香港教育大學
The Education University of Hong Kong

Honours Project entitled

Hong Kong pre-service General Studies teachers'

self-efficacy in STEM teaching

Submitted by

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Declaration

I, Chuk In 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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Abstract

The purposes of this study were to investigate what factors affect Hong Kong pre-service General Studies teachers' self-efficacy in STEM teaching and how to increase Hong Kong pre-service General Studies teachers' self-efficacy in STEM teaching.

This study included 24 voluntary senior pre-service General Studies teachers. All of them completed a self-evaluation questionnaire about self-efficacy in STEM teaching. After that, 3 extremes were selected to be interviewed further.

Results showed that there was no obvious correlation between pre-service General Studies teachers' STEM teaching self-efficacy and their academic experiences. While there was positive correlation between their STEM teaching self-efficacy and teaching experiences. Moreover, suggestions that aids increasing pre-service General Studies teachers' STEM teaching self-efficacy were also discussed.

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1. Introduction

STEM (science, technology, engineering, and mathematics) education has been internationally discussed for decades (Kennedy & Odell, 2014). It is believed that it could enhance students' knowledge integration, higher-order thinking skills and 21st century skills such as critical thinking, creativity, communication competency, digital literacy, flexibility and initiative (Rifandi & Rahmi, 2019).

For future profession preparation, Hong Kong government also followed foreign countries' footsteps and first proposed STEM education in the 2015 Policy Address (Education Bureau, 2016). In General Studies Curriculum Guide for Primary Schools (Primary 1 – Primary 6) (Education Bureau, 2017), STEM education was listed as one of the directions of curriculum development for Hong Kong next generation to maintain competitiveness and face current various global changes.

To face this education reform, Education Bureau keeps promoting and helping teachers to prepare themselves for STEM teaching. The Education University of Hong Kong also provides related resources and training to equip pre-service teachers. However, the promotion of STEM education was described as an urgent reform and most in-service teachers felt not well-prepared (Geng, Jong & Chai, 2018).

As a pre-service General Studies teacher, I understand there will be lots of opportunities and challenges of handling STEM-related teaching activities in the future workplace. Therefore, I would like to investigate General Studies major students' self-efficacy in STEM teaching, especially after receiving related training, and see whether they are ready to teach STEM-related topics. Also, I would like to investigate whether enough support is given to pre-service General Studies teachers through interviews.

2. Literature Review

2.1 STEM

The concept of STEM was first proposed by the National Science Foundation (NSF) in the United States in the early 2000s. Due to avoid the wave of scientific and technical industry retirement and maintain future prosperity, the promotion of STEM education was started in the United States at that time (White, 2014).

STEM integrates four types of disciplinary knowledge (Science, Technology, Engineering, and Mathematics), which stimulates students' all-rounded academic knowledge application and thinking. Students would also be able to solve daily problems with creativity by applying engineering design skills (English & King, 2015; Morrison, 2006). It is believed that learning STEM could fulfill the demands of 21st-century workplaces and cultivate creative problem solvers and marketable workforces (Hooker, 2017; White, 2014). Then, STEM reform has become a hit trend across global education systems (Liang & Fung, 2022). Thus, to maintain Hong Kong next generation's competitiveness, the concept of STEM education was introduced in 2015 (Education Bureau, 2016).

2.2 Teachers' self-efficacy (SE)

"Teacher self-efficacy" means a teacher's belief in his or her ability to accomplish a particular teaching task (Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998, as citied in Jamil, Downer & Pianta, 2012). It is an expansion of the concept "self-efficacy", suggested by Bandura (1977). Teacher SE can affect students' learning and achievement, attitude and it is believed that encouraging the development of teacher

efficacy becomes important (Cantrell, Young & Moore, 2003; Kelley, Knowles, Holland, & Han, 2020).

Cantrell, Young & Moore (2003) organized that there are also four aspects affecting pre-service teachers' SE, they are "mastery experiences", "physiological and emotional arousal", "vicarious experiences" and "verbal persuasion".

