香港教育大學
The Education University of Hong Kong

A Project entitled:

Evaluating pre-service teacher's STEM literacy and self-efficacy in teaching STEM

Submitted by

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Declaration

I, *Chan Mei Chun* declare that this research report represents my own work under the supervision of *Ms. Man Mei Sum,* and that it has not been submitted previously for examination to any tertiary institution.

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1. Abstract

Hong Kong has promoted STEM education in the General Studies (GS) curriculum to foster students' inventive abilities.; thus, GS teachers should allocate appropriate time for conducting STEM activities to enhance students' learning (Curriculum Development Council, 2017). The level of pre-service teachers' STEM literacy and self-efficacy will affect their teaching. This research evaluates GS pre-service teachers' literacy and self-efficacy toward STEM education. Mix-mode research will be adopted to conduct the study. Eighty responses to the questionnaire about STEM literacy and self-efficacy in teaching STEM were collected from pre-service GS teachers. The semi-structured interviews were conducted with four pre-service teachers with different STEM backgrounds.

In the finding of this research, it can be found that pre-service teachers' STEM literacy and self-efficacy would be affected by their STEM background. Pre-service teachers with better STEM teaching and learning experience would have a higher level of STEM literacy. If they had a higher level of STEM literacy, their self-efficacy would also be increased. Apart from these, this research also reveals that GS students had difficulty developing STEM literacy in the GS curriculum. Based on the finding and discussion in this research, the study provides suggestions for tertiary education to enhance GS pre-service teachers' STEM literacy and self-efficacy.

Keywords: STEM literacy, self-efficacy, pre-service teacher

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1. Introduction

Since 2015, Hong Kong has emphasized STEM education, an abbreviation for Science, Technology, Engineering, and Mathematics (Curriculum Development Council, 2015). In addition to fostering students' creativity, collaboration, and problem-solving abilities, as well as their innovation and entrepreneurial spirit as necessary for the 21st century, the goal of STEM education is to strengthen students' capacity to integrate and apply knowledge and skills to solve authentic problems through various STEM learning activities (Education Bureau, 2016).

Nonetheless, a problem in Hong Kong is that pre-service GS teachers may need help implementing STEM education as they may need more STEM training and knowledge. Compared to other countries, Hong Kong educators are behind the times when promoting STEM education. Some pre-service teachers in Hong Kong may have low levels of STEM literacy as they have never undergone STEM training. Lack of STEM experience and low levels of STEM literacy may also affect their self-efficacy in teaching. However, a teacher's sense of self-efficacy impacts a student's academic performance in several ways, such as appropriate teaching methods, classroom issues, and other strategies (Mojavezi & Tamiz, 2012). It reflects that it is necessary to evaluate pre-service GS teachers' STEM literacy and self-efficacy to raise suggestions to tertiary institutions on increasing their STEM literacy and self-efficacy, which can enhance students' learning.

2. Literature Review

2.1 Developing STEM literacy through STEM education

STEM education is an interdisciplinary approach that encourages students to apply science, technology, engineering, and mathematics in real-life settings that connect classrooms, communities, workplaces, and the wider world to develop STEM literacy (Nurlaely, Permanasari & Riandi, 2017). In light of Hong Kong's ongoing curriculum renewal, the General Studies curriculum has begun to promote STEM education in the strand of "Science and Technology in Everyday Life" to give students learning opportunities to demonstrate their ability to solve daily problems in real-life (Curriculum Development Council, 2017).

The objective of STEM education is STEM literacy (Bybee, 2013). STEM literacy refers to the ability to recognize, use, and integrate concepts from science, technology, engineering, and mathematics to comprehend complicated issues and develop novel solutions (Zollman, 2012). It should not be considered a content area only but rather a deictic means (consisting of knowledge, skills and abilities) to further learning (Huang, Erduran, Luo, Zhang & Zheng, 2022). The literature shows that STEM literacy consists of knowledge (recognizing concepts), skills (using concepts), and attitude (attitude toward STEM education).

However, different scholars also have an additional focus on STEM literacy. Huang et al. (2022) think STEM literacy emphasizes discipline, knowledge, skills, and attitude. On the other hand, Attard, Grootenboer, Attard, and Laird (2020) think that STEM literacy emphasizes enhancing skills (creativity, problem-solving, teamwork, and higher-order thinking) rather than disciplinary knowledge, especially in Asian countries. Actually, for the situation in Hong Kong, STEM literacy will be more focused on skills for integrating and applying knowledge to think about different designs for solving daily problems. Curriculum Development Council (2015) mentioned that students in Hong Kong already performed well in science, technology, and mathematics knowledge but seldom did hands-on activities. It is necessary to increase their skills in solving daily problems by designing and thinking of different solutions in hands-on activities. Therefore, skills, one of the components of STEM literacy, are most important in Hong Kong's STEM education. It will be the focus of the research.

2.2 Problem-solving skills in STEM education

According to Struyf, Loof, Pauw & Petegem (2019), STEM education encourages students to pursue a deeper understanding. It facilitates the acquisition of 21st-century skills, which include problem-solving, invention, creativity, cooperation, and critical thinking (Koul, Frasera & Nastitia, 2018). The most crucial ability that today's students need is problem-solving, which they require both inside and outside the classroom (Rahman, 2019). Students have to deal with

different problems in the real world. It takes more than just information and knowledge (Netwong, 2018). It reveals that problem-solving skills are the most important one in STEM literacy. Considering the importance of problem-solving abilities mentioned above, the research on pre-service teachers' STEM literacy will center on their problem-solving ability.

Premalatha (2020) mentioned that problem-solving is synonymous with thinking, reasoning, critical thinking, and creative thinking. The act of thinking is considered cognitive processing, which includes both types of thinking, such as directed thinking (problem-solving) and undirected thinking (like daydreaming). Ordering, comparing, contrasting, evaluating, and selecting skills are among the many that can be used in problem-solving. In general, according to Akçay and Ceylan (2020), there are a few steps involved in problem-solving, including:

i) Noticing the problem

ii) Collecting information about the problem

iii) Identifying possible solutions

iv) Apply the most suitable solutions

v) Assessing the solution

Problem-solving skills, one of the STEM literacy elements, are related to STEM education. People that receive STEM education are better equipped to use the fields of science, technology, engineering, and mathematics to solve problems (Akçay & Ceylan, 2020). The design cycle from The Curriculum Development Council (CDC) is used as the framework in STEM education for this purpose. It is the process of developing the best possible solutions to a problem (Curriculum Development Council, 2017). The design cycle is beneficial to students learning problem-solving abilities in STEM education. Similar design cycle and problem-solving steps are provided in the table as follows:

Table 1: The steps of the design cycle and problem-solving skills

Steps	**Design Cycle** (The Curriculum Development Council, 2017)	**Problem Solving Skills** **(**Akçay & Ceylan., 2020)
1	Define the needs and problems	Noticing the problem
2	Search, select and organize relevant information	Collecting information about the problem
3	Develop a solution	Identifying possible solutions
4	Implement and manage the solution, focusing on testing and improvement	Apply the most suitable solutions
5	Discuss with others the proposed solution and its effectiveness	Assessing the solution

2.3 Pre-service teacher's self-efficacy

According to Nielsen (2022), self-efficacy generally refers to confidence in one's ability to organize and carry out essential tasks to achieve a particular result. Individuals who have high self-efficacy view problems as chances to learn essential knowledge and skills while also coping mechanisms. Contrarily, those with poor self-efficacy tend to question their abilities and avoid difficulties, which results in less perseverance when dealing with challenging circumstances (Bandura, 1994, as cited in Salar, 2021).

According to Sharp, Brandy, Tuft & Jay (2016), pre-service teachers with high levels of self-efficacy are more motivated to put in extra time, effort, and perseverance in teaching STEM and vice versa. It reflects that pre-service teachers' self-efficacy affects their teaching effectiveness in STEM education, as their self-efficacy can strongly predict classroom behaviours (Flores & Day, 2006). Personal performance, vicarious experience, verbal persuasion, and psychological state are the four informational sources that either increase or decrease a teacher's sense of self-efficacy (Bandura,1977). Yada et al. (2021) mentioned that personal experience describes a person's past success or failure in a certain circumstance. This source has been deemed the most potent of the four for boosting self-confidence. The impact of watching someone else complete a challenging activity is known as a "vicarious experience" (Yada et al., 2021). The third source is verbal persuasion, or positive criticism can boost someone's self-efficacy. Finally, psychological and emotional variables like worry, tension, and

weariness might have an impact on one's level of self-efficacy (Yada et al., 2021). These resources will impact how prospective teachers develop and practice literacy teaching techniques throughout the educational program and outside the classroom. As ‘‘personal experience’’, one of the four elements, has been found to influence self-efficacy the most, according to Yada et al. (2021), pre-service teachers' personal experience in STEM will be investigated in this research.

