A Project entitled

Students' Experience of STEM Week: Attitude towards STEM, Intellectual Risk Taking, Collaboration and 21st Century Skills

Submitted by

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Declaration

I, Chan Wing Laam , declare that this research report represents my own work under the supervision of Dr. Wan Zhi Hong, and that it has not been submitted previously for examination to any tertiary institution.

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Introduction

In 2003, Hong Kong primary four students' test result was ranked third in the Programme for International Student Assessment (PISA) which was stunning. However, in 2011, Hong Kong primary four students' test result was ranked ninth in the PISA. This illustrates that the science of primary students was obviously inferior year by year. In order to brush up students' science, the Hong Kong government have been implementing the STEM education.

Since 2016, most of the primary schools in Hong Kong have been implementing STEM education in their curriculum, but they tended to consider STEM as other learning experience instead of a teaching method of the regular classes. One of the most popular ways is to organize a STEM week at school for students to participate the STEM activities or do a STEM project in the particular week. Some people claimed that students might be benefited from the STEM week, for example, the improvement of science.

However, some people may think that STEM week is not very useful to teaching students science because of the inadequate time spent on activities. In accordance with the news report made by On.cc, around 32% of the interviewees think that STEM is ineffective and some of them think that it is due to limited time spent on STEM education (On.cc, 2018). Therefore, the current project focused on students' experience of STEM week that many primary schools implemented to teach STEM in the spare time and aimed to investigate the following three research questions:

1. Do students have a positive attitude towards STEM after STEM week?
2. Do students tend to take intellectual risk and work in collaboration in STEM disciplines after STEM week?
3. Does STEM week assist students in developing their 21st century skills?

Literature review

STEM

STEM literally means “Science”, “Technology”, “Engineering” and “Mathematics”. However, the focus of STEM is not only the knowledge of these four subjects, but also the inquiry skills that are required in these four aspects. In general, students can improve the skills in communication, problem solving, data analysis, following procedures, evidence-based argumentation, developing a resolution and creating a product (Froschauer, 2015). In detail, there are different skills in the four aspects. Science emphasizes applying scientific methods such as observation, designing experiments, testing variables and analyzing data; Technology focuses on identifying specific needs, addressing problem and evaluating the relevance and effectiveness of existing technology; Engineering is emphasizing on determining criteria, generating multiple solutions or designs, prioritizing criteria and re-testing to optimize the final solution or design; whereas Mathematics focuses on using instruments for measuring, analyzing data mathematically and using mathematics reasoning (Bybee, 2013). STEM education cannot focus on these aspects independently. The four subjects should be intertwined with each other. Hence, most of the STEM activities is to create a product for solving problem in daily life. During producing and designing a new thing, the skills of Science, Technology, Engineering as well as Mathematics are comprehensively used by students.

In Hong Kong, based on the definition of STEM the government created its own target and principles of STEM education. Due to the constantly changing world in 21st century, equipping students with the ability to deal with the alterations and challenges in the world is more important than imparting knowledge to students. Accordingly, STEM education in Hong Kong aims at fostering student to be lifelong learners of STEM-related subjects, developing a firm knowledge base in students, raising their interests in Science, Technology, Engineering and Mathematics, enhancing students' capability to integrate and apply knowledge and skills, fostering students' creativity, collaboration and problem solving skills, also improving the partnerships with community stakeholders, and last but not least, establishing experts in STEM-related areas to nurture the development of Hong Kong (Education Bureau, 2016). As a result, the international competitiveness of Hong Kong will be increased owing to the development of STEM-related areas and improvement of students.

To promote the STEM education, the Hong Kong government encourages primary schools to teach STEM through project-based learning (PBL). The Hong Kong government encourages schools to organize STEM-related learning activities for students, and also provides students with numerous STEM-related competitions or activities at territory-wide, national and international levels to participate (Education Bureau, 2016). Also, teachers generally implement a wide range of instructional techniques various instructional activities in their efforts to engage students, such as hands-on activities, small group activities, discussions and experiments (Cohen, 2018). In the activities and competition, students are required to form a group and make a STEM product together to solve a problem. For example, students are required to make a vacuum cleaner to solve a problem in their daily life which is the fragment of rubber. Ellingson (2018) said that "Open-ended problems require complex thinking but also allow for individual differences in students and promote teamwork, which may improve student motivation, interest and collaboration" (p.19). Therefore, the STEM education was claimed to be benefited from project-based learning.