First, "mastery experiences" means successful teaching performances, it was considered as an indicator of teaching capability, and it was the most powerful influencing factor of teachers' SE as successful teaching experiences helps increasing it, while experiences of failure lower it (Pendergast, Garvis & Keogh, 2011; Pfitzner-Eden, 2016).

Second, "physiological and emotional arousal" means people's somatic and emotional states can affect judging their capabilities. Positive mood and no physical debility help people perceiving SE and capability. While stress and pain can diminish the awareness of SE (Bandura, 1994).

Third, "vicarious experience" means the act of imagining oneself teaching or watching someone model teaching. Clark & Newberry (2019) mentioned that various studies have shown that vicarious experiences correlate with higher teaching SE.

Forth, "verbal persuasion" means encouragement, mentoring, and feedback from others. In Mulholland and Wallace (2001)'s research, they found that feedback from classmates or other teachers can boost beginning teachers' SE.

2.3 Hong Kong teachers' STEM teaching self-efficacy

The implementation of STEM education in Hong Kong is less than a decade and related local research is in its infancy. Although the Hong Kong Government has kept offering substantial funding and training seminars for frontline educators (Liang & Fung, 2022), most in-service teachers felt not well-prepared to teach STEM, such as their attitude towards STEM, content knowledge, pedagogies, and the ability to design STEM curricula (Geng, Jong & Chai, 2018; Lin, Chai & Jong 2021; Cheng & Yeh, 2022).

Because of the nascent STEM reform, studies of pre-service teachers' STEM teaching SE are still in emerging state. This study will contribute to the existing literature on this aspect.

3. Research questions and hypotheses

RQ1: What factors affect Hong Kong pre-service General Studies teachers' self-efficacy in STEM teaching?

RQ2: How to increase Hong Kong pre-service General Studies teachers' self-efficacy in STEM teaching?

Hypotheses for RQ1:

There are **three predictions**. First, pre-service General Studies teachers who studied STEM-related electives in senior high school have higher SE in STEM teaching than their peer who have not studied STEM-related electives. Second, pre-service General Studies teachers who are minoring in STEM have higher SE in STEM teaching than their peer who are not minoring in STEM. Third, pre-service General Studies teachers with STEM-related teaching experiences have higher SE in STEM teaching than their peer who are without related experiences.

For the **first** point, teachers' conceptions about STEM are undoubtedly affected by their major (Yip & Chan, 2019). Also, mentioned in Lin, Chai & Jong (2021)'s research, teachers need to prepare STEM content knowledge and skills. Holding STEM activities would involve designing and conducting fair tests, doing experiments, and explaining natural phenomena and scientific principles which out of the ordinary General Studies curriculum. It is believed that pre-service General Studies teachers who studied STEM-related electives in senior high school have the advantages, for example, they have more consolidated fundamental scientific knowledge than others and some of them had experiences on designing and conducting fair tests with completing Biology SBA project.

For the **second** point, STEM minor students gain both theoretical STEM pedagogies and practical mock teaching experience in the courses. Meanwhile, many schools utilized government fundings and purchased STEM tools as Littlebits, mBot and Micro:bit to facilitate students' STEM learning. Pre-service General Studies teachers in STEM minor have more chances to get familiar with them. Even, they must use these tools to design a learning activity as the course assignment requirement. As mentioned by Geng, Jong & Chai (2018), teachers would feel more prepared when they know STEM teaching pedagogies and own the ability to design STEM curricula. Therefore, pre-service General Studies teachers who are studying in STEM minor have had more experiences of unitizing STEM pedagogies and knowledge than the normal which would boost their SE in future STEM teaching.

For the **third** point, pre-service General Studies teachers who have relevant teaching experience would have higher SE to face future STEM teaching because they have practiced for it. No matter the previous teaching experiences were satisfying or not, they had started to build a resilient sense of efficacy to deal with STEM lessons (Bandura, 1994). It would lead to their high SE in STEM teaching.