The literature shows the direct effect between personal experience and self-efficacy (see figure-1). Shahat, Al-Balushi & Al-Amri (2022) mentioned that pre-service teachers with STEM teaching and learning experience have greater levels of self-efficacy in terms of conceptual understanding and skill sets in STEM. It reflects that pre-service teachers with STEM experience can enhance their STEM literacy (conceptual understanding of STEM and skills) and self-efficacy. There is a relationship between STEM experience, STEM literacy, and self-efficacy. Adams, Miller, Saul, and Pegg (2014) mentioned that pre-service teacher education program offering STEM courses (learning experience) could enhance their STEM literacy, while it can also be enhanced by STEM teaching experience (Pressick-Kilborn & Prescott, 2020). It reflects that the STEM experience can enhance student teachers' STEM literacy.

On the other hand, Premalatha (2020) mentioned that problem-solving skills could enhance student teachers' self-efficacy in teaching. It means that STEM literacy (problem-solving skills) will enhance pre-service teachers' self-efficacy in teaching STEM. Therefore, considering the above literature, my predictions of the relationship between personal experience and self-efficacy are an indirect effect as a researcher (see figure-2). I predict that pre-service teachers with personal STEM teaching and learning experience will have higher STEM literacy (problem-solving skills). Then their self-efficacy in teaching STEM will be increased. My research will be analyzed whether the prediction is true or false.

Figure 1: The direct effect between personal experience and self-efficacy

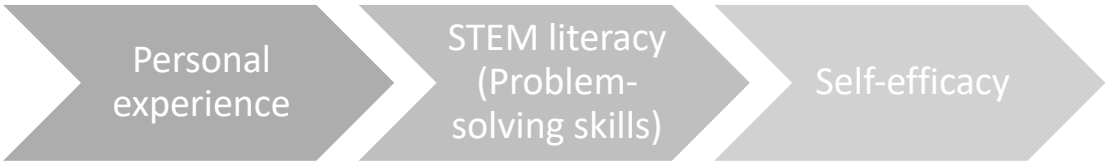

Figure 2: The indirect effect between personal experience and self-efficacy

2.4 Pre-service teacher's challenges and education

Educators in STEM fields encounter several challenges (Lee, Chai & Hong, 2018). According to Wu, Peng, and Hu (2021), pre-service teachers in China frequently lack the skills

necessary to create and administer an integrated STEM curriculum. Apart from these, Pre-services teachers in Turkey also lack expertise in STEM fields and their applications (Yuksel, Delen & Sen, 2020). It reveals that pre-service teachers in different countries were also concerned about STEM teaching. Pre-service teachers in Hong Kong may face the same challenge. In Hong Kong, Geng, Jong, and Chai (2019) mentioned that half of the in-service teachers were concerned about implementing STEM education, while only 5% were well-prepared for STEM teaching. GS pre-service teachers may face the same challenges; thus, analyzing their self-efficacy and confidence in teaching STEM is necessary. Because of the limited literature, the research gap about pre-service teachers' STEM literacy and self-efficacy in HK is meant to be filled through this research.

A student's success in these subjects may depend on pre-service teachers' understanding of and attitudes toward STEM integration and applications (Yuksel, Delen & Sen, 2020). It reflects the necessity of enhancing pre-service teachers' literacy and self-efficacy in teaching STEM. Salar (2021) mentioned that pre-service teachers in Turkey think that pre-service teachers do no not feel entirely prepared to incorporate the STEM fields as the training is insufficient. The fact in Turkey shows that pre-service teachers' understanding of and attitudes toward STEM education will be affected by teacher education. It is critical to decide whether STEM education can be a success.

In teacher training programs, pre-service teachers can improve their teaching efficacy the most (Velthuis, Fisser & Pieters, 2014). According to Pressick-Kilborn and Prescott (2020), school-University partnerships can enrich student teachers' confidence and enthusiasm in teaching STEM. It provides an authentic and valuable space where pre-service teachers can develop their knowledge, skills, and identity as effective teachers. As pre-service teachers' confidence in teaching STEM will be enhanced by the school-university partnership, it reveals the relationship between their level of self-efficacy in teaching STEM and STEM training. This report suggests increasing their self-efficacy through tertiary education to boost pre-service teachers' STEM literacy and self-efficacy.

3. Research objective and questions

This research aims to investigate pre-service teachers' STEM literacy and self-efficacy. There is no prior research on pre-service teachers' STEM literacy and self-efficacy in Hong Kong. Therefore, this research will enrich this research gap.

To perform a successful study, some research questions will be conducted as the research guideline. The research questions are as follows:

1. What is the difference between pre-service GS teachers with and without STEM teaching and learning experience's STEM literacy and self-efficacy level, respectively?
2. Will pre-service teachers' self-efficacy be affected by their level of STEM literacy?

Based on the above research question, it aims to provide suggestions for tertiary education to increase GS pre-service teachers' STEM literacy and self-efficacy through the education program.

4. Methodology

4.1 Research method

The research design will use a mixed mode, combining qualitative and quantitative research to investigate pre-services GS teachers' STEM literacy and self-efficacy. Mixed-mode research can investigate the research question in depth (Creswell, 2019).

In the qualitative section of the research, in-depth interviews will be conducted to collect opinions from pre-service GS teachers. The semi-structured interview allows for asking open-ended questions for data collection (Adams, 2010).

In the quantitative section of the research, pre-service GS teachers will be invited to fill in a questionnaire to analyze their STEM literacy and self-efficacy.

4.2 Participants

The GS students at The Education University of Hong Kong will be invited to do the questionnaires. Convenience and snowball sampling were adopted for the questionnaire and in-

depth interviews, respectively. For the quantitative part, GS major students in EdUHK between years one to five will be invited to do a questionnaire survey through convenience sampling as it is a "Convenient" selection of participants.

For the qualitative part, snowball sampling will be used in the interview section to approach pre-service GS teachers with different learning and teaching experience in STEM education. Four GS pre-service teachers with different STEM backgrounds will be invited to do the interview. It aims to discover the difference in STEM literacy and self-efficacy between GS students with and without STEM teaching and learning experience.

4.3 Data collection and analysis

1) Questionnaire

To assess pre-service GS teachers' STEM literacy and self-efficacy, they will be required to fill in a questionnaire with three parts, including personal information (6 items), STEM literacy (7 items), and self-efficacy (11 items) (See Appendix—questionnaire). Viewing the related literature, no specific scales can assess pre-service teachers' STEM literacy and self-efficacy with a focus on problem-solving skills. Therefore, the questionnaire of this research will be a modified version referring to scales in different literature. The questions about STEM literacy in this research refer to the STEM literacy questionnaire developed by Chamrat, Manokarn & Thammaprateep (2019), while the questions about self-efficacy make reference

to STEM Teaching Self-efficacy Scale (STSS) developed by Yang (2021). It would be modified as having more relationship with problem-solving skills because problem-solving skills are the most important element in STEM literacy. In the part of personal information, their education level, teaching, and learning experience will be collected. In part on STEM literacy and self-efficacy, a 5-point scale from one (strongly disagree) to five (strongly agree) will be used to assess the level of pre-service teachers' STEM literacy and self-efficacy. The data of pre-service GS teachers with and without STEM teaching and learning experiences can be compared in this research. It can also be determined whether their self-efficacy is related to their level of STEM literacy by analyzing quantitative data from questionnaires.

2) Interview

In-depth interviews will be conducted to collect opinions from pre-service GS teachers. The questions are divided into four parts: personal information (3 items), STEM literacy (4 items), self-efficacy (8 items), and suggestions for GS education (2 items) (see Appendix—interview questions). It is flexible and allows GS pre services teachers to share their thoughts and experiences on the topic. It aims to collect more opinions that can be responded to the research question. The interview will be conducted in Cantonese with an audio recording, translated into English transcription (see Appendix—interview transcription).

