Computer programming skill should be introduced at the early stage in education as it is one of the competencies required for the 21st century to survive in this technology-driven environment. However, educators should be made aware that teachings of programming are not only confined to acquiring only the skill but it could also increase the understanding in fundamental subjects like language, mathematics and science. Creating a programming project involves mathematical thinking, problem solving, sequencing and logical thinking. This study investigates the methods to teach basic mathematical concepts and the effect of learning Scratch programming on primary students’ problem-solving skills. It was carried out in an explanatory sequential mixed methods design with the participation of 95 primary school students from 5 different schools. The quantitative and qualitative results had shown that the students could develop programs that exhibit their problem and logical thinking skills. It can also be shown that that all the students find Scratch programming easy to learn, enjoyed the programming class and wanted to improve their programming skills. In addition, they could also understand the basic mathematical concept and the various different aspects of mathematics. Nevertheless, their excitement in learning the skills should be encouraged, nurtured and sustained by providing a good support system in schools.

Keywords: Programming, Mathematical Concept, Problem Solving Skills, Sequential and Logical Thinking.
1. Introduction

Nowadays, schools must move beyond the typical focus on basic competency in core subjects to promoting understanding of content at much higher levels by integrating the 21st century skills into all subject areas. The societies in the 21st century are living in a high-technology and internet-based environment. The characteristics of this environment includes access to an abundance of information, rapid changes in the technology tools that requires more than average thinking skills and content knowledge. The skills on creativity, critical thinking, communication and team work is essential to prepare students for the future. The action plan as emphasized by the Education Ministry strived that education should appear as Key-Stage standard instead of merely grade-based standards [1]. The curriculum should be written such that it could inspire or encourage the curriculum developer or policy makers to adopt and adapt to the 21st century skills, regional value and global competencies. There are two main bodies that measures and ranked the achievement of mathematics, science and other significant skills internationally, Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA). Average mathematics scores of 8th-grade students as measured by TIMSS, recorded Malaysia at 26, with Korea and Singapore at first and second place. However, the score achieved by the students in Malaysia is below TIMSS scale average. PISA measures student performance in mathematics, reading, and science literacy every three years. For the assessment year of 2012, PISA administration cycle focuses on reading, mathematics, science, problem solving and financial. Malaysia was ranked at 52, compared to Singapore at 2, Korea at 5, Vietnam at 17, Romania at 45, UAE at 48 and Thailand at 50.

Feurzeig et al. [2] and Howe et al. [3] proclaimed that programming has essential advantages for teaching Mathematics as it contributes to rigorous thinking, key insights to concepts such as variables & functions, generalizing problems, and promote problem solving skills. It is observed as an important skill for the development of problem solving skills and logical reasoning [4, 5]. Therefore, its integration throughout all educational levels, as well as the early ages, is considered valuable and various research studies have been carried out to explore the phenomenon in more detail.

This paper aims to study and examine the performance of the primary school students’ performance based on these two questions:

- Can Scratch be used to promote mathematical thinking skills?
- In what ways can it be used to teach year four to six mathematics curricula?

2. Malaysian Curriculum for Mathematics

The design of the national standard based school curriculum is focused on developing holistic individuals that demonstrate innovative, creative and critical thinking skills. Hence, the goal of Malaysian Ministry of Education is to engender citizens who are competent and knowledgeable, who hold great moral principles and who are responsible and able to achieve a high level of individual well-being and contribute to the improvement of the society, the family, and the nation at large [6]. These competencies are primarily inculcated using these five main areas as indicated in Fig. 1.
The primary school mathematics curriculum framework, however, is based on thoughtful learning that emphasize on these four main themes described in Fig. 2:

**Fig. 1. Five main areas of competencies for mathematics curriculum [7].**

**Fig. 2. Four main themes for mathematics curriculum [7].**

Figure 3 illustrates the performance level to measure the mathematical skills and competencies required for the primary school mathematics. The descriptor framework and their general descriptor are defined distinctly. The competencies involved the three components; knowledge, skills and values. The knowledge give priorities on the cognitive and affective domain that can be achieved by the students and the skills focuses on what the students should know and able to do conceptually and practically. In addition, the values illustrate the level of performance that the students need to demonstrate as indicator of success, known as descriptor.

The performance indicates that the students nowadays, should go beyond know, understand and able to do in mathematics, but they are also expected to do with exemplary manner. That is, they should be able to demonstrate and apply the mathematical knowledge and skills in a new situation in a systematic, positive, creative, innovate and exemplary manner.
Performance Level 1
- Descriptor Framework: Know.
- General Descriptor: Demonstrate basic mathematical knowledge and perform basic skill.