Attitude

Studies explained that students' negative attitude towards studying science, which is the decline of students' interest in science, is came from the traditional instructions (Han, 2017). This negative attitude towards science may be one of the factors that contributed to Hong Kong primary students' regression in science. Therefore, increasing students' motivation in learning science is very important.

Motivation means the process of internal attraction that encourages, manipulates and continues the behavior, and the idea of motivation explains why a person acts in a particular way (Baron, 1989). In other words, learning motivation is the interest that encourages students to keep making great efforts to learn or achieve the greatest academic success.

Han (2017) pointed out that "PBL were found to exert a positive influence on students' interest in learning and their conviction in the utility of STEM subjects" (p.534). Also, students' test results and overall academic achievement enhanced due to increased students' interest and positive attitudes towards learning STEM disciplines (Han, 2017). However, the studies have not investigated the relation between duration of STEM activities and the effectiveness of STEM education in terms of increasing students' motivation. There were two factors that should be considered to investigate students' motivation on STEM: value and interest. Personal value is the firmly fixed and abstract motivation that guides, justifies or explains attitudes, norms, beliefs and behaviour' (Davidov, Schmidt & Schwartz, 2008). Whereas interests were found to be very important for learning motivation, achievements and processes (Krapp, Hidi & Renninger, 1992). Since Uitto, Juuti, Lavonen, Byman and Meisalo (2011) claimed that "There were significant correlations between the attitude and value factors. Interest and attitude were also significantly correlated.", value and interest should be investigated together when determining students' attitude towards STEM.

Intellectual risk taking and collaboration

STEM is supposed to be a tool to help students learning about science. Helping students develop their capability to reason scientifically is a crucial goal of science education, as well as a key attribute of scientific reasoning; However, given the uncertain nature of scientific inquiry, whether students are willing to take risks is one of the primary factors (Beghetto, 2009). Therefore, we should discover the students' willingness to take intellectual risks to find out how effective the STEM education is, just like the science education. Beghetto (2009) stated that intellectual risk-taking means "engaging in adaptive learning behaviors (sharing tentative ideas, asking questions, attempting to do and learn new things) that place the learner at risk of making mistakes or appearing less competent than others" (p.210). Therefore, students' tendency to try something they are unfamiliar with or they feel embarrassed about is a good criterion to determine students' willingness to take intellectual risk.

In Hong Kong, STEM activities adopt the collaborative project-based learning that enables students to learn STEM in groups. They provide students with opportunities for a lot of collaboration with groupmates to complete a STEM related project. Blending collaborative learning and project-based learning results in positive outcomes for students such as improvement of student learning, enhancement of ability to work together and improvement of technological skills (Baser, Ozden & Karaarslan, 2017). Therefore, investigating students' collaboration in

STEM is useful for researchers to understand whether STEM week is a collaborative project-based learning activity that enhances students' collaborative skills.

21st century skills

The current world economy has been changed from manufacturing-oriented to knowledge-oriented. The job market also followed the shift in the world economy. Core competencies for the workplace in 2020 will be very different to those are in these days because they depend on the changing world economy. The education is intertwined with the job market that the curriculum is always designed for the students' future career. It is very important to prepare students for the world they are going to face after graduation by 2020. 21st century skills are initially intended to prepare students to remain relevant in life and work during the 2020, which undoubtedly are more complex and competitive than nowadays. In 2020, the top 5 21st century skills demanded in workplaces will be complex problem solving, critical thinking, people management and coordinating with others (World Economic Forum, 2018). STEM education is a key element to remain a leader in innovation and a world economic frontrunner (Thomasian, 2011). Also, STEM education is a perfect medium to foster 21st century skills and making a society that is capable of competing internationally (Khalil & Osman, 2017). For example, students designing and presenting their invention in STEM activities can help them to nurture their creativity and communication skills. Therefore, the Hong Kong government implements STEM education to enhance students' capability to integrate and apply knowledge and skills across various STEM disciplines, and to develop their creativity, collaboration and problem-solving skills, as well as to nurture their innovation and entrepreneurial spirit which are important in the 21st century (Education Bureau, 2016). This project focused on ten 21st century skills that would be developed through STEM education, i.e. communication skills, presentation skills, problem solving skills, scientific thinking, collaboration skills, innovation, creativity, technology skills, critical thinking as well as life and career skills (Sahin, Gulacar & Stuessy, 2015).