5 Finding

5.1 Participants in the research

For the quantitative part, there were 80 responses to the questionnaire. The number of eighty GS students finished all responses between year one to year five. Most respondents were from year two (23.75%), then the second most were year three (22.5%) and year five students (22.5%), and the fourth most were year four students (20%). Year one students (11.25%) were the least. All the respondents with STEM teaching experience also have a learning experience in STEM education. The following table shows the overview of respondents' background information in STEM.

Table 2: Overview of respondent's background information (N refers to number)

Background information	N (%)
Respondents with STEM minor	25 (31.3%)
Respondents with STEM learning experience	57 (71.25%)
Respondents with STEM learning experience without STEM teaching experience	25 (31.25%)
Respondents with STEM teaching experience	32 (40%)
Respondents with STEM teaching and learning experience	32 (40%)
Respondents with STEM minor and learning experience	17 (21.25%)
Respondents without STEM teaching and learning experience	23 (28.75%)

For the qualitative part, four GS students were invited to do interviews. Four interviewees also learned basic STEM knowledge in GS major core courses but had different STEM backgrounds. Below is the overview of the interviewee's background information.

Table 3: Overview of interviewee's background information

	Year	Minor	Teaching experience
Interviewee A	3	Creativity in STEM/STEAM (2 courses)	Without
Interviewee B	4	Chinese Language Inclusive Education	Without
Interviewee C	5	Creativity in STEM/STEAM Chinese Language	Yes
Interviewee D	5	Chinese Language Counseling	Yes

5.2. Level of STEM literacy in problem-solving skills

This part will be analyzed the difference between pre-service GS teachers (PST) with and without STEM teaching and learning experience's STEM literacy, respectively.

Table 4: Overview of respondents' STEM literacy in problem-solving skills

		Mean	Median
A	PST with learning experience without teaching experience in STEM	3.7	4
B	PST with STEM teaching and learning experience	4	4
C	PST with STEM minor and teaching experience	4.26	4
D	PST without STEM learning and teaching experience	2.93	3

Table four shows the mean and median scores of pre services teachers' STEM literacy. The Median and Mean were near, showing the data's accuracy. It could be found that pre services teachers with STEM minor and teaching experience had the highest mean score of STEM literacy (4.26). In contrast, pre services teachers without STEM teaching and learning experience had the lowest mean score of STEM literacy (2.93).

Apart from this, the testing item in the questionnaire is connected with the steps of problem-solving skills, which aims to evaluate the difference between GS PST with and without STEM teaching and learning experience's STEM literacy (problem-solving skills). The letters 'A', 'B,' 'C,' and 'D' refer to PST with different STEM backgrounds, respectively, according to table 4. Below is a deeper table about the means of PST STEM literacy in different processes of problem-solving skills:

Table 5: Data of testing items of respondents' STEM literacy in problem-solving skills

(M refers to mean)

Testing items **(STEM literacy in problem-solving skills)**	**M (A)**	**M (B)**	**M (C)**	**M(D)**
Item 1 (Step 1: Noticing the problem)	3.76	3.94	4.24	2.96
Item 2 (Step 2: Collecting information about the problem)	3.8	4.13	4.24	3
Item 3 (Step 3: Identifying possible solutions)	3.72	3.91	4.18	2.96

Item 4 (Step 4: Apply the most suitable solutions)	3.68	4.06	4.35	2.74
Item 5 (Step 4: Apply the most suitable solutions)	3.56	4	4.29	2.74
Item 6 (Step 5: Assessing the solution)	3.72	3.91	4.18	3.13
Item 7 (Step 5: Assessing the solution)	3.68	4.09	4.35	2.96

Table five shows the mean score in different testing items of pre-service teachers' STEM literacy in problem-solving skills with different STEM backgrounds. It can be found that pre services teachers with STEM minor and teaching experience had the highest mean score of STEM literacy in all testing items. In contrast, pre-service teachers without STEM teaching and learning experience had the lowest mean score in all testing items. It could also be found that pre-service teachers with teaching and learning experiences' STEM literacy (problem-solving skills) in all testing items were higher than pre-service teachers who had learning experience only.

5.3 Level of self-efficacy by using problem-solving skills

This part will be analyzed the difference between pre-service GS teachers (PST) with and without STEM teaching and learning experience's STEM self-efficacy, respectively.

Table 6: Overview of respondents' STEM self-efficacy

		Mean	**Midian**
A	PST with learning experience without teaching experience in STEM	3.66	4
B	PST with STEM learning and teaching experience	3.94	4
C	PST with STEM minor and teaching experience	4.17	4
D	PST without STEM learning and teaching experience	2.86	3

Table six shows the mean and median scores of pre-service teachers' self-efficacy in teaching STEM. It can be found that pre-service teachers with STEM minor and teaching experience had the highest mean score of self-efficacy (4.17). In contrast, pre-service teachers without STEM teaching and learning experience had the lowest mean score of self-efficacy (2.86).

Table 7: Items that show respondents' STEM positive self-efficacy

Items	Description	A	B	C	D
		Positive (%)			
5	I can motivate students to participate in STEM problem-solving learning activities.	72%	84.4%	82.4%	56.5%
7	I can determine whether the students have achieved the learning goals in STEM problem-solving activities.	76%	81.3%	82.4%	56.5%

Overall, pre-service teachers with or without STEM teaching and learning experience also show positive self-efficacy in two items (refer to table 7). Over half of the pre-service teachers show positive self-efficacy in items 5 and 7. Over 80% of respondents with STEM teaching and learning experience indicated that they could motivate students to participate in STEM problem-solving learning activities (item 5) and determined whether they have achieved the learning goals in STEM problem-solving activities (item 7). On the other hand, even though

respondents without STEM experience have a lower level of self-efficacy, over half of them (56.5%) indicated that they could motivate students to participate in STEM problem-solving learning activities (item 5) and determined whether the students have achieved the learning goals in STEM problem-solving activities (item 7).

Table 8: Items that show respondents' STEM negative self-efficacy.

Items	Description	A	B	C	D
		Unc and Neg (%)			
3	I have the ability to enhance students' STEM literacy (problem-solving skills).	52%	34.4%	29.4%	78.2%
6	By using problem-solving skills, I can answer students' questions in STEM lessons.	60%	34.4%	29.4%	78.2%
8	By using problem-solving skills, I can give the student feedback on their STEM learning.	40%	15.7%	11.8%	69.5%
9	By using problem-solving skills, I can provide efficient learning activities in STEM education.	40%	25%	17.7%	60.9%

However, many respondents felt uncertain or negative in items 3, 6, 8, and 9 about self-efficacy in teaching STEM (see table 8), especially for the PST without STEM teaching and learning experience or only had learning experience without teaching experience. Over 60% of respondents who did not have STEM experience had a negative self-efficacy regarding items 3, 6, 8, and 9. It can be found that 78.2% of PST without STEM teaching and learning

experience think they were not sure they could enhance students' STEM literacy (item 3) and answer students' questions (item 6). Over 40% of respondents with only STEM learning experience had a negative self-efficacy regarding items 3, 6, 8, and 9. Those items, such as providing efficient learning activities, need deeper STEM understanding. Pre-service teachers who lacked STEM experience had lower STEM literacy. They lacked in-depth STEM knowledge, therefore, had lower self-efficacy in teaching.

Overall, respondents did not have a higher level of self-efficacy in teaching STEM, especially pre-service teachers without teaching and learning experience. Even though pre-service teachers with STEM learning experience without STEM teaching experience, they also did not have a higher level of self-efficacy. Comparing the data of these four groups of pre-service teachers with different STEM backgrounds, the pre-service teacher with STEM teaching and learning experience had a higher level of self-efficacy, especially those with a STEM minor.

5.4 Relationship between STEM literacy and self-efficacy in teaching STEM by using problem-solving skills

The mean of pre-service teachers' STEM literacy and self-efficacy can be found in the questionnaire. To compare their STEM literacy and self-efficacy, it can find that pre-service teachers' STEM literacy is related to their self-efficacy (see figure 3). When PST with STEM

minor and teaching experience have a higher level of STEM literacy (4.26), they will also have a higher level of self-efficacy (4.17). In contrast, when PST without STEM learning and teaching experience have a lower level of STEM literacy (2.93), they will also have a lower level of self-efficacy (2.86). It reveals a significant correlation between STEM literacy and self-efficacy.