Performance Level 2
- Descriptor Framework: Know and understand.
- General Descriptor: Demonstrate the understanding in communicating mathematically, able to interpret and explain what they have learned.

Performance Level 3
- Descriptor Framework: Know, understand and able to do.
- General Descriptor: Able to use mathematical knowledge to perform specific skills in a particular situation.

Performance Level 4
- Descriptor Framework: Know, understand and able to do with good manner.
- General Descriptor: Demonstrate the mathematical skill systematically and procedurally.

Performance Level 5
- Descriptor Framework: Know, understand and able to do with admirable manner.
- General Descriptor: Demonstrate the mathematical skill systematically and procedurally in a new situation; consistently with a positive attitude.

Performance Level 6
- Descriptor Framework: Know, understand and able to do with exemplary manner.
- General Descriptor: Apply the mathematical knowledge and skills systematically and procedurally in a new situation; systematically, positively, creatively, innovatively and exemplary.

Fig. 3. The performance, descriptor framework and general descriptor for the national mathematics primary school curriculum [7].

3. Scratch Programming

Scratch, created by the Massachusetts Institute of Technology (MIT) Media Laboratory and launched in 2007, is a visual, block based programming language designed to facilitate media manipulation for beginners [8]. It is a new and innovative program that allows children to learn easily how to program and create multimedia games and applications. The name was derived from the scratching technique used by hip-hop disc jockeys that spin vinyl records back and forth with their hands to mix music clips together in creative ways. This is similar to what can be achieved with Scratch, mixing media in different ways to create something new. The organization that created Scratch is focused to develop an environment where people could study, invent, use creatively digital technologies to enhance the way they think, express and communicate ideas and primarily to explore scientific frontiers [9]. What is so remarkable about Scratch is that students can have great fun while learning and developing thinking skills by creating games and animations [10].

Scratch is easy to use, whereby students can program their projects by simply putting together graphical blocks, without any of the obscure punctuation and syntax of traditional programming languages. In this way, Scratch makes programming accessible and more appealing to a much broader audience, so the program is more simplistic, appealing and relevant to young programmers but still being able to challenge even the most experience programmers. The program can be used in many different ways, with the different subjects and areas of the key stage curriculum. The appealing aspect of Scratch is that students can have great fun adding and creating sprites and backgrounds using the blocks for motion, looks, sound, pen, control, sensing, operators, variables can drag and move into the script area.
3.1. Fundamental mathematics of Scratch

Creating any project with Scratch involves the use of many different blocks for appropriate mathematical operations such those shown in Fig. 4(a) and different scripts available in Fig. 4(b).

<table>
<thead>
<tr>
<th>Blocks</th>
<th>Functions</th>
<th>Blocks</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>![math_blocks]</td>
<td>Basic mathematical operations such as addition, subtraction, multiplication and division</td>
<td>![logical_blocks]</td>
<td>Logical operations such AND, OR and NOT</td>
</tr>
<tr>
<td>![comparison_blocks]</td>
<td>Basic blocks to compare whether a number is less than or equal to or greater than</td>
<td>![modulo_block]</td>
<td>Modulo operation, round operation and to compute the square root of a number</td>
</tr>
</tbody>
</table>

(a)

- **Motion**
  - The movement of a sprite is controlled by the motion blocks. The sprite can be instructed to move a number of steps or to turn a number of degrees.

- **Look**
  - The sprite can be instructed to say or think about something for a length of time, to switch from one costume to another or to switch to another backdrop using the look blocks.

- **Sound**
  - These block is used to create sound, musical notes from the selected instruments. The volume of the sound can also be adjusted using these blocks.
The pen blocks can be used to draw patterns, diagrams or any illustrations. There are a variation of color to choose from.

Fig. 4 (a) The basic mathematical operations in Scratch
(b) Blocks available to create Scratch scripts.

The initial placement of scratch in a specific position requires the knowledge of two dimensional coordinates. The origin is in the middle of the ‘stage’ and the coordinates of both ‘x’ and ‘y’ to move a sprite can be positive or negative. Using the motion command in the scripts, and by inserting the number of steps, user can control the magnitude and direction of the sprites movement. In the development of coordinate geometry, the students must make the connection that values for x correspond to the horizontal movement of the sprite and the values for y corresponds to the vertical movements. Figure 5(a) illustrates the backdrop with the x and y coordinates, while Fig. 5(b) illustrates the scripts that control the magnitude and the angle of the movement to draw a 100×100 square. The values can be adapted to the problems to be solved.

