impact on metacognitive regulation skills and student achievement. This quantitative survey was conducted by 201 Form 2 students from four secondary schools in Pasir Gudang District, Johor, Malaysia. The results show that the level of students' metacognitive regulation skills and the level of achievement in mathematics is moderate. Correlation analysis also showed there was a significant correlation between metacognitive regulation skills and student achievement. The implications from this research suggest that stakeholders including ministries, curriculum developers, education departments and teachers need to take initiatives to strengthen and improve the reputation of curriculum transformation in line with the 21st-century learning era in producing quality education.
Keywords: *curriculum transformation, mathematics learning, metacognitive regulation skills, students' achievement, 21st-century learning.*

Introduction

The Malaysia National Education Blueprint, (MNEB 2013-2025) has been introduced with six key milestones and 11 moves that are seen as underpinning the reform of the education curriculum in Malaysia (MOE, 2013; Jamil et al., 2017). The industrial revolution 4.0 has brought about changes in the education system. The goal of education is to transform individuals who can compete globally with mental strength and knowledge (Philippe, 2018; Tamuri & Hussin, 2017; Warner & Kaur, 2017). Curriculum reform is required as recent developments in the global education system coincide with current educational technology developments (Philippe, 2018). Thus, the application and integration of technology are at the heart of the changes in the curriculum in Malaysia (Ibharim et al., 2015). Additionally, exposure to 21st-century skills as a whole is focusing on student success as human capital is also a key element of the new curriculum content (MOE, 2013, 2016).

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The beginning of this curriculum change is the implementation of the School Standard Curriculum (SSC), replacing the School Integrated Curriculum (SIC), introduced around 2014 (Salehudin et al., 2015; MNEB, MOE, 2013). The challenge to the education system especially in schools is the level of teacher and student readiness, and even the physicality of a school also needs to be revisited to provide a more conducive learning environment (Ibharim et al., 2015; Hassan, 2019). Further, to address this challenge, the 21st-century learning concept was introduced as a follow-up to the curriculum change (Salehudin et al., 2015). 21st Century learning has become the medium of implementation and testing of the success of the new curriculum introduced. Communication, collaborative, critical and creative thinking skills are crucial to teaching and learning (Salehudin et al., 2015; Yunos, 2015; Johnson & Hoyte, 2015) and were seen to generate competitive students through 21st-century learning (Ismail, 2018; Arbaa et al., 2017; Zain et al., 2015). Much research has been carried out during the introduction and implementation of the 21st-century learning either in the context of implementation in Malaysia or beyond to serve as a backup, guide and also for improvement. In Malaysia, researchers such as Vinathan (2016), Tamuri and Hussin (2017), Arbaa et al. (2017), Salehudin et al. (2015), Jamil et al (2017), Ibharim et al. (2015) and Zain et al. (2015), have conducted studies on the needs, challenges and 21st-century skills as a catalyst in implementing 21st-century learning. The results show that 21st-century learning is very important in bringing about curriculum reform, especially teaching and learning approaches. Specifically, 21st-century learning has changed the learning environment in schools. Motivation, attitude, student readiness and learning environment improved and changed for the better and positive, compared to traditional practices reported in the study by Yunos (2015), Ismail and Ahmad (2017) and Iberahim et al. (2017). In addition, the importance of 21st-century learning is also reflected in student achievement compared to traditional learning. This result was reported in a study in Malaysia by Ibharim et al. (2015), Zohedi et al. (2017), Ngasiman (2014), Iberahim et al. (2017) and beyond by Hossain and Tarmizi (2013), Warner and Kaur (2017) and Johnson and Hoyte (2015), which shows that student achievement is increasing in line with 21st-century learning practices, using specific approaches such as cooperative learning, technology or ICT integration as well as modules and learning models that developed by the researcher himself.