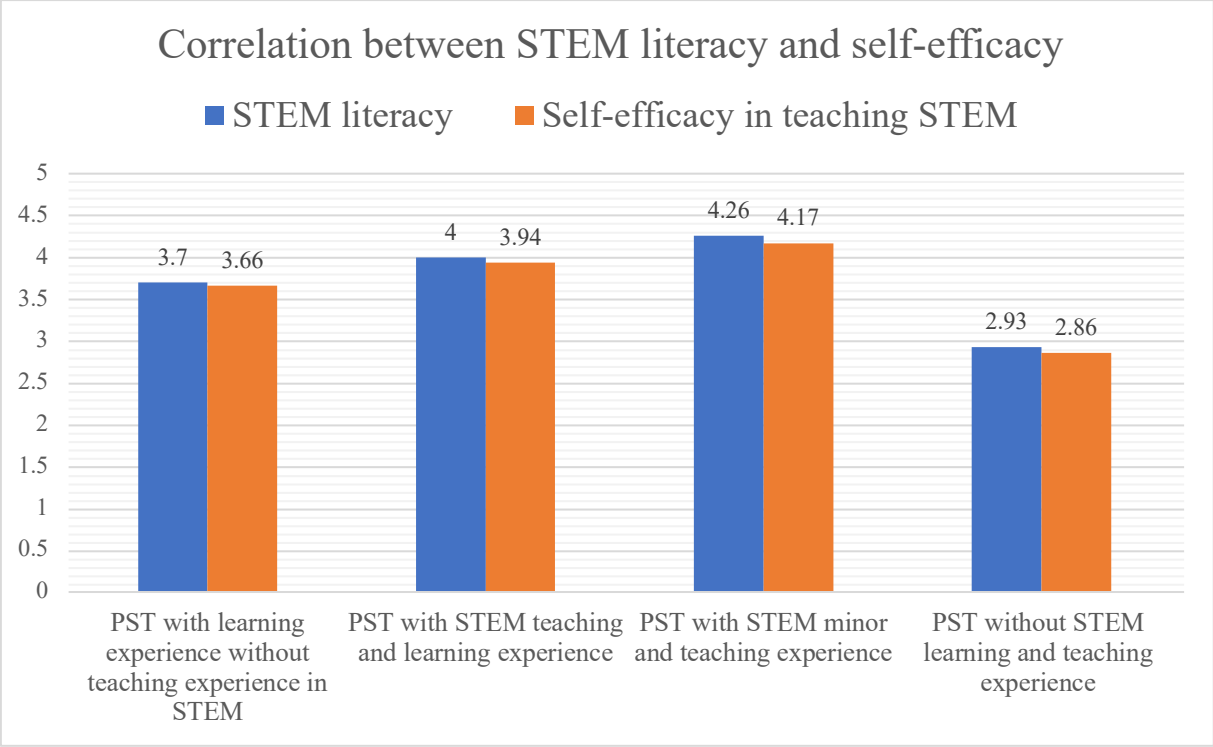

Figure 3: Correlation between STEM literacy and self-efficacy

Interviewees with or without STEM teaching and learning experience also think that STEM literacy will affect their confidence in STEM teaching. Self-efficacy refers to confidence in one's ability to organize and carry out essential tasks to achieve a particular result (Nielsen,

2022). If STEM literacy affects pre-service teachers' confidence in STEM teaching, it also affects their self-efficacy in STEM teaching. All interviewees also thought that they would be more confident in STEM teaching after developing their STEM literacy. Below are the reasons why the level of STEM literacy affects their self-efficacy:

> *Through the development of STEM literacy, I have a certain knowledge base and skills to transfer knowledge to students. I can also make the teaching content more prosperous and diverse. When STEM literacy develops to a certain level, I also have more confidence in teaching STEM.*
>
> *Interviewee A*

> *Before cultivating students' STEM literacy, I should also deconstruct STEM literacy by myself to understand how to develop STEM literacy in students.*
>
> *Interviewee B*

> *Because developing STEM literacy, such as knowledge and skills, will allow me to gain more knowledge to teach students STEM content. Developing STEM skills, such as problem-solving skills, also will enable me to understand how to help students develop STEM skills. It makes my teaching more holistic and better.*
>
> *Interviewee C*

Because teachers need to have STEM literacy to develop STEM literacy in students. If the teacher's STEM literacy is low, the student will learn to limit things.

Interviewee D

They mentioned that they should develop their own STEM literacy (knowledge and skills) before cultivating students' STEM literacy. Interviewee C also mentioned that developing STEM literacy allows her to gain more knowledge to teach students STEM content and learn how to develop students' STEM skills. After developing their STEM literacy (knowledge, skills, and attitude), they all said they would be more confident in STEM teaching. If they have a higher level of STEM literacy, they will have more confidence in STEM teaching, which means self-efficacy. Both questionnaire and interview results also show the correlation between STEM literacy and self-efficacy.

6 Discussion

6.1 STEM literacy in problem-solving skills

Pre-service teachers' STEM teaching and learning experience will affect their STEM literacy. The testing items in the questionnaire are based on steps of problem-solving skills with reference to Akçay & Ceylan (2020). It can be found that pre-service teachers with STEM learning backgrounds have a higher level of STEM literacy than PST without STEM experience in all test items which relate to problem-solving skills. The results are consistent with the earlier

research that STEM learning experience can enhance STEM literacy (Adams et al., 2014). Apart from these, not only can STEM literacy be enhanced by the STEM learning experience (Adam et al., 2014), but it can also be enhanced by the STEM teaching experience (Pressick-Kilborn & Prescott (2020). The data from the questionnaire also shows that the pre-service teacher with STEM teaching and learning experience has the highest level of STEM literacy in comparison to PST who do not have any STEM experience or have STEM learning experience only. It also matches the earlier research that STEM literacy can be enhanced by both STEM teaching and learning experience. It can reveal that having both STEM teaching experience and learning experience will be significantly beneficial to the pre-service teachers' STEM literacy level.

All the interviewees also have STEM learning experiences because of courses in majors or minors of Creativity in STEM/STEAM. However, although all of them have STEM learning experience, two interviewees (Interviewees A & B) without STEM teaching experience did not know what STEM literacy is. It can be found that pre-service teachers' understanding of STEM literacy is still insufficient. In the following interview response, interviewees A and B also mentioned that their understanding of STEM literacy (knowledge and problem-solving skills) is limited because of a lack of STEM teaching and learning experience. It shows a direct relationship between STEM experience and STEM literacy.

STEM education emphasizes creativity and problem-solving skills. It is a flexible subject, yet I lack practical experience in STEM teaching.

Interviewee A

My major courses also have not taught STEM knowledge in deep. Therefore, I lack STEM knowledge and am unfamiliar with STEM topics.

Interviewee B

Although interviewees C and D have STEM teaching experience, they also faced challenges in teaching STEM. As research in STEM literacy is only focused on problem-solving skills, other STEM literacy, like creativity, is hard to measure in this research. Therefore, PST with STEM experience may also have difficulty in other elements of STEM literacy.

The difficulty I faced before was a lack of STEM literacy; therefore, I needed more time to self-learning STEM content. I also needed to research STEM applications, such as coding. Apart from these, I felt difficult to answer students' questions. Developing STEM literacy, such as knowledge and skills, will allow me to gain more knowledge to teach students STEM content. Developing STEM skills, such as problem-solving skills, also will enable me to understand how to help students develop STEM skills. It makes my teaching more holistic and better.

Interviewee C

Teachers need to have STEM literacy to develop STEM literacy in students. If the teacher's STEM literacy is low, the student will learn to limit things.

Interviewee D

As interviewee D mentioned in the above interview response, pre-service teachers' STEM literacy will affect students' STEM literacy. Interviewee D mentioned that if teachers have a lower level of STEM literacy, the students will learn to limit things. Interviewee C also mentioned that she struggled to understand STEM applications and answer students' questions because she faced the problem of a lack of STEM literacy before. Students' level of STEM literacy will be affected negatively. Therefore, it is necessary to provide STEM training and workshop for pre-service teachers in tertiary education.