Method

Participants

For all research questions, convenience sampling was used for recruiting participants in this project. The reason that this sampling method was used is the researcher can conveniently access to the subject. Therefore, all participants were researcher's students studying in the placement school of block practice. The participants of this research were primary 5 students. These students were from one class, which was 5A. They had participated in a STEM week of their school before participating in this study. During the STEM week, students have learnt how to make a robot that could pull heavy things, then robots from different groups would compete against one another. Robots joined a 2-round competition where two robots would pull against each other which was similar to a tug of war. Students could revise their robot after the first round of the competition, and the robot that had the greatest strength in second round would be the champion.

All students participated in this study were on a voluntary basis. Since the participants were under the age of 18, all participants' parents and the school were informed to sign a consent form, and they fully understand that they had every right to withdraw from the study at any time without negative consequences. A total of 23 primary 5 students responded to the questionnaire and the data of all participants were included into data analysis. 10 of the students were female and 13 of the students were male.

Measures

Attitude towards STEM PBL Questionnaire

The Attitude towards STEM PBL Questionnaire (Appendix A) was a self-administered questionnaire. It was based on a study by Han & Carpenter (2014). The questionnaire consisted of 13 questions. The questions could be divided into two factors, which were value and interest. Each question had 4 options for the participants to choose from, which were “Strongly disagree”, “Disagree”, “Agree” and “Strongly Agree”. The description and sample items of all of three factors are presented in Table 1. The questionnaire was written in traditional Chinese which was the students’ native language. Through analyzing the data from the questionnaire, researcher would understand the primary students’ attitudes towards STEM PBL after the STEM week.

Table 1 Description and sample items of the two factors of STEM attitude

Factor (no. of items)	Description and sample items
Value (7)	To what extent students believe technology is beneficial. "Thanks to technology, there will be greater opportunities for future generations."
Interest (6)	To what extent students want to do more STEM activities in the future "I would like to do another STEM activity like this sometime."

STEM Intellectual Risk Taking and Collaboration Questionnaire

The Intellectual Risk Taking Questionnaire (Appendix C) was also a self-administered questionnaire. It was a revised version of the questionnaire done by Beghetto (2009) which was for measuring intellectual risk taking. Some questions from the questionnaire done by Han &

Carpenter (2014) were adopted to measure students' collaboration in STEM. The questionnaire consisted of 9 questions. The questions were about the two factors, i.e. intellectual risk taking and collaboration. Each question had 4 options for the participants to choose from, which were "Strongly disagree", "Disagree", "Agree" and "Strongly Agree". The description and sample items of both factors are presented in Table 2. The questionnaire was written in traditional Chinese which was the students' native language. By analyzing the data of the questionnaire, researcher would understand primary students' willingness to take intellectual risk when learning STEM and their collaboration after the STEM week.

Table 2 Description and sample items of the two factors

Factor (no. of items)	Description and sample items
Intellectual risk taking (6)	To what extent students take risk to learn new things that they are not familiar with. "During STEM, I like doing new things even if I am not very good at them."
Collaboration (4)	To what extent students believe that the collaborative activities in STEM help developing cooperative skills. "I can develop cooperative skills through group work."

21 st Century Skill Questionnaire

The 21st Century Skill Questionnaire (Appendix B) was a self-administered questionnaire. It was based on the study done by Sahin, Gulacar & Stuessy (2015). The questionnaire consisted of 10 questions. The questions were about how much interviewees believe that participation in STEM week contributed to learning different types of 21st century skills including communication skills, presentation skills, problem solving skills, scientific thinking, collaboration skills, innovation, creativity, technology skills, critical thinking as well as life and career skills. Each question had 4 options for the participants to choose from, which were "Strongly disagree", "Disagree", "Agree" and "Strongly Agree". All items were written in traditional Chinese which is the students' native language. By analyzing the data of the questionnaire, researcher would understand the primary students' 21st century skill development after the STEM week.