Review of Relation between Metacognitive Regulation Skills and Mathematics Learning in 21st Century Learning Era

In mathematics education, the challenge of 21st-century learning is not only from a new curriculum point but also to the wide and holistic improvement up to the mathematical value and attitude of students (MOE, 2016). Focus is on developing people who are mathematically literate through the application of four essential elements namely learning, values, skills and mathematical processes. However, mathematics achievement and student math skills are still modest (Ibrahim & Iksan, 2017). According to Menz and Cindy Xin (2016), students' mastery and mathematics skills are related to students' metacognitive skills. Levels of achievement in mathematics will be high if metacognitive skills are high (Fazal Ahmad et al., 2010). Metacognitive was first introduced by Flavell (1978) as reported in Papaleontiou-Louca (2008) and Schraw and Moshman (1995), which is the individual's ability to aware, perceive, take action, monitor the thinking process and behavior of thinking activities, especially in learning.

Metacognitive skills are actions, behaviors and exercises that include components such as awareness (knowledge), experience and regulation of cognition (Nelson and Narens, 1990; Papaleontiou-Louca, 2008; Schraw and Moshman, 1995). According to Tarricone (2011), metacognitive skills have their rankings with metacognitive regulation at a high level and are a secondary cluster. According to Hasbullah (2015), Cera et al. (2013) and Do Toit and Do Toit

(2013), in mathematics learning, metacognitive regulation functions are as a layout of actions and thinking processes during learning especially when students complete mathematics tasks. There are three subcomponents in metacognitive regulation, namely, planning, monitoring and evaluation (Panaoura et al. 2009; Tarricone, 2011). Planning begins when students set learning goals, answering the learning questions for what and what resources to learn. Management including predicting before learning, defining strategies, and allocating time required for each task is also included in the planning subcomponent (Papaleontiou-Louca, 2008; Schraw and Moshman, 1995). According to Nelson and Narens (1990), monitoring is the action or activity that ensures learning performance and current level of understanding, the latest findings of what is being learned based on the tasks being performed. Assessment is the final process of the individual assessing the outcome and level of achievement in the learning as well as the effectiveness of the learning, and whether the pre-selected learning strategies are in line with the content (Hasbullah, 2015; Amin & Sukestiyarno, 2015; Smith & Mancy, 2018).

Mathematical learning is an abstract process in understanding the concepts, diagrams, patterns and layouts of steps in solving problems based on specific formulas (Crish, 2015). According to Su et al. (2016) and Tzohar-Rozen and Kramarski (2014), this process is related and highly dependent on one's thinking skills. There are specific procedures or steps for solving mathematics problems that need to be followed (Ahmad et al., 2018; Tony Karnain et al., 2014). Based on the Polya Model reported by Moos and Ringdal (2012), Loh (2016), Van Der Stel et al. (2010) and Zakiah (2017), the steps include, knowing the source of the problem (mathematical concepts), designing solution strategies, operating to solve problems and evaluate actions. These measures will test one's thinking (Su et al., 2016). Based on aspects such as knowing, planning, operating and evaluating, it appears that these steps are related to the practice of metacognitive regulation skills. It can be concluded that mathematics learning is significant with metacognitive regulation skills. Previous studies have reported that metacognitive regulation skills are significant in influencing conceptualization, mathematical problem-solving skills, thinking skills, and student learning performance (Abdullah et al., 2017; Ahmad et al., 2018; Daher et al., 2018; Du Toit & Kotze, 2009; Kazemi et al., 2010; Legg & Locker, 2009; Leidinger & Perels, 2012; Menz & Cindy Xin, 2016; Nongtodu & Bhutia, 2017; Pantiwati & Husamah, 2017; Shaw, 2008; Stephanou & Mpiontini, 2017; Su et al., 2016; Van der Stel et al., 2010).

Teacher teaching practices play a role in improving students' metacognitive regulation skills. Thus, the selection of strategies, methods and approaches for learning by teachers should be in line with students' metacognitive regulation skills (Ibrahim & Iksan, 2017; Adnan & Arsad, 2018). In line with the exposure and implementation of 21st-century learning that emphasizes the learning environment, the learning approach should be more focused on the development of students' metacognitive regulation skills. This is because, with the presence and integration of various learning mediums such as technology, internet of things, web-based and mobile apps, these regulation skills are easier to develop because the medium is very important in attracting students' passion, attitudes, motivation and readiness to engage in each learning activities (Yunos, 2015). Learning practices based on metacognitive strategies have a new touch with the implementation of 21st-century learning. Studies by several researchers such as Listiani et al. (2014), Smith and Mancy (2018), Suriyon et al. (2013) and Hasbullah (2015), have shown that practice or learning activities based on metacognitive strategies greatly influence mathematical learning and achievement of students by applying some of the approaches introduced under the implementation of 21st-century learning.