In general, it is predicted that pre-service General Studies teachers' academic knowledge, interest to STEM and working experience would affect their self-efficacy in future STEM teaching.

Hypotheses for RQ2:

There are no hypotheses for RQ2 as it is a qualitative research question, and the researcher should not have too much bias, assumptions, or correct answers in mind.

4. Research design

4.1 Research orientation

As SE is a broad topic with four aspects affecting it, to narrow down the research orientation, pre-service teachers' mastery experiences and verbal persuasion experiences are selected to be the research focuses because these experiences are solid and easier to be recalled, especially Bandura (1994) mentioned that mastery experiences are the most effective way of creating a strong sense of SE.

While inviting participants to recall their physiological emotional state and vicarious experiences are too reliable on their feelings, not much solid objective evidence can be collected for data analyze.

4.2 Sampling Method

Mixed methods (quantitative and qualitative) were applied in the research. The data of RQ1 was collected in self-evaluation questionnaires firstly, then interviews were conducted to collect the data of RQ2.

For the self-evaluation questionnaire, Year 4 to 5 General Studies major students were invited to complete the research. The rest of year of study was not invited as they have not gone to Block Practice or finish their STEM minor. This part of research used volunteer sampling, participants can reject to complete the research. It was affordable and easy to approach senior General Studies major students as peer. The questions are about participants' year of study, academic background including electives studied in secondary level, major, minor (s), free electives, other STEM-related learning or working experiences. Also, few more self-evaluated statements are given for them to vote.

For the interview part, judgement sampling is used. Extreme case sampling is a part of judgement sampling, it focuses on unusual individuals (Etikan, Musa & Alkassim, 2016). Pre-service General Studies teachers with extreme low or extreme high self-efficacy in STEM teaching are invited to conduct a one-on-one interview for deeper investigation. Their experience and sharing may answer RQ2 “How to increase Hong Kong pre-service General Studies teachers' self-efficacy in STEM teaching?”.

4.3 Instruments

4.3.1 Self-evaluation questionnaire

There were 17 questions. The first 3 questions were about participants’ academic background and teaching experiences. Then, the following 14 questions were asking for participants’ SE in are “mastery experiences” and “verbal persuasion” aspects in form of a 5-point Likert scale. The results would show the correlation between pre-service teachers’ SE and their background.

Table 1: Self-evaluation questionnaire

Background information	
1	Did you study any **STEM-related elective** subjects in senior high school?
	Yes
	No
2	Did you study any Creativity and **STEM/STEAM minor** courses in EdUHK?
	Yes
	No
3	Did you have any STEM teaching or **working experiences**?
	Yes
	No

Self-evaluation					
	Strongly disagree (1)	Disagree (2)	Uncertain (3)	Agree (4)	Strongly agree (5)
4	I understand what STEM education is.				
5	I know STEM-related pedagogies.				
6	I designed STEM activities/lessons.				
7	I believe I can design STEM activities/lessons in future teaching.				
8	I conducted STEM activities/lessons.				
9	I believe I can conduct STEM activities/lessons in future teaching.				
10	I answered students' STEM-related questions.				
11	I believe I can answer students' STEM-related questions in future teaching.				
12	I solved technical problems happened in STEM activities/lessons.				
13	I believe I can solve technical problems happened in STEM activities/lessons in future teaching.				
14	I tried to inspire students' interests in STEM.				
15	I believe I can inspire students' interests in STEM in future teaching.				
16	I received specific feedbacks, encouragement, and advice for my STEM teaching experiences.				
17	I believe I will find better ways to teach STEM.				

4.3.2 Interview

Participants with extreme questionnaire results were invited to be interviewed. There were 10 key questions to lead out in-depth understanding of pre-service teachers' thoughts with different academic and working backgrounds. Interviewees were welcome to use their first language to express their thoughts and they were noticed to be audio recorded.