Data Analysis

For the all research questions, data was analyzed by calculating the mean and standard deviation (SD). Since the questions were rated using a four-point Likert scale (strongly disagree = 1, disagree = 2, agree = 3, and strongly agree = 4), the researcher could conclude that STEM week is not a useful activity for teaching STEM when the mean conducted from the questionnaires is lower than 3. However, an important disadvantage of mean is that it is sensitive to extreme values, especially when the sample size is small. Therefore, comparing the standard deviations was also important for measuring the central tendency, especially when comparing the girls' performances to the boys' performances. All data were rounded to 2 decimal places if necessary.

Attitude towards STEM Learning

Table 3 Students' attitude, value and interest towards STEM after STEM week

		All		Male		Female	
		Mean	SD	Mean	SD	Mean	SD
Value							
1	Thanks to technology, there will be greater opportunities for future generations.	3.30	0.93	3.15	1.14	3.5	0.53
2	Thanks to engineering, there will be greater opportunities for future generations.	3.35	0.88	3.31	1.11	3.4	0.52
3	Thanks to mathematics, there will be greater opportunities for future generations.	3.39	0.89	3.31	1.11	3.5	0.53
4	Interdisciplinary study is helpful to understand each subject better.	3.26	0.92	3.23	1.09	3.3	0.67
5	Technology enables studying to be more interesting.	3.35	0.98	3.31	1.11	3.4	0.84
6	STEM is important to me.	3.13	0.87	3.15	0.99	3.1	0.74
7	I like what we do in STEM.	3.39	0.66	3.46	0.66	3.3	0.67
	Total:	3.31	0.87	3.27	1.01	3.36	0.64
Interest							
1	I like STEM.	3.48	0.59	3.69	0.48	3.2	0.63
2	STEM is my favourite subject.	3.13	0.92	3.15	0.99	3.1	0.88
3	The activities we do in classes are useful for learning.	2.52	1.31	2.77	1.42	2.2	1.14
4	I feel involved in my work through the activities in STEM lessons.	3.30	0.93	3.31	1.11	3.3	0.67
5	I would like to do another STEM activity like this sometime.	3.39	0.94	3.38	1.12	3.4	0.70
6	The STEM activities are really meaningful to me.	3.17	0.98	3.15	1.07	3.2	0.92
	Total:	3.17	1.00	3.24	1.07	3.07	0.90

Value

In accordance with table 3, the whole class's average score of value was about 3.31. The value was greater than 3. Also, all means of the 7 items were higher than 3. This demonstrated that students generally had a positive attitude towards STEM after STEM week in terms of value.

From table 3, boys' mean of value was 3.27 whereas girls' mean of value was 3.36. The mean score of girls was greater than boys. Moreover, boys' standard deviation (1.01) was greater than girls' (0.64). In other words, boys were more spread from the mean, and some of their data was relatively extreme or the differences among boys were big. The data of girls were clustered closely around the mean, which means the differences among girls was smaller. This showed that the girls generally had a more positive attitude than boys in terms of value.

Interest

From table 3, the overall mean of interest was about 3.17. The value was greater than 3. It showed that students had a positive attitude towards STEM after STEM week in general. More specifically, all items had mean value greater than 3, except item 17, which was "The activities we do in classes are useful for learning.".

According to table 3, the boys' mean of interest was 3.24 and girls' mean was 3.07. Boys had greater mean than girls. However, boys' standard deviation (1.07) was greater than girls' (0.90). In other words, the boys were more spread from the mean, and some of their data was relatively extreme or the differences among boys were big. The data of girls were clustered closely around the mean, which means the differences among girls was smaller. Therefore, there were insufficient evidences to prove boys were generally more interested in STEM than girls did.

Intellectual risk taking

Table 4 Students' intellectual risk taking in STEM after STEM week

		All		Male		Female	
		Mean	SD	Mean	SD	Mean	SD
Intellectual risk taking							
1	I like doing new things even if I am not very good at them.	3	0.08	2.92	0.86	3.1	0.74
2	I share my ideas even if I am not sure they are correct.	2.91	0.85	2.85	0.90	3	0.82
3	I will try to do new things even if I am not sure how.	3.22	0.85	2.92	0.95	3.6	0.52
4	I try to find new ways of doing things even if they might not work out.	3.04	0.93	2.77	1.01	3.4	0.70
5	I try to learn new things even if I might make mistakes.	3.09	0.79	2.92	0.86	3.3	0.67
6	I ask questions even if other students will think the question is stupid.	3.09	0.85	3	0.91	3.2	0.79
	Total:	3.06	0.84	2.90	0.89	3.27	0.71

From table 4, the overall mean of IRT was about 3.06. The value was greater than 3. It showed that students generally tended to take intellectual risk in STEM after STEM week. Specifically, only the mean of item 2 (2.91), "I share my ideas even if I am not sure they are correct.", was less than 3. This showed that students were usually shy to share their ideas to others.