6.2 Self-efficacy by using problem-solving skills

Respondents without STEM experience show a low level of self-efficacy in teaching STEM in eleven testing items of questionnaires in comparison to pre-service teachers with STEM experience. In items 5 and 7, PSTs, whether with or without STEM experience, also felt confident in motivating students to participate in STEM problem-solving learning activities and determining whether the students have achieved the learning goals in STEM problem-solving activities. It reflects that PSTs were also confident in enhancing students' motivation and setting up the learning goals in the STEM lesson. However, PST with learning experience only or without any STEM experience also had a negative self-efficacy in items 3, 6, 8, and 9, as more

than 40% of them have a negative self-efficacy (uncertain, disagree, and strongly disagree) in these four items. They thought they could not enhance students' STEM literacy (problem-solving skills) (item 3). By using problem-solving skills, they could not answer students' questions (item 6) and provide feedback to students in STEM lessons (item 8). They also thought they could not provide efficient learning activities in STEM lessons by using problem-solving skills (item 9). It could show that PSTs could motivate students' learning and determine learning goals (items 5&7). However, they did not have the confidence to teach STEM efficiently regarding items 3, 6, 8 and 9, which need an in-depth understanding of STEM education, especially PSTs without STEM teaching and learning experience or PSTs have learning experience only. They had a lower level of STEM literacy, and they did not have confidence in helping students to develop STEM literacy. It matches the previous literature in which Premalatha (2020) mentioned that their STEM literacy would affect PSTs' self-efficacy. Apart from these, interviewees A and B, without STEM teaching experience, also felt unconfident in STEM teaching because of lack of STEM literacy.

> *STEM education emphasizes creativity and problem-solving skills. It is a flexible subject, yet I lack practical experience in STEM teaching.*
>
> *Interviewee A*

> *I don't feel confident because I am not good at science. My major courses also have not taught STEM knowledge in deep. Therefore, I lack STEM knowledge*

and am unfamiliar with STEM topics. It causes me to have difficulty in designing the STEM curriculum.

Interviewee B

In contrast, Interviewees C and D, with STEM teaching and learning experience, felt confident in STEM teaching. Because of the teaching and learning experience, interviewees C and D also mentioned that they learned different teaching techniques for teaching STEM and skills for teaching STEM. As interviewee D tried to prepare teaching materials and curricula in STEM teaching experience, she could also have more understanding of the basic tools of STEM. Even though interviewee D did not have a STEM minor, she also felt confident in STEM teaching because of a lot of teaching experience and learning experience in her major. She joined the teaching development scheme conducted by EdUHK. Its scheme was a school-university partnerships proposal cooperating with primary and secondary schools. In this process, she could develop her STEM literacy by designing curricula, preparing teaching materials, publishing teaching kits, and teaching. She could also learn the skills of teaching STEM from her colleagues. It also matches with Pressick-Kilborn, and Prescott (2020) mentioned that school-university partnerships could enrich pre-service teachers' confidence in teaching STEM, providing a valuable space for PST to develop their STEM literacy. It reflects that school-university partnership is essential for boosting pre-service teachers' STEM literacy and self-efficacy. Below is the interviewee C and D's responses why they felt confident in teaching STEM:

Because during my five years in college, I minored in STEM and learned different teaching techniques for teaching STEM. I also have STEM teaching experience in primary schools, which gives me more confidence in teaching.

Interviewee C

Because I have relevant teaching experience. I've participated in "通過在線 STEAM 教學使創意思維可視化和具體化教學發展計劃" teaching development scheme before, which conducted by EdUHK. It cooperated with primary school and secondary school. In this process, I've tried to design curricula and teaching. It is practiced in primary school students. I also published teaching kits. Apart from these, I also work at an education center to design STEM courses and teach in elementary school classrooms. From these experiences, I gained a lot of hands-on experience and learned the skills of teaching STEM from my colleagues. In preparing teaching materials, I also have more understanding of the basic tools of STEM so that I can feel more confident.

Interviewee D

6.3 Relationship between personal experience, STEM literacy and self-efficacy in teaching STEM by using problem-solving skills

The correlation graphic indicates a significant relationship between pre-service teachers' STEM literacy and self-efficacy in STEM teaching by using problem-solving skills. If pre-service teachers have a higher level of STEM literacy (problem-solving skills), they will be

more confident in teaching, which matches Premalatha (2020) mentioned. The questionnaire and interviewee results reflect that personal teaching and learning experience in STEM relates to pre-service teachers' STEM literacy. Therefore, it can prove that the predictions of the relationship between personal experience and self-efficacy are an indirect effect is true. If pre-service teachers have STEM teaching and learning experience, they will also have a higher level of STEM literacy. Their self-efficacy will also be increased. The interviewees also mentioned that their STEM literacy would affect their confidence in STEM teaching. Interviewees A and C also mentioned that through the development of STEM literacy, they could have certain knowledge and skills to understand how to help students develop STEM skills. When STEM literacy develops to a certain level, they will have more confidence in teaching STEM. As interviewees B and D said, before cultivating students' STEM literacy, they should also deconstruct STEM literacy by themselves to understand how to develop STEM literacy in students. Otherwise, students will learn limited STEM literacy. It reflects that if they have a higher level of STEM literacy, they will have a higher level of self-efficacy in STEM teaching.

6.4 Suggestion

The interviewees also think that GS students cannot develop STEM literacy in the GS majors' curriculum. To improve this problem, the tertiary institutions (department of GS) can

adjust the GS major courses and provide workshops with internship opportunities for GS students.

6.4.1 Adjustment of GS major courses

The testing result in the questionnaire from respondents also reflects that PSTs needed an in-depth understanding of STEM education, especially PSTs without STEM teaching and learning experience or PSTs had learning experience only. Therefore, it is necessary to modify the GS major courses curriculum. All the interviewees also think that GS students could not develop STEM literacy in GS major curriculum as they could only learn fundamental knowledge in the GS curriculum. Interviewee D also mentioned that she heard school authorities point out before that the GS curriculum was designed without STEM elements; therefore, the knowledge of STEM in the major is limited. To solve this problem, the school only provides STEM minor. If GS students do not take STEM as a minor, they may have difficulty developing STEM literacy. Below are the interviewees' opinions:

> *Because the courses and class hours related to STEM education in major are limited, even though attending those courses. I also lacked STEM knowledge, including programming. As a result, I failed to develop adequate STEM literacy.*
>
> *Interviewee B*

It is because we can only learn fundamental topics in the GS curriculum, such as basic knowledge of science and social sciences. We will also learn pedagogy and classroom management, yet the core courses about STEM education are limited. It may cause GS students low STEM literacy, such as knowledge (Coding) and skills. We also have not learned how to stimulate students' problem-solving skills in the GS curriculum. Therefore, GS students cannot develop STEM literacy well in GS major curriculum, while a STEM minor will be better.

Interviewee C

The STEM courses in majors only teach basic knowledge for STEM teaching. STEM is not a significant subject in the GS curriculum. I've heard school authorities point out before that the GS curriculum was designed without STEM elements. Therefore, the knowledge of STEM in the major is also relatively shallow, and it does not allow students to master how to teach STEM. To solve this problem, the school has only provided STEM Minor. It means GS students without STEM minors may struggle to develop STEM literacy.

Interviewee D

To solve this problem, the school can increase the number of compulsory STEM courses in the GS curriculum, as the interviewees suggest. In the following response, interviewee B mentioned that STEM is a trend in the GS curriculum; therefore, schools should offer more

major STEM courses to teach students how to design STEM courses and construct knowledge. Interviewee D also mentioned that increasing the number of core STEM courses in the GS curriculum may be challenging as limited class hours. If it is hard to increase the STEM courses, schools can teach more pedagogy in STEM education.

> *I think schools can increase the number of compulsory STEM courses in the curriculum so that students can have a solid understanding of STEM. In addition, schools can buy more advanced STEM equipment to improve the educational experience for pupils.*
>
> *Interviewee A*

> *STEM is a trend in GS education; therefore schools should offer more major STEM courses to allow students to learn how to design STEM courses and construct knowledge, thereby building students' confidence in teaching STEM.*
>
> *Interviewee B*

> *I understand that schools have limited class hours, and increasing the number of core STEM courses in the GS curriculum is challenging. I hope that when preparing the content of the STEM courses in my major, the school can teach more pedagogy in STEM education.*
>
> *Interviewee D*

6.4.2 Workshop with internship opportunities

Apart from the learning experience, the teaching experience of STEM is also essential for pre-service teachers. From the data of the questionnaire, it can be found that pre-service teachers with STEM teaching and learning experience will have a higher level of STEM literacy and self-efficacy than PST with learning experience only. In the following response, Interviewee D also mentioned that as major STEM courses in the GS curriculum were knowledgeable, GS students may be unable to apply the knowledge in the actual situation of STEM teaching. It may make them feel unconfident in actual teaching.