Research Problem

The credibility and success of 21st-century learning in producing mathematical scholars requires special studies to be documented as evidence. According to NCTM (2000), Chris (2015), Abdullah et al. (2017), Philippe (2018), and Palmer and Johannson (2018), the success of curriculum and mathematics education is when, students can solve problem-solving on a regular or non-routine question, applying concepts and building relationships among them, selecting appropriate mathematical methods, applying and following the process of reasoning and then apply mathematical knowledge in the areas of discussion, counting and can also apply mathematical skills to higher-order thinking skills, HOTS's tasks. Besides, students should be able to demonstrate their creative and critical thinking skills at a high level (Philippe, 2018; Su et al. 2016). According to Nongtodu and Bhutia (2017) and Menz and Cindy Xin (2016), mathematics problem solving and thinking skills are directly related to aspects of students' metacognitive skills. Metacognitive skills are students' skills in managing learning and thinking activities (Schraw & Moshman, 1995; Du Toit & Kotze, 2009). Accordingly, according to Tarricone (2011), metacognitive regulation skills play a major role in thinking skills and formulate a taxonomy of metacognitive skills. Therefore, studies need to be conducted to determine the level of students' metacognitive regulation skills after the implementation of 21st-century learning. This study is important for the initial evaluation of an approach or curriculum after several years of introduction. As discussed, studies of 21st-century learning are largely focused on the challenges, needs and effectiveness of 21st-century learning activities or methods, but few studies have examined the impact of a particular skill on students during the implementation of 21st-century learning. Thus, the researchers implemented this initiative to conduct a more in-depth study of metacognitive skills by taking the metacognitive regulation skills as a construct to target student achievement. Also, this study is important to look at and compare the impact of 21st-century learning implementation on school categories which is regular secondary schools and cluster schools. Cluster school is a school rating based on academic excellence as well as curriculum (MOE, 2006). Students with excellent academic achievement results are eligible and selected to attend cluster schools. School categories represent disparities in student achievement, and this is a measurement of how the implementation of 21st-century learning will reduce the achievement gap within these two categories of schools.

The aim of this research was to examine students' metacognitive regulation skills after the implementation of 21st-century learning and to see their relationship to student achievement in mathematics subjects. Based on the research problem mentioned, a set of research questions have been developed as follows:

1. What are the levels of student achievement after the implementation of 21st-century learning by school categories?
2. What is the level of students' metacognitive regulation skills after the implementation of 21st-century learning by school categories?
3. Is there a difference in the level of student achievement by school categories?
4. Is there a difference between students' metacognitive skills level by school categories?
5. Is there a relationship between metacognitive regulation skills and student achievement after the implementation of 21st-century learning?

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Research Methodology

General Background

The present research was conducted to examine students' metacognitive regulation skills after the implementation of 21st-century learning and to see the correlation to student achievement in mathematics subjects. Guided by the design of a survey using a quantitative approach, this research was conducted involving students in two categories of schools.

Samples

This research has involved 201 students at four secondary schools in the district of Pasir Gudang, Johor, Malaysia. According to Johanson and Brooks (2010) and Darussalam and Hussin (2018), the total sample size for the survey study was to look at the specific relationship and make the comparison is adequate with the number of samples at least 30. Using simple and purposive sampling techniques, Form 2 students between the ages of 13-14 years, are selected by categories of school, which is 2 regular secondary schools and 2 cluster schools of excellence. The following table shows the demographic data of the students involved.

Table 1
Student demographics data

Demographic		Regular school		Cluster school	
		Frequency	Percentage (%)	Frequency	Percentage (%)
Gender	Male	51	46.8	43	46.7
	Female	58	53.2	49	53.3
Overall		109	54.23	92	45.77

The number of samples from the regular school students was 109 (54.23%), exceeding the sample from the cluster school students only involving 92 (45.77%).