Table 2: Interview questions

1	Do you think "studied STEM electives for HKDSE" help your future STEM teaching?
2	Do you think "studied STEM minor" help your future STEM teaching?
3	Do you think "with certain STEM teaching exp." help your future STEM teaching?
4	How do you notice these job opportunities?
5	For the above three aspects, which one is the most important?
6	Review your survey answers, what did you consider at that time?
7	How to increase Hong Kong pre-service GS teacher's self-efficacy in STEM teaching?
8	Did you feel confused to STEM teaching? Do you have any positive changes? Why?
9	Did you have chance to view peers or experienced educators' STEM teaching?
10	If you can view others' teaching, will it be helpful for your future STEM teaching?

5. Findings

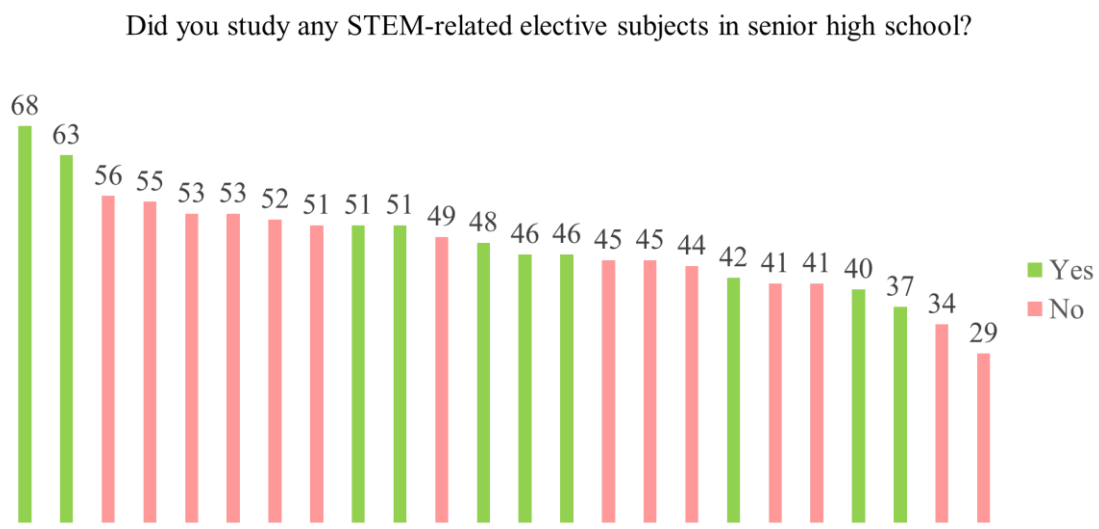
5.1 RQ1: What factors affect Hong Kong pre-service General Studies teachers' self-efficacy in STEM teaching?