In accordance with table 4, boys' mean of IRT was 2.90 whereas girls' mean was 3.27. The mean score of girls was higher than boys. Moreover, boys' standard deviation (0.89) was greater than girls' standard deviation (0.71). In other words, the boys were more spread from the mean, and some of their data was relatively extreme or the differences among boys were big. The data of girls were clustered closely around the mean, which means the differences among girls was smaller. This showed that girls were more willing to take intellectual risk than boys did after STEM week.

Collaboration

Table 5 Students' collaboration in STEM after STEM week

		All		Male		Female	
		Mean	SD	Mean	SD	Mean	SD
Collaboration							
1	I can discuss with friends in groups.	3.30	0.93	3.23	1.09	3.4	0.70
2	I can express my opinion freely in groups.	3	0.95	2.92	1.12	3.1	0.74
3	I can develop cooperative skills through group work.	3.13	097	3	1.1	3.3	0.82
	Total:	3.14	0.94	3.05	1.07	3.27	0.74

According to table 5, the whole class's mean of collaboration was about 3.14. The value was greater than the 3. Also, every means of the 3 items of collaboration were higher than 3. These showed that students generally worked in collaboration in STEM after STEM week.

From table 5, the boy's mean was 3.05 whereas girls' mean was 3.27. Girls' mean was greater than boys. Moreover, boys' standard deviation (1.07) was greater than girls' (0.74). In other words, the data of boys were more spread from the mean, and some data of boys was relatively extreme or the differences among boys were big. The data of girls were clustered closely around the mean, which means the differences among girls was smaller. This showed that the girls were more willing to work in collaboration than boys after STEM week.

21st century skills

Table 6 Students' 21st century skills after STEM week

		All		Male		Female	
		Mean	SD	Mean	SD	Mean	SD
21st century skills							
1	How much do you believe that participation in STEM week contributed to improving your communication skills?	3.22	0.95	3.23	1.17	3.2	0.63
2	How much do you believe that participation in STEM week contributed to improving your presentation skills?	2.91	1.08	2.77	1.36	3.1	0.57
3	How much do you believe that participation in STEM week contributed to improving your problem solving skills?	3.17	0.98	3	1.22	3.4	0.52
4	How much do you believe that participation in STEM week contributed to improving your scientific thinking?	3.17	0.98	3.08	1.26	3.3	0.48
5	How much do you believe that participation in STEM week contributed to improving your collaboration skills?	3.04	1.02	2.85	1.21	3.3	0.67
6	How much do you believe that participation in STEM week contributed to improving your innovation skills?	3	0.95	2.77	1.17	3.3	0.48
7	How much do you believe that participation in STEM week contributed to improving your creativity?	3.22	0.90	3.15	1.07	3.3	0.67
8	How much do you believe that participation in STEM week contributed to improving your technology skills?	3.30	0.93	3.15	1.14	3.5	0.53
9	How much do you believe that participation in STEM week contributed to improving your critical thinking?	3.30	0.88	3.23	1.09	3.4	0.52
10	How much do you believe that participation in STEM week contributed to improving your life and career skills?	3	1.09	2.85	1.28	3.2	0.79
	Total:	3.13	0.97	3.01	1.17	3.3	0.58

From table 6, the overall mean of 21st century skills was about 3.13. The value was greater than 3. It showed that students generally developed 21st century skills after STEM week. Specifically, only the mean of item 2 (2.91), "How much do you believe that participation in STEM week contributed to improving your presentation skills?", was less than 3. This showed that students could not develop the presentation skills in the STEM week.

In lines with table 6, boys' mean was 3.01 whereas girls' mean was 3.3. The mean score of girls was higher boys. Moreover, boys' standard deviation (1.17) was greater than girls' (0.58). In other words, the data of boys were more spread from the mean, and some data of boys was relatively extreme or the differences among boys were big. The data of girls were clustered closely around the mean, which means the differences among girls was smaller. This showed that girls generally develop 21st century skills more successfully than boys.