> *At present, the STEM courses of major subjects are also knowledgeable, but GS students may not be able to apply everything they have learned in class.*
>
> *Interviewee D*

To improve pre-service teachers' STEM literacy and self-efficacy, the school can offer long-term STEM workshops with opportunities for internships at the school for GS students, as interviewees C and D suggested. Even though interviewee D does not have a STEM minor, she also feels confident in STEM teaching because she joined the teaching development scheme conducted by EdUHK with a school-university partnership before. She could develop her STEM literacy by joining the STEAM scheme in the process of teaching in primary school and preparing teaching materials and kits. It can enhance her STEM literacy and self-efficacy. Pressick-Kilborn and Prescott (2020) mentioned that school-university partnerships could

provide a place for PST to develop their STEM literacy and enrich student teachers' confidence and enthusiasm in teaching. Therefore, providing STEM workshop and programs are essential. Experienced teachers and professors can lead students to teach STEM in schools. Through those experiences, their STEM literacy and self-efficacy can be increased. Below are the suggestions from interviewee C and D:

> *In addition to minor courses in STEM, schools can offer long-term STEM workshops for students to learn STEM knowledge and teaching methods. They may also provide opportunities for internships at the school for GS students. For example, schools can give Micro: bit workshops for students to learn about stem teaching using technology. And then, during the workshop, EdUHK can provide opportunities for students to practice in elementary school.*
>
> *Interviewee C*

> *Schools can also set up more workshops and programs cooperating with different community centers or primary and secondary schools. Experienced teachers and professors lead students to teach STEM in centers or schools, allowing students to accumulate teaching experience.*
>
> *Interviewee D*

7. Conclusion

7.1 Limitation of the research

There are three limitations in the research. First, the sample size of questionnaires (80 responses) is limited; therefore, it only represents some of the pre-service GS teachers in Hong Kong. For another, considering the importance of problem-solving abilities mentioned above, STEM literacy in this research is only centered on problem-solving skills. However, according to Koul et al. (2018), STEM skills refer to 21st-century skills rather than problem-solving skills only. STEM literacy consists not only of STEM skills but also of STEM knowledge and attitude, according to Huang et al. (2022). Therefore, analyzing STEM literacy in this research is not comprehensive. Third, it uses questionnaires to evaluate PSTs' STEM literacy (problem-solving skills); yet the data may not be accurate. Their personality may affect the choices of STEM literacy and self-efficacy they chose in the questionnaire.

7.2 Implications

This research aims to enrich the research gap on pre-service teachers' STEM literacy and self-efficacy in Hong Kong. The finding shows the difference in pre-service GS teachers' STEM literacy and self-efficacy with different STEM learning and teaching background. It also suggests methods to improve pre-service teachers' STEM literacy and self-efficacy by adjusting GS major courses and providing workshops with internship opportunities. Based on this research, further research could be considered to evaluate the effectiveness of STEM

education in the GS curriculum in building pre-service teachers' STEM literacy and self-efficacy.

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Appendix—Questionnaire

Information

	Items	Answers
1	What is your study year in EdUHK?	1/2/3/4/5
2	Do you have experience in teaching STEM?	Yes / No
3	Can you describe your teaching experience in STEM?	Open question
4	Have you learned STEM in EdUHK or other organizations?	Yes / No
5	Do you have a STEM minor?	Yes / No
6	Can you describe your learning experience in STEM?	Open question

STEM Literacy in problem-solving skills

(1: Strongly disagree / 5: Strongly agree)

	Items	1	2	3	4	5
STEM application						
1	I can define the needs and problems in real life.					
2	I can search, select and organize the relevant information about the problems.					
3	I can identify different possible solutions to solve the problems.					
4	I can apply concepts and practices of STEM to be able to create things.					
5	I can apply the concepts and practices of STEM to solve problems.					

6	I can test and make improvements to the new things that I created.					
7	I can assess the effectiveness of new things that I created.					

Self-efficacy in teaching STEM by using problem-solving skills

	Items	1	2	3	4	5
Pedagogical Self-efficacy						
1	I can use different teaching strategies, methods, and techniques in conducting STEM problem-solving learning activities.					
2	I can use appropriate teaching methods to enhance students' problem-solving in STEM education.					
3	I have the ability to enhance students' STEM literacy (Problem-solving skills).					
4	By using problem-solving skills, I can guide students' learning in STEM education.					
5	I can motivate students to participate in STEM problem-solving learning activities.					
6	By using problem-solving skills, I can answer students' questions in STEM lessons.					
7	I can determine whether the students have achieved the learning goals in STEM problem-solving activities.					
8	By using problem-solving skills, I can give the student feedback on their STEM learning.					

9	By using problem-solving skills, I can provide efficient learning activities in STEM education.					
10	By using problem-solving skills, I can conduct STEM learning activities according to students' age and needs.					
11	I can teach STEM learning elements (problem-solving skills) in class.					

Appendix—Interview questions (Conducted in Cantonese)

第一部分：個人資料

First part: Personal information

1. 你的就讀年級是什麼？

   What is your study year?

2. 你的主修及副修科目是什麼？

   What is your major and minor subject?

3. 你有接受過 STEM 教學的課程或培訓嗎？如有，你能分享你接受 STEM 教學的課程或培訓的經驗嗎？

   Do you have STEM learning experience? If yes, can you share your learning experience?

第二部分：有關 STEM 素養

Second part: About STEM literacy

1. 請問你知道什麼是 STEM 素養嗎？如知道，你認為什麼是 STEM 素養？

   Do you know what STEM literacy is? If yes, what is STEM literacy?

2. 你認為什麼是解難能力？

   What is a problem-solving skill?

3. 你認為解難能力與 STEM 素養有什麼關係？

   What is the relationship between problem-solving skills and STEM literacy?

4. 你認為解難能力與 STEM 教育有什麼關係？

   What is the relationship between problem-solving skills and STEM education?

第三部分：有關對 STEM 教育的自我效能

Third part: About self-efficacy toward STEM education

1. 你有信心教授 STEM 的課程嗎？

   Are you feel confident in teaching STEM?

2. 你能分享在 STEM 範疇上的教學經驗嗎？（如有教學經驗）

   Can you share your teaching experience in STEM?

3. 在教授 STEM 的過程中，如何發展學生的解難能力？

   How can we enhance students' problem-solving skills in the process of STEM education?

4. 你能分享在 STEM 範疇上發展學生解難能力的經驗嗎？（如有教學經驗，而在 Q2 的分享未有提及發展學生解難能力的經驗）

   Can you share your experience enhancing students' problem-solving skills in STEM education?

5. 你在教授 STEM 的時候，遇到了什麼困難和挑戰？（如有教學經驗）

   During teaching STEM, what difficulties and challenges have you faced before?

6. 你認為 STEM 的教學經驗或學習經歷會否使你更有信心進行 STEM 教學？

   Do you think you will be more confident in STEM teaching after having a STEM teaching and learning experience?

7. 你認為發展自己的解難能力會否使你更有信心進行 STEM 教學？

   After developing your problem-solving skills, do you think you will be more confident in STEM teaching?

8. 你認為發展自己的 STEM 素養（包括知識、技能和態度）會否使你更有信心進行 STEM 教學？

   Do you think you will be more confident in STEM teaching after developing your STEM literacy (including knowledge, skills, and attitude)?

第四部分：對 STEM 教育的建議

Fourth part: Suggestions in STEM education

1. 你認為小學常識主修的大學課程足夠讓學生培養 STEM 素養嗎？

   Do you think GS students can develop STEM literacy in GS major curriculum?

2. 你需要教大在不同方面（例如政策或課程）能如何協助你進行 STEM 教學？

   Do you have any suggestions for EdUHK to assist your STEM teaching in different aspects, such as policy and curriculum?

Appendix—Interview transcription

The students in the GS major will be invited to do the semi-structured interview. It will conduct in Chinese, while the transcription will be presented in English. In the following transcription, ‘‘Q’’ refers to the interviewer, while ‘‘R’’ refers to the interviewee.