Procedure and Instruments

This research utilized two instruments, namely the Metacognitive Regulation Questionnaire and the Mid-Year Test Scores. The items included in the Metacognitive Regulation Questionnaire were four rates (1, never; 2, sometimes; 3, always; 4, very often). The questionnaire was amended from two inventories, which is the Metacognitive Awareness Inventory, MAI (Schraw & Dennison, 1994) and also the Junior Metacognitive Awareness Inventory, Jr. MAI (Sperling et al., 2001). The questionnaire consisted of constructs from the subcomponents of metacognitive regulation, namely, the planning constructs consisting of 12 items, monitoring with 15 items and the third construct is the evaluation that consisting of 8 items with a total content of the questionnaire containing 35 items. First, to test the validity of content and language, 2 experts were selected based on the areas of expertise in mathematics and language fields, to review and evaluate the suitability, language, consistency and usability of each item. This is that since the original inventory is in English and the researchers have converted it into Malay. Consequently, following some modification, a pilot test was performed to determine the reliability of the questionnaire. The questionnaire was allocated to 20 Form 2 students in this pilot test, where the student was not involved in the actual study and as suggested Johanson and Brooks (2010), the number of samples in the pilot study was sufficient for a survey study with only at least 12 samples being used. Using the Alpha Model, the reliability index was determined. The results obtained were alpha values *a*, was .924 indicating a high-reliability index and the instrument appropriate to use in the actual study. To determine student achievement, the mid-year exam score was used as the student achievement indicator.

Data Analysis

Based on the research questions, the data were analyzed by instrument. To obtain achievement scores, data from the mid-year test sets were evaluated using the total marks and grades obtained. The student achievement was classified into four levels, poor, intermediate, good and excellent. Subsequent to these scores and grades the descriptive analysis was performed to determine the mean and interpret its level. Data on metacognitive regulation questionnaires were also analyzed to obtain mean and interpreted according to subcomponent of metacognitive regulation. In order to perform comparisons and to see the correlation, inferential statistical tests are used. Due to the type of data that is ordinal data, non-parametric tests such us Mann Whitney and Spearman correlation test were used based on the suggestions by Darussalam and Hussin (2018). All data were analyzed using the statistical package for the social studies, SPSS version 23. Further descriptive and inference analysis were performed using the following table.

Table 2
Four levels of 4-point Likert scale

Mean Range	Interpretation
1.00 – 1.74	Low
1.75 – 2.49	Moderate Low
2.50 – 3.24	Moderate-High
3.25 – 4.00	High

Source: Alico and Guimba (2015)

Table 3
Correlation coefficient value

Correlation Coefficient (r)	Interpretation
0	No correlation
>0 – .25	Very weak correlation
>.25 – .50	Enough correlation
>.50 – .75	Strong correlation
>.75 – .99	Very strong correlation
1.00	Perfect correlation

Source: Sarwono (2016)

Research Results

The present research involved two categories of secondary schools, namely regular schools and cluster schools of excellence. Table 4 shows the results of the student achievement scores analyzed by level and school category.

Table 4
Analysis of student achievement scores by level and school category

Indicator	Regular school, *n*=109		Cluster school, *n*=92	
Achievement Level	Frequency	Percentage (%)	Frequency	Percentage (%)
Poor	24	22.0	1	1.1
Intermediate	58	53.2	26	28.3
Good	23	21.1	50	54.3
Excellent	4	3.7	15	16.3
Achievement Analysis	Mean	Std. deviation	Mean	Std. deviation
Marks	50.72	13.994	67.23	14.112
Grade	2.06	.761	2.86	.689
Interpretation	Moderate Low		Moderate-High	

Overall achievement showed that students in the cluster school performed higher than the regular schools with mean scores and grades of 67.23 and 2.86 respectively, compared to 50.72 and 2.06. The level of achievement also differed significantly between the two categories of schools, for example, cluster schools had more students at good and excellent levels with 50 (54.3%) and 15 (16.3%) students compared to the regular school of just 23 (21.1%) and 4 (4.7%) students.