Discussion

Attitude towards STEM learning

Except items related to self-regulated learning and usefulness for learning, the mean scores of other items in value and interest were higher than 3. It is obvious that, students have a positive attitude towards STEM in general. The possible reason was that the level of the task was suitable for students. Students were required to build a robot by connecting a circuit and joining the components together, which was very easy. Many students succeeded in these steps and their robot functioned well. Success in achieving objectives is a positive incentive that motivates people to reinforce the successful behaviour, that is repeated in similar situations (Armstrong, 2014). When students succeeded in building robot, they have the sense of achievement that motivated them to continue learning STEM. This might also be explained by the delights of robotics. Mosley, Ardito & Scollins (2016) say that "The usage of robotics is very captivating, and it is immediately gratifying to the students as it engages them in a very exciting way" (p.125). Since the activity of the current STEM week was making robot, students had more interest in STEM after the STEM week. Consequently, students had positive attitudes towards STEM after STEM week.

Comparing the attitudes of girls and boys, girls had a more positive attitude than boys in terms of value, whereas boys had more interest in STEM than girls did. The possible reason was that boys had preceding technical and mechanical experience that girl might lack to accomplish tasks in a technology and engineering classroom setting, and that might result in boys found these kinds of activities more attractive (Weber, 2012).

Intellectual risk taking

This study found that students' mean score of IRT was higher than 3. It is obvious that, students tended to take intellectual risk after STEM week. This could be explained by the interest in STEM. Beghetto (2009) stated that "More interested students are also more willing to take intellectual risks when learning and will have the ‘‘staying power" necessary for working through frustrations, set-backs, and failures in pursuit of their interests." (p.217). As a result, students were more willing to take intellectual risk after STEM week.

Comparing the IRT of girls and boys, girls performed better on intellectual risk taking than boys. Boys' mean score of IRT was even lower than 3. Suppose girls were generally less inclined to take intellectual risks than boys (Byrnes, Miller & Schafer, 1999). This could be explained by science ability that students with higher levels of science ability were more inclined to engage in IRT (Beghetto, 2009). Although several boys were superior in science in the investigated class, girls generally had relatively higher levels of science ability than the remaining boys. That was probably why girls in this class performed better on IRT in STEM.

Collaboration

This study found that students' mean score of collaboration was higher than 3. It is obvious that, students tended to work in collaboration after STEM week. This could be explained by the collaborative PBL. Collaborative PBL is an efficient way to build up collaborative skills and students would enjoy working in collaboration, even if they had group conflicts (Baser, Ozden & Karaarslan, 2017). Since the STEM week was a form of collaborative project-based learning, students learned how to work collaboratively in STEM week.

Comparing the collaboration of girls and boys, the mean score of girls was higher than the mean score of boys. In other words, the girls performed better on the collaboration than the boys. This could be explained by girls' stronger sense of collaboration. Female are keen to verbally discuss how they should complete the task in collaboration, while male had a higher tendency to work individually (Yeh, Lan & Lin, 2018). Therefore, girls were more willing to work in collaboration than boys in STEM.

21st century skills

This study found that students' mean score of 21st century skills was higher than 3. It is obvious that, STEM week enabled primary students to develop 21st century skills in only a few days. This could be explained by STEM integration that helps improving problem-solving skills, critical and analytical thinking of students, that guide them to a better real-world connection in the curriculum (Khalil & Osman, 2017).

Comparing the 21st century skills of girls and boys, the mean score of girls was higher than boys. In other words, the girls performed better on the 21st century skills than the boys. The possible reason of this was that girls performed equally well in different 21st century skills whereas boys performed well in just several 21st century skills, therefore, the mean score of boys would be lower.

Limitation

The most significant limitation was the small sample size. Extreme data is not rare when collecting data. It may affect the result of a study but the influences of it depend on its sample size. When the sample size is large, one or two extreme data brings a small influence. However, the sample size of this study was too small that one or two data brought great influences on the result of the mean. Mean is very easily affected by the extremely low or extremely high numbers in the data set. Consequently, the mean might be overestimated or underestimated due to the extreme values. Another limitation was the uncertain reliability of the data. The researcher could not control the reliability since some students might just randomly choose and the answers were not telling the truth. However, it was difficult for the researcher to check each and every student to ensure the reliability.