Interviewee: Student A (Year 3)	
Background information: *Without STEM teaching experience and with two courses in STEM minor*	
Q :	What is your study year?
R:	I am a year three student.
Q:	What is your major and minor subject?
R:	My major is General Studies, and my minor is Creativity in STEM/STEAM.
Q:	Do you have STEM learning experience? If yes, can you share your learning experience?
R:	Yes, I studied the courses from the minor of Creativity of STEM, which includes creativity in teaching and creativity & STEM for environmental sustainability.
Q:	Do you know what STEM literacy is?
R:	No.
Q:	STEM literacy refers to recognizing, using, and integrating concepts from science, technology, engineering, and mathematics to comprehend complicated issues and develop novel solutions. Apart from this, do you know what problem-solving skills are?

R:	Problem-solving skills refer to thinking of various solutions to solve problems. People with problem-solving skills will try to make changes to think of different solutions rather than complaining and giving up.
Q:	What is the relationship between problem-solving skills and STEM literacy?
R:	STEM literacy enhances people's ability to solve daily problems, which means problem-solving skills.
Q:	What is the relationship between problem-solving skills and STEM education?
R:	STEM education aims to enhance students' ability to create things and solve problems.
Q:	Are you feel confident in teaching STEM?
R:	Not really. STEM education emphasizes creativity and problem-solving skills. It is a flexible subject, yet I lack practical experience in STEM teaching.
Q:	How can we enhance students' problem-solving skills in the process of STEM education?
A:	Teachers can set a problem that needs to be solved and then guide students to think about the solutions using strategies (SCAMPER &CPS) and technology. It can improve students' problem-solving skills.
Q:	Do you think you will be more confident in STEM teaching after having a STEM teaching and learning experience?
A:	Yes, during the learning process in EdUHK, I learned more about using various devices, such as micro: bit and drones. Then, I can integrate them into the teaching, which makes me feel more confident in teaching.
Q:	After developing your problem-solving skills, do you think you will be more confident in STEM teaching?

A:	Yes, improving my problem-solving skills allows me to deal with various difficulties in teaching; thus, I will be more confident in teaching STEM.
Q:	Do you think you will be more confident in STEM teaching after developing your STEM literacy (including knowledge, skills, and attitude)?
A:	Of course, through the development of STEM literacy, I have a certain knowledge base and skills to transfer knowledge to students. I can also make the teaching content more prosperous and diverse. When STEM literacy develops to a certain level, I also have more confidence in teaching STEM.
Q:	Do you think GS students can develop STEM literacy in GS major curriculum?
A:	No. Currently, most of the core courses for the General Studies major still focus on basic knowledge only. Since it lacks compulsory STEM-related courses; therefore, students understanding of STEM literacy is still insufficient.
Q:	Do you have any suggestions for EdUHK to assist your STEM teaching in different aspects, such as policy and curriculum?
A:	I think schools can increase the number of compulsory STEM courses in the curriculum so that students can have a solid understanding of STEM. In addition, schools can buy more advanced STEM equipment to improve the educational experience for pupils.

Interviewee: Student B (Year 4 student)	
Background information: *Without STEM teaching experience and a STEM minor*	
Q :	What is your study year?
R:	I am a year four student.
Q:	What is your major and minor subject?
R:	My major is General Studies, and my minors are Chinese Language and Inclusive Education.
Q:	Do you have STEM learning experience? If yes, can you share your learning experience?
R:	Yes, in the GS major courses in EdUHK, I learned what STEM is, the application of STEM education in different primary schools, and the pedagogy.
Q:	Do you know what STEM literacy is?
R:	No.
Q:	STEM literacy refers to recognizing, using, and integrating concepts from science, technology, engineering, and mathematics to comprehend complicated issues and develop novel solutions. Apart from this, do you know what problem-solving skills are?
R:	I believe that problem-solving ability is the ability of students to solve problems when they encounter issues in different topics.
Q:	What is the relationship between problem-solving skills and STEM literacy?
R:	Problem-solving skills is one of the STEM literacy elements.
Q:	What is the relationship between problem-solving skills and STEM education?

R:	STEM is a flexible subject, not learning by rote knowledge. Students will encounter different problems in STEM activities that need to be solved by students to develop students problem-solving abilities.
Q:	Are you feel confident in teaching STEM?
R:	I don't feel confident because I am not good at science. My major courses also have not taught STEM knowledge in deep. Therefore, I lack STEM knowledge and am unfamiliar with STEM topics. It causes me to have difficulty in designing the STEM curriculum.
Q:	How can we enhance students' problem-solving skills in the process of STEM education?
A:	In order to build students' problem-solving abilities, teaching activities should be student-centered. It should allow students to try more in the classroom while it should not directly teach by teachers. Students' problem-solving abilities can be enhanced in solving problems in STEM education.
Q:	During teaching STEM, what difficulties and challenges have you faced before?
A:	I lack STEM knowledge, so I need more preparation before teaching, including teaching content and methods.
Q:	Do you think you will be more confident in STEM teaching after having a STEM teaching and learning experience?
A:	Yes, through STEM teaching and learning experience, I can develop my STEM literacy, such as STEM knowledge and problem-solving skills. It can make me feel more confident in teaching STEM.
Q:	After developing your problem-solving skills, do you think you will be more confident in STEM teaching?

A:	Yes, class activities in STEM education are mostly a process of problem-solving. It needs problem-solving skills. Therefore, if I have a high level of problem-solving skills, I will feel more confident in teaching students.
Q:	Do you think you will be more confident in STEM teaching after developing your STEM literacy (including knowledge, skills, and attitude)?
A:	Yes, before cultivating students' STEM literacy, I should also deconstruct STEM literacy by myself to understand how to develop STEM literacy in students.
Q:	Do you think GS students can develop STEM literacy in GS major curriculum?
A:	Not enough, because the courses and class hours related to STEM education in major are limited, even though attending those courses. I also lacked STEM knowledge, including programming. As a result, I failed to develop adequate STEM literacy.
Q:	Do you have any suggestions for EdUHK to assist your STEM teaching in different aspects, such as policy and curriculum?
A:	STEM is a trend in GS education; therefore, schools should offer more major STEM courses to allow students to learn how to design STEM courses and construct knowledge, thereby building students' confidence in teaching STEM. Schools can also provide internships for students to teach STEM in different schools.

Interviewee: Student C (Year 5 student)	
Background information: *With STEM teaching experience and a STEM minor*	
Q:	What is your study year?
R:	I am a year five student.
Q:	What is your major and minor subject?
R:	My major is General Studies, and my minors are Chinese Language and Creativity in STEM/STEAM.
Q:	Do you have STEM learning experience? If yes, can you share your learning experience?
R:	Yes, I have studied creativity in STEM/STEAM for three years. My tutor encourages me to create things. I will identify the problem in daily life and then solve the everyday problem by using creativity and STEM.
Q:	Do you know what STEM literacy is? If yes, what is STEM literacy?
R:	Yes, STEM literacy refers to using creativity and technology to create new inventions to solve the difficulties in daily life.
Q:	What is a problem-solving skill?
R:	Problem-solving skills refer to the ability of a person to use different skills and methods to solve difficulties in daily life.
Q:	What is the relationship between problem-solving skills and STEM literacy?
R:	Whether a person has a high problem-solving ability can be seen through STEM literacy, which combines knowledge in science, technology, engineering, and mathematics to solve problems.
Q:	What is the relationship between problem-solving skills and STEM education?

R:	If STEM education is taught well, students will be better able to solve problems and difficulties in their daily lives. I believe that STEM education aims to improve students' creativity and problem-solving ability so that when students encounter problems, they can think outside the box and think of different ways to solve problems in daily life.
Q:	Are you feel confident in teaching STEM?
R:	Yes, because during my five years in college, I minored in STEM and learned different teaching techniques for teaching STEM. I also have STEM teaching experience in primary schools, which gives me more confidence in teaching.
Q:	Can you share your teaching experience in STEM?
R:	I taught STEM using Micro: bit in primary school before. We chose a life topic related to the safety of night cyclists. Students needed to design bike clothing and helmets using Micro: bit, such as using Micro: bit to switch LED lights on the helmet. Therefore, students combined technology to solve problems in daily life. It could also enhance students' problem-solving skills.
Q:	How can we enhance students' problem-solving skills in the process of STEM education?
A:	I will encourage students to use their creativity more, let students pay attention to things in daily life, and use creativity to solve difficulties in everyday life. When it comes to creating something new, students will encounter obstacles. Therefore, I will encourage students to think outside the box and think of more ways to solve problems with multi-angle thinking to improve students' problem-solving abilities.
Q:	During teaching STEM, what difficulties and challenges have you faced before?