Figure 1: Self-evaluation questionnaire result summary

Participant	Question																	Score /70
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
2	**Y**	**Y**	**Y**	4	4	5	5	5	5	5	5	5	5	5	5	5	5	**68**
20	**Y**	**N**	**Y**	4	4	5	4	5	4	4	4	5	4	5	5	5	5	**63**
5	**N**	**N**	**Y**	4	4	4	3	4	4	4	4	4	4	4	4	4	5	**56**
22	**N**	**Y**	**Y**	4	4	3	3	4	4	4	5	3	4	4	4	4	5	**55**
14	**N**	**N**	**Y**	4	4	2	4	5	4	4	4	3	4	4	4	3	4	**53**
16	**N**	**N**	**Y**	4	3	4	4	4	4	5	4	4	3	4	3	4	3	**53**
13	**N**	**Y**	**Y**	4	4	4	3	4	3	4	3	4	3	4	4	4	4	**52**
1	**N**	**Y**	**Y**	4	4	4	4	4	4	4	3	3	3	4	3	3	4	**51**
10	**Y**	**Y**	**Y**	4	4	4	3	4	3	4	4	2	3	4	4	4	4	**51**
11	**Y**	**Y**	**Y**	4	3	4	4	4	4	4	4	2	4	4	4	2	4	**51**
4	**N**	**N**	**Y**	4	4	3	3	4	3	4	3	4	3	4	3	4	3	**49**
6	**Y**	**Y**	**Y**	4	3	4	3	4	4	4	3	4	3	3	3	2	4	**48**
9	**Y**	**Y**	**Y**	4	4	3	3	4	3	2	3	2	3	4	4	4	3	**46**
19	**Y**	**Y**	**N**	4	4	4	3	2	3	2	3	4	3	4	3	3	4	**46**
7	**N**	**Y**	**Y**	4	4	4	3	5	3	2	1	2	1	5	4	2	5	**45**
24	**N**	**Y**	**N**	4	4	3	3	2	3	3	3	3	2	4	4	3	4	**45**
17	**N**	**Y**	**Y**	4	3	2	2	4	4	3	2	2	2	4	4	4	4	**44**
18	**Y**	**Y**	**Y**	3	4	2	3	4	4	4	4	2	3	2	2	2	3	**42**
15	**N**	**Y**	**Y**	4	3	4	2	4	2	3	2	3	2	4	2	3	3	**41**
23	**N**	**Y**	**Y**	3	3	4	2	4	3	3	3	2	2	3	3	4	2	**41**
8	**Y**	**N**	**N**	4	3	3	2	3	2	3	3	3	3	3	3	2	3	**40**
3	**Y**	**N**	**Y**	3	4	2	2	2	2	2	2	2	2	4	3	4	3	**37**
12	**N**	**Y**	**N**	3	3	2	3	2	2	2	2	2	3	2	3	2	3	**34**
21	**N**	**N**	**N**	3	2	2	2	2	2	2	2	2	2	2	2	2	2	**29**

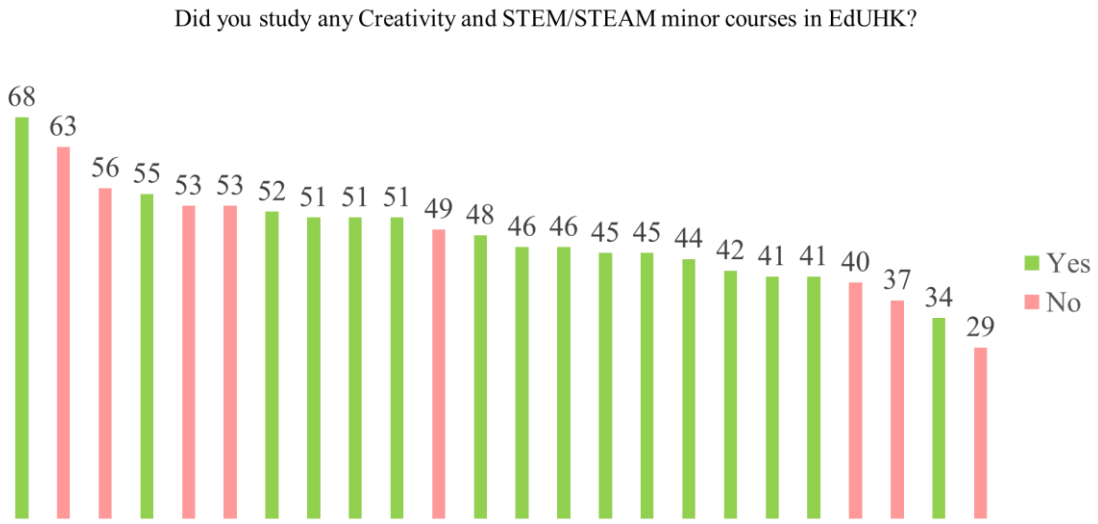
In this study, 24 voluntary senior pre-service General Studies teachers completed the self-evaluation questionnaire about their SE in STEM teaching. After answering their academic background and STEM working experiences, they voted for the self-evaluated SE session. In this self-evaluated SE session, 14 statements about their STEM teaching mastery experiences and verbal persuasion experiences were asked. If they strongly agreed with the statements, they tended to get a higher score. The total score of this self-evaluated SE session was 70 and the median of the scores was 47. In Figure 1, all participants' score were shown and arranged in order, according to their scores from higher to lower.