Conclusion

From what have been discussed above, it could be conclude that: students have a positive attitude towards STEM after STEM week; students developed 21st century skills in only a few days; students tend to take intellectual risk and work in collaboration in STEM after STEM week. Although the duration of STEM week was very short, it was still useful for nurturing students' attitude, 21st century skills and intellectual risk taking and collaboration in STEM. This result suggested that STEM week is especially suitable for the schools that had never developed STEM education before or have a tight schedule on teaching the main subjects. Students' attitude, intellectual risk taking, collaboration and 21st century skills towards STEM will instantly improve in a short period. If schools want to develop STEM education, they can implement the STEM week first and then adopt the regular class of STEM gradually to keep developing students' attitude, intellectual risk taking, collaboration and 21st century skills towards STEM.

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Appendices

Appendix A

STEM 專題式學習的學習動機問卷

*請在適當的空格內填上✓

性別：☐男 ☐女

	非常不同意	不同意	同意	非常同意
1. 科技將會令下一代有更多的機會。	☐	☐	☐	☐
2. 工程將會令下一代有更多的機會。	☐	☐	☐	☐
3. 數學將會令下一代有更多的機會。	☐	☐	☐	☐
4. 跨學科研究有助於更好地理解每個科目。	☐	☐	☐	☐
5. 科技使學習更有趣。	☐	☐	☐	☐
6. STEM 對我很重要。	☐	☐	☐	☐
7. 我喜歡我們在 STEM 方面的工作。	☐	☐	☐	☐
8. 我喜歡 STEM。	☐	☐	☐	☐
9. STEM 是我最喜愛的科目。	☐	☐	☐	☐
10. 我們在課堂上的活動對學習有用處。	☐	☐	☐	☐
11. 我覺得我參與了 STEM 課堂上的活動。	☐	☐	☐	☐
12. 我想再做一些相似的 STEM 活動。	☐	☐	☐	☐
13. STEM 活動對我來說真的很有意義。	☐	☐	☐	☐

Appendix B

21 世紀技能問卷

性別：☐男 ☐女

*請在適當空格內填上✓。

	非常不同意	不同意	同意	非常同意
1. 您認為參加 STEM 周有多少有助於改善你的溝通技巧？	☐	☐	☐	☐
2. 您認為參加 STEM 周有多少有助於改善你的匯報技巧？	☐	☐	☐	☐
3. 您認為參加 STEM 周有多少有助於改善你的解難能力？	☐	☐	☐	☐
4. 您認為參加 STEM 周有多少有助於改善你的科學思維？	☐	☐	☐	☐
5. 您認為參加 STEM 周有多少有助於改善你的合作技巧？	☐	☐	☐	☐
6. 您認為參加 STEM 周有多少有助於改善你的創新？	☐	☐	☐	☐
7. 您認為參加 STEM 周有多少有助於改善你的創意？	☐	☐	☐	☐
8. 您認為參加 STEM 周有多少有助於改善你使用的科技能力？	☐	☐	☐	☐
9. 您認為參加 STEM 周有多少有助於改善你的批判性思考？	☐	☐	☐	☐
10. 您認為參加 STEM 周有多少有助於改善你的生活和職業技能？	☐	☐	☐	☐

Appendix C

STEM 智能冒險與合作評估問卷

*請在適當的空格內填上✓

性別：☐男 ☐女

在 STEM 智能冒險方面：	非常不同意	不同意	同意	非常同意
1. 即使我不擅長新事物，我也會嘗試新事物。	☐	☐	☐	☐
2. 即使我不確定，我也分享了我的想法。	☐	☐	☐	☐
3. 即使我不確定如何，我還是嘗試做新事。	☐	☐	☐	☐
4. 我試圖尋找新的解決方法，即使它們可能沒有用。	☐	☐	☐	☐
5. 我試圖學習新的東西，即使我可能做錯。	☐	☐	☐	☐
6. 即使其他學生認為這不是一個聰明的問題，我也會提問。	☐	☐	☐	☐

在 STEM 分組活動時：	非常不同意	不同意	同意	非常同意
1. 我可以和組員一起討論。	☐	☐	☐	☐
2. 我可以在小組中自由表達我的意見。	☐	☐	☐	☐
3. 我可以通過小組工作培養合作技能。	☐	☐	☐	☐