Accordingly, the findings from the metacognitive regulation questionnaire show that overall, the metacognitive regulation skills are at a moderate-high level for both categories of schools. However, the scores for the cluster schools were higher (Mean = 2.86; SD= .808) than for the regular schools (Mean= 2.70; SD= .844). Table 5 below shows in detail the analysis of students' metacognitive regulation skills for both categories of schools.

Table 5
Analysis of metacognitive regulation skills by subcomponent and based on school category

Subcomponents	Regular school, *n*=109			Cluster school, *n*=92		
	Mean	*SD*	Interpretation	Mean	*SD*	Interpretation
Planning	2.65	.841	Moderate-High	2.83	.791	Moderate-High
Monitoring	2.76	.843	Moderate-High	2.93	.802	Moderate-High
Evaluation	2.64	.850	Moderate-High	2.79	.846	Moderate-High
Overall Score	2.70	.844	Moderate-High	2.86	.808	Moderate-High

The mean values for the subcomponents of the metacognitive regulation obtained were in the range of 2.64 to 2.93, where the Monitoring of the cluster school recorded the highest values and the lowest values were the subcomponents of the Evaluation of the regular school. Subsequently, comparisons of both achievement scores and metacognitive regulation skills scores by school category were conducted using the Mann Whitney Test. Table 6 and Table 7 show the results of the inference analysis.

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Table 6
Comparison analysis of student achievement score by marks and grade based on school category

Indicator/School		Mean Rank	Sum of Rank	*Z*	*p*
Marks	Regular school	73.26	7985.00	-7.362	.0001*
	Cluster school	133.87	12316.00		
Grade	Regular school	76.63	8353.00	-6.905	.0001*
	Cluster school	129.87	11948		

Note: *p<.05

The results obtained with $p = .0001$, < .05, confirmed that there is a significant difference between the achievement score of the regular school and the cluster school in both analyzes that use marks or grades.

Table 7
Analysis of comparison of metacognitive regulation skills by school category

School	Mean Rank	Sum of Rank	*Z*	*p*
Regular school	91.10	9930.00	-3.299	.001*
Cluster school	112.73	10371.00		

Note: *p<.05

The comparative analysis of the metacognitive regulation skill scores also found that there is a significant difference between regular school and cluster school scores of $p = .001$, which was less than the significance level of.05.

For an in-depth study, a correlation assessment was undertaken to analyze the relationship between achievement scores and metacognitive regulation scores as a whole and by school category. Next is the result of the study of the correlation.

Table 8
Correlation analysis of metacognitive regulation skills and achievement scores for overall students and by school category

Indicator/School	Overall	Regular school	Cluster school
Correlation coefficient	.171*	-.004	.175
Sig. (2-tailed)	.015	.968	.095

Note: *Correlation is significant at the .05 level (2-tailed)

There was a significant correlation between achievement scores and metacognitive regulation skill scores for overall students. However, the correlation was very weak. While the correlation between achievement scores and metacognitive regression skills of cluster school was also very weak at .175 and negative correlation was obtained with -.004 for regular school. Both did not show significant relations.

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Discussion

This research was a survey to look at the impact of 21st-century learning implementation after five years of introduction and disclosure in schools across Malaysia. This research is focused on looking at the impact on students' metacognitive regulation skills and associating them with student achievement. This research involved 201 students from four secondary schools in the regular daily and cluster schools. Comparisons between metacognitive regulation skills and student achievement from these two types of schools were implemented. The findings indicate that there are significant differences in achievement and students' metacognitive regulation skills between the two schools. The achievement and metacognitive regulation skills of the cluster school are higher than the regular school. Overall, the achievement and students' metacognitive regulation skills were moderate. Correlation analysis also showed a very weak relationship between overall student achievement and metacognitive regulation skills.