Figure 2: Relationship between studied STEM-related electives and SE score



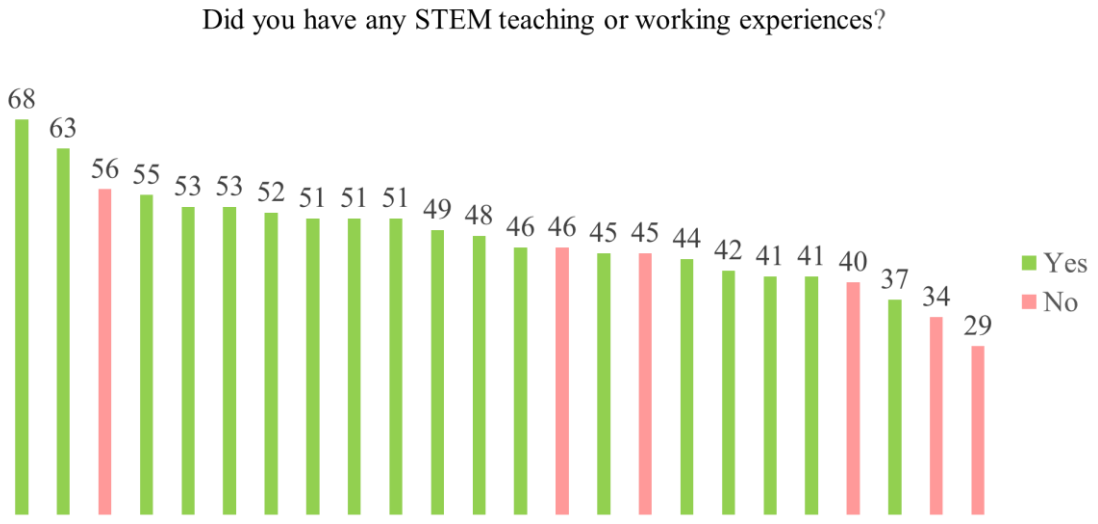
It was predicted that pre-service General Studies teachers who studied STEM-related electives in senior high school would have higher SE in STEM teaching. However, it may not be true although the first two highest SE participants did study STEM-related electives in senior high school. From the 3rd highest to the 8th highest, even they did not study STEM-related electives in senior high school, they still felt higher SE. Therefore, it was claimed that **no obvious correlation** between studied STEM-related electives and SE score.

Figure 3: Relationship between studied STEM minor and SE score



It was predicted that pre-service General Studies teachers who studied STEM minor would have higher SE in STEM teaching. However, it also may not be true. Using median=47 as an indicator, in the first 12th highest SE data, 5 out of 12 participants did not study any STEM minor courses. Meanwhile, most of the participants whose SE score lower that 47 had taken STEM minor courses. Therefore, there was **no obvious correlation** between studied STEM minor and SE score.

Figure 4: Relationship between had STEM teaching experiences and SE score



It was predicted that pre-service General Studies teachers who had STEM-related teaching experiences would have higher SE in STEM teaching. According to Figure 4, SE score of participants without STEM teaching experiences majorly lower than median=47. It showed that without STEM teaching experiences can negatively affect pre-service teachers' SE. Therefore, correlation was believed existing between studied STEM minor and SE score.

Moreover, according to the interviewed participants, they claimed that having STEM teaching experiences did help boosting their SE.

"I would feel unconfident if I only studied a STEM minor course before teaching. However, after mentoring, listening to others' experience sharing, and accumulating substantial teaching experience, I now have the confidence to face STEM teaching – Participant 2"

"General Studies is now linked to STEM, so now I want to find more part-time jobs in STEM teaching area. – Participant 21"

5.2 RQ2: How to increase Hong Kong pre-service General Studies teachers' self-efficacy in STEM teaching?

At present, STEM knowledge has been tried to include in the General Studies major courses, and the EdUHK continues to promote various STEM workshops and introduce related job opportunities. Moreover, participants suggested more.