One example is to create a scratch project for students to understand currency concepts and how to create the following variables - the cost of one bunch of bananas, the cost of an apple, the number of bananas required, the number of apples required, the total cost of both bananas and apples, the payment and finally
the balance that the shopkeeper has to return. The finished project is as shown in Fig. 6 and the scripts are illustrated in Fig. 7.

In this activity, the students have to apply the basic mathematical operations to perform the calculation for each element below:

- If the cost of a bunch of bananas is 2.50, how to calculate for 2 bunches of banana - applying the multiplication concept.
- If the total cost of bananas are 5.00 and apples are 3.20, how to calculate the total purchase - applying the addition concept.
- If the payment is made using 20.00 note, how to calculate the balance given to the customer - applying the subtraction concept.

![Scratch project](image)

**Fig. 6. The completed Scratch project.**
4. Methodology

The workshops on Scratch programming were first conducted in 2014 and the objective was primarily to introduce the primary school students to basic computer programming. The one to one-half day workshop had covered these topics: Sprite movement, drawing, creating musical notes, creating animations and creating interactive computer games.

In this research design, quantitative and qualitative data were collected and analysed. The quantitative data were based on the pre and post tests and the rubric marks given by the jury during the competition conducted at the end of the workshop. For the pre and post-tests, 20 multiple choice questions were presented to the students and 1 mark is given for each correct answer. Meanwhile for the competition, four juries were appointed which comprise of two teachers and two lecturers. The students were divided into a group of two and they were instructed...
to create a short animation. They need to apply all the concept learned and be able to solve any problems encountered in designing the visual programming. The rubrics measures their creativity, problem solving skills, usage of suitable scripts for movements, communications and sound.

5. Results and Discussions

Table 1 shows the descriptive statistical analysis performed on pre and post test data. There is a significant increase for the average mark obtained by the students, from 29% to 52%. Meanwhile, Fig. 8 shows the distribution of the marks obtained by the students in the pre and post-test. It can be clearly seen that more students performed much better in the test after they have been taught on the Scratch programming concepts.

<table>
<thead>
<tr>
<th></th>
<th>Pre test</th>
<th>Post test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>29.4118</td>
<td>52.1822</td>
</tr>
<tr>
<td>Standard Error</td>
<td>2.0775</td>
<td>2.6831</td>
</tr>
<tr>
<td>Median</td>
<td>29.4118</td>
<td>52.9412</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>11.5670</td>
<td>14.9387</td>
</tr>
<tr>
<td>Sample Variance</td>
<td>133.7947</td>
<td>223.1648</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.2310</td>
<td>0.8913</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.3093</td>
<td>0.1850</td>
</tr>
<tr>
<td>Range</td>
<td>47.0588</td>
<td>70.5882</td>
</tr>
<tr>
<td>Minimum</td>
<td>11.7647</td>
<td>11.7647</td>
</tr>
<tr>
<td>Maximum</td>
<td>58.8235</td>
<td>82.3529</td>
</tr>
<tr>
<td>Count</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>Confidence Level (95.0%)</td>
<td>4.2428</td>
<td>5.4796</td>
</tr>
</tbody>
</table>

Fig. 8. The distribution of marks obtained by the students.

Figure 9 illustrates the performance by the students for each group. The average is calculated from the marks given by each jury. We can see that the students are more comfortable to use movements in their project as compared to sound. This is quite surprising because based on the observations, the students
prefer to create animation with extensive use of movements and sound. Another good thing is that more students are making use of communication which is basically a harder concept to learn. Thus, by being able to apply this concept, the student displayed an obvious problem-solving skill and logical thinking. Initial analysis shows that there is a wide gap for the marks given by each jury and Fig. 10 gave this indication for the creativity category for Group 12 and Group 14. However, it can be seen from the trend that the marks are somehow balanced for Group 9, 11, 13 and 15.

![Bar Chart](image)

**Fig. 9. Performance by the students in the competition.**

![Bar Chart](image)

**Fig. 10. Marks given for creativity by each jury.**

The investigation on the curriculum for mathematics as presented provides invaluable information on the approach on how visual programming could integrate fundamental mathematical concepts to teach primary school students. Although no data was collected, a qualitative analysis on the students’ behaviour indicates a positive acceptance and understanding on the concept presented.
6. Conclusion
This study analysed the data collected for pre and post-test and it be seen that there is a remarkable increase in their understanding on the concepts learned. The questions are designed not only to test their knowledge but also on their ability to analyse the programs and determine the output of the program. This ability is necessary to evaluate their problem solving and logical thinking skill. The students had also displayed these traits and their creativity during the competition. These findings somehow would need to be confirmed by further studies. In addition, the development of the scratch scripts to enhance the learning of mathematics is also discussed. Validation will be made on controlled group to evaluate the method.

Acknowledgment
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References