Based on this finding, it can be inferred that the introduction of 21st-century learning also needs to be simplified by looking at the environment, teaching and learning methods, resources, infrastructure and the need to strengthen implementation aspects. The effect of student implementation and competence will be given priority while preparing, organizing and implementing teaching and learning to concentrate on particular student skills such as problem-solving capabilities, management skills, critical thinking skills and many more. As has been suggested from the study results such as Jamil et al (2017), Tamuri and Hussin (2017), Vinathan (2016), Salehudin et al. (2015) and Arbaa et al. (2017). According to Tamuri and Hussin (2017) and Arbaa et al. (2017), 21st-century skills are a priority in implementing 21st-century learning, among which are communication skills and critical thinking skills. According to Smith and Mancy (2018), the impetus for communication skills and critical thinking skills is a metacognitive skill in which learning methods that engage in collaborative activities can have an impact and influence each student's metacognitive, communication and thinking skills during learning. Consequently, based on the results of this analysis, metacognitive regulation skills, which are a core part of metacognitive proficiency, are only at a moderate point. This decision would be a problem if enhancements were not made to the implementation of 21st-century learning. The findings of the Idris et al. (2015) and Abdullah et al. (2017) studies indicate that metacognitive skills are also at a moderate rate. A report by Asmuni (2011) conducted before the introduction of 21st-century learning in Malaysia also reveals that the degree of metacognitive actions is modest in solving mathematical problems. Thus, even after five years of implementing 21st-century learning in Malaysia, this trend remains unchanged.

However, the positive and reliable result of previous research is that there is a significant correlation between student achievement and metacognitive regulation skills. This result was supported by studies in Malaysia by Hassan and Rahman (2017), Anwar (2015), Ibrahim and Iksan (2017), Abdullah et al. (2017), and Idris et al. (2015), while abroad, similar results were reported from the findings of studied by Stephanou and Mpiontini (2017), Leidinger and Perels (2012), Su et al. (2016), Ahmad et al. (2018), Menz and Cindy Xin (2016), Pantiwati and Husamah (2017), Nongtodu and Bhutia (2017), Kazemi et al. (2010) and Daher et al. (2018). However, the correlation index showed a very weak level as contrasted to the findings of Hassan & Rahman (2017), which showed a very high correlation among metacognitive awareness with student performance. Its significant finding is attributed to the scope of the study, which is that the study focuses on metacognitive regulation and has been recognized by Tarricone (2011), metacognitive regulation has a higher rating than metacognitive awareness and researchers Hassan and Rahman (2017) have also discussed that when engaging non-routine mathematics problems, metacognitive awareness strategies are changing. It can also be argued that facets of metacognitive regulation skills will be prioritized in the design and creation of 21st-century learning strategies. In the 21st-century learning environment should provide the opportunity to practice metacognitive regulation skills and optimize their development. Students with higher metacognitive regulation skills show better levels of learning achievement. The findings of this analysis have shown that students from cluster schools that have been chosen on the basis of better grades have better metacognitive regulation skills than students who do not perform well. In line with the findings of Anwar (2015), which shows that outstanding students have a higher level of metacognitive behaviour. These metacognitive skills need to be constantly trained and developed in line with 21st Century skills. Therefore, the implication is that the parties need to work together and discuss the issues and find solutions to improve the implementation of 21st century learning to enhance the impact on student competencies.

Conclusions and Recommendations

This research problems may be addressed with results demonstrating that the level of student achievement and metacognitive regulation skills are at a moderate level and there is a positive correlation between metacognitive regulation skills and student achievement. Thus, it can be concluded that 21st-century learning practices in Malaysia are still in the early stages and need some improvement. For example, the development of methods, activities, models or modules of learning based on metacognitive regulation strategies that meet the requirements of the 21st-century teaching approach is highly encouraged and will help strengthen 21st-century learning. Technology integration can also enhance the effectiveness of learning delivery and enhance students' competence as well as change the learning environment. Further studies are also needed to further develop the results of this study. As a suggestion some improvements and modifications should be made, for example, changing the dimension by involving more samples, involving other critical subjects such as science, chemistry, physics and so on. In addition, research can also be conducted to look at other skills, such as computational skills, leadership skills and so on based on 21st-century learning needs. In conclusion, this study provides the impression that when a curriculum is implemented, it should always be followed by monitoring and evaluation. Regular reviews will ensure the smoothness and effectiveness of the new curriculum introduced. This research found that the gap of achievement is still wide and needs the effort of the stakeholders.

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