First, **more lesson plan writings and mock teaching opportunities**. Instead of only teaching pre-service General Studies teachers to code, they should know how to combine STEM into their daily lessons.

"Giving students chances to incorporate STEM elements into General Studies lessons, with teacher and peer's commentary on lesson plans and implementation issues – Participant 9"

"Coding is now a large part of STEM, but in addition to teaching basic programming, I also hope that emphasizing how STEM can be integrated into General Studies. For example, the lecturer demonstrated how to teach "Four Seasons" with STEM elements, and then asked the students to also design a General Studies-based STEM teaching plan – Participant 21"

Second, **inviting frontline teachers as guest speaker** to share real teaching cases.

"It would be helpful if the frontline teachers could share the lesson plans that they designed and describe the design concepts, implementation difficulties and students' reactions at the time – Participant 21"

Third, **holding STEM field trips** for students to understand real teaching cases.

"I think visits can be arranged for students to know the current STEM activities, and they can even become staff members to assist in activities – Participant 2"

Forth, **holding STEM activities** for students to boost interests in STEM.

"In order to enhance the interest of pre-service teachers in STEM, the EdUHK can run a Fun Day, so that they can experience the fun of STEM, and gradually be active to explore STEM teaching.– Participant 2"

6. Discussion

Combined the findings from self-evaluation questionnaires and interviews, they were partly similar to the original predictions.

For the first two predictions, even the questionnaire result showed that studied STEM-related electives or STEM minor would not obviously boost pre-service teachers' SE), interviewees did not deny the benefits of studied STEM knowledge. It showed that studied STEM-related electives or STEM minor were not the key elements to affect ones' SE in STEM teaching.

While for the third prediction, either the self-evaluation questionnaire results or the interviews, participants' responses proved there was a positive correlation between having STEM teaching experiences and SE score. Having various STEM teaching means having higher SE. This correlation was reasonable and fit the SE theory suggested by Bandura (1994) as mentioned, which mastery teaching experiences were the most effective way of creating a strong sense of SE.

Except from accumulating teaching experiences, interviewees also suggested several practical ways to increase Hong Kong pre-service General Studies teachers' SE in STEM teaching based on their experiences. Their suggestions were also referenceable and feasible. For example, arranging more lesson plan writings and mock teaching with teacher and peer's commentary promotes verbal persuasion which can boost beginning teachers' SE (Mulholland and Wallace, 2001). Also, interviewees agreed that observing peers and expertise' lessons would help them learn more from others and boost their SE, which involves "vicarious experience", another key factor of affecting SE (Clark & Newberry, 2019).

Therefore, more practical STEM teaching and teacher-student interaction are indispensable for boosting pre-service General Studies teachers' SE in STEM teaching.

7. Conclusion

In this study, limited research participants (N=24) only represented a part of Hong Kong pre-service General Studies teachers, Nonetheless, the findings showed the positive correlation between having STEM teaching experiences and SE score while academic background was not a key factor. Also, to boost their SE, it is highly recommended to provide more practical experiences within the teaching training program. For further research, it would be informative to study which teacher training methods can effectively increase pre-service General Studies teachers' SE and their actual STEM teaching efficacy. The study might be a reference for pre-service STEM teachers' training program.

Reference

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191.

Bandura, A. (1994). Self-efficacy. In V. S. Ramachaudran (Ed.), *Encyclopedia of human behavior* (Vol. 4, pp. 71-81). New York: Academic Press.

Clark, S., & Newberry, M. (2019). Are we building preservice teacher self-efficacy? A large-scale study examining teacher education experiences. *Asia-Pacific Journal of Teacher Education, 47*(1), 32-47.

Cantrell, P., Young, S., & Moore, A. (2003). Factors affecting science teaching efficacy of preservice elementary teachers. *Journal of Science Teacher Education, 14*(3), 177-192.