A:	The difficulty I faced before was a lack of STEM literacy; therefore, I needed more time to self-learning STEM content. I also needed to research STEM applications, such as coding. Apart from these, I feel difficult to answer students' questions.
Q:	Do you think you will be more confident in STEM teaching after having a STEM teaching and learning experience?
A:	Yes, through taking STEM courses, I can learn about STEM knowledge. Also, through my STEM teaching experience, I will know what difficulties students at different levels generally encounter. When I devote myself to the education industry in the future, I will also be able to produce teaching materials according to their difficulties. I can also design teaching materials depending on their needs. It makes me more confident in teaching.
Q:	After developing your problem-solving skills, do you think you will be more confident in STEM teaching?
A:	Yes, there will be a lot of difficulties in teaching STEM, such as failure when making different STEM products. Therefore, developing problem-solving skills gives me more confidence in solving challenges in teaching.
Q:	Do you think you will be more confident in STEM teaching after developing your STEM literacy (including knowledge, skills, and attitude)?
A:	Yes, because developing STEM literacy, such as knowledge and skills, will allow me to gain more knowledge to teach students STEM content. Developing STEM skills, such as problem-solving skills, also will enable me to understand how to help students develop STEM skills. It makes my teaching more holistic and better.
Q:	Do you think GS students can develop STEM literacy in GS major curriculum?

A:	No, it is because we can only learn fundamental topics in the GS curriculum, such as basic knowledge of science and social sciences. We will also learn pedagogy and classroom management, yet the core courses about STEM education are limited. It may cause GS students low STEM literacy, such as knowledge (Coding) and skills. We also have not learned how to stimulate students' problem-solving skills in the GS curriculum. Therefore, GS students cannot develop STEM literacy well in GS major curriculum, while a STEM minor will be better.
Q:	Do you have any suggestions for EdUHK to assist your STEM teaching in different aspects, such as policy and curriculum?
A:	In addition to minor courses in STEM, schools can offer long-term STEM workshops for students to learn STEM knowledge and teaching methods. They may also provide opportunities for internships at the school for GS students. For example, schools can give Micro: bit workshops for students to learn about stem teaching using technology. And then, during the workshop, EdUHK can provide opportunities for students to practice in elementary school.

Interviewee: Student D (Year 5 student)	
Background information: *With STEM teaching experience and with one course in STEM minor*	
Q :	What is your study year?
R:	I am a year five student.
Q:	What is your major and minor subject?
R:	My major is General Studies, and my minors are Chinese Language and counseling.
Q:	Do you have STEM learning experience? If yes, can you share your learning experience?
R:	Yes, I studied STEM in major courses. It involves some STEM knowledge and pedagogy. I also learned one STEM course: nurturing creativity through Visual Arts activities.
Q:	Do you know what STEM literacy is? If yes, what is STEM literacy?
R:	Yes, I think STEM literacy refers to knowledge of Science, Technology, Engineering, and Mathematics.
Q:	Besides knowledge, STEM literacy refers to using and integrating concepts from science, technology, engineering, and mathematics to comprehend complicated issues and develop novel solutions. Besides, do you know what problem-solving skill is?
R:	Problem-solving skills refer to whether a person can adopt appropriate solutions to solve problems.
Q:	What is the relationship between problem-solving skills and STEM literacy?
R:	Skills in STEM literacy are related to problem-solving.

Q:	What is the relationship between problem-solving skills and STEM education?
R:	I think that problem-solving skills are often used in STEM education. Most STEM teaching methods are based on one problem, so students need to use problem-solving skills. STEM knowledge can be used as a foundation for STEM teaching, allowing students to think of solutions to different problems by using the knowledge.
Q:	Are you feel confident in teaching STEM?
R:	Yes, because I have relevant teaching experience.
Q:	Can you share your teaching experience in STEM?
R:	Yes. I've participated in "通過在線 STEAM 教學使創意思維可視化和具體化教學發展計劃" teaching development scheme before, which conducted by EdUHK. It cooperated with primary school and secondary school. In this process, I've tried to design curricula and teaching. It is practiced in primary school students. I also published teaching kits. Apart from these, I also work at an education center to design STEM courses and teach in elementary school classrooms. From these experiences, I gained a lot of hands-on experience and learned the skills of teaching STEM from my colleagues. In preparing teaching materials, I also have more understanding of the basic tools of STEM so that I can feel more confident.
Q:	How can we enhance students' problem-solving skills in the process of STEM education?
A:	We can teach with a problem-based approach; for example, we can ask questions about everyday life and let students use the tools to solve the problem. In the process, students can familiarize themselves with problem-

	solving, starting by identifying problems, thinking about solutions, and then making improvements. Through different attempts, students can better understand the problem-solving process, thereby enhancing their problem-solving ability.
Q:	Can you share your experience enhancing students' problem-solving skills in STEM education?
A:	In order to make the class more interesting and develop students' problem-solving skills, I tried to teach with a problem-based method. In a previous teaching session, I attempted to ask students how to turn on the lights at night without turning them on themselves. By asking questions about daily life, students could come up with solutions, such as asking students to use the tools I provided to detect the photometry and then automatically turn on the lights to solve the problem.
Q:	During teaching STEM, what difficulties and challenges have you faced before?
A:	Yes, I thought the most significant difficulty was that there were a lot of obstacles in the teaching process of STEM. In most cases, STEM education requires the production of hands-on work, which involves different areas, such as online programming, connections, and student manual problems. There would be many things to deal with in the classroom that could not be anticipated. In addition, different students had different levels. In the group activities, the progress of each group was different. Each group would have various problems that need to be solved. Besides, the attitude of students was also a big problem. In the regular lesson, students were used to following the teacher's instructions to achieve successful work. However, during the creative process of STEM classes, students might experience a

	lot of failures. For students, students were not prepared for loss, and it was easy to feel defeated, which affected their participation in the classroom.
Q:	Do you think you will be more confident in STEM teaching after having a STEM teaching and learning experience?
A:	Yes, the curriculum also taught the basic STEM concepts and how to design the classroom, inspiring me to develop STEM. However, teaching cannot be done immediately but requires constant experimentation and accumulation of experience. Even with the guidance of others, it isn't easy to apply the knowledge to the real environment without experience. Therefore, teaching experience is significant in finding the proper teaching method and becoming more confident in teaching STEM.
Q:	After developing your problem-solving skills, do you think you will be more confident in STEM teaching?
A:	Yes, because the teacher is like the support of the students and is responsible for leading the students. When students encounter difficulties, students may not be able to solve them by themselves. Therefore, the role of teachers is significant in helping students solve problems. If I had problem-solving skills, I would have been more confident teaching STEM and assisting students.
Q:	Do you think you will be more confident in STEM teaching after developing your STEM literacy (including knowledge, skills, and attitude)?
A:	Yes, because teachers need to have STEM literacy to develop STEM literacy in students. If the teacher's STEM literacy is low, the student will learn to limit things.
Q:	Do you think GS students can develop STEM literacy in GS major curriculum?

A:	Not enough because the STEM courses in majors only teach basic knowledge for STEM teaching. STEM is not a significant subject in the GS curriculum. I've heard school authorities point out before that the GS curriculum was designed without STEM elements. Therefore, the knowledge of STEM in the major is also relatively shallow, and it does not allow students to master how to teach STEM. To solve this problem, the school has only provided STEM Minor. It means GS students without STEM minors may struggle to develop STEM literacy.
Q:	Do you have any suggestions for EdUHK to assist your STEM teaching in different aspects, such as policy and curriculum?
A:	I understand that schools have limited class hours, and increasing the number of core STEM courses in the GS curriculum is challenging. I hope that when preparing the content of the STEM courses in my major, the school can teach more pedagogy in STEM education. At present, the STEM courses of major subjects are also knowledgeable, but GS students may not be able to apply everything they have learned in class. Therefore, schools can also set up more workshops and programs cooperating with different community centers or primary and secondary schools. Experienced teachers and professors lead students to teach STEM in centers or schools, allowing students to accumulate teaching experience.