Cheng, M. M. H., & Yeh, F. Y. (2022). STEM Teacher Professional Development for Primary School Teachers in Hong Kong. In *Concepts and Practices of STEM Education in Asia* (pp. 271-287). Singapore: Springer Nature Singapore.

Education Bureau. (2016). *Promotion of STEM education: Unleashing potential in innovation.* https://www.edb.gov.hk/attachment/en/curriculum-development/renewal/STEM%20Education%20Report_Executive%20Summary_Eng.pdf

Education Bureau. (2017). *General Studies Curriculum Guide for Primary Schools (Primary 1 – Primary 6).* https://www.edb.gov.hk/attachment/en/curriculum-development/cross-kla-studies/gs-primary/GSCG_2017_Eng.pdf

English, L. D., & King, D. T. (2015). STEM learning through engineering design: Fourth-grade students' investigations in aerospace. *International journal of stem education, 2*(1), 1-18.

Geng, J., Jong, M. S.-Y., & Chai, C. S. (2018). Hong Kong Teachers' Self-efficacy and Concerns About STEM Education. *The Asia-Pacific Education*

Researcher, 28(1), 35–45.

Hooker, M. (2017). *A Study on the Implementation of the" Strengthening Innovation and Practice in Secondary Education Initiative" for the Preparation of Science, Technology, English and Mathematics (STEM) Teachers in Kenya to Integrate Information and Communication Technology (ICT) in Teaching and Learning* (Doctoral dissertation, Queen's University Belfast. Faculty of Arts, Humanities and Social Sciences, July).

Jamil, F. M., Downer, J. T., & Pianta, R. C. (2012). Association of pre-service teachers' performance, personality, and beliefs with teacher self-efficacy at program completion. *Teacher Education Quarterly, 39*(4), 119-138.

Kelley, T. R., Knowles, J. G., Holland, J. D., & Han, J. (2020). Increasing high school teachers self-efficacy for integrated STEM instruction through a collaborative community of practice. *International Journal of STEM Education, 7*(1), 1-13.

Kennedy, T. J., & Odell, M. R. (2014). Engaging students in STEM education. Science *Education International, 25*(3), 246-258.

Liang, W., & Fung, D. (2022). Designing STEM education in small class teaching environments: The Hong Kong experience. *The Asia-Pacific Education Researcher*, 1-21.

Lin, P.-Y., Chai, C. S., & Jong, M. S.-Y. (2021). A study of disposition, engagement, efficacy, and vitality of teachers in designing science, technology, engineering, and mathematics education.*Frontiers in Psychology, 12*.

Morrison, J. S. (2006). Attributes of STEM education: The students, the academy, the classroom. *TIES STEM education monograph series.*

Mulholland, J., & Wallace, J. (2001). Teacher induction and elementary science teaching: Enhancing self-efficacy. *Teaching and Teacher Education, 17*(2),

243–261.

Pendergast, D., Garvis, S., & Keogh, J. (2011). Pre-service student-teacher self-efficacy beliefs: an insight into the making of teachers. *Australian journal of teacher education, 36*(12), 46-57.

Pfitzner-Eden, F. (2016). Why do I feel more confident? Bandura's sources predict preservice teachers' latent changes in teacher self-efficacy. *Frontiers in psychology*, 7.

Rifandi, R., & Rahmi, Y. L. (2019). STEM education to fulfil the 21st century demand: a literature review. *Journal of Physics: Conference Series, 1317*(1), 012208.

White, D. W. (2014). What is STEM education and why is it important. *Florida Association of Teacher Educators Journal, 1*(14), 1-9.

Yip, V. W., & Chan, K. K. H. (2019). Teachers' conceptions about STEM and their practical knowledge for STEM teaching in Hong Kong. In Hsu, Y. S. & Yeh, Y. F. (Eds.), *Asia-Pacific STEM Teaching Practices* (pp. 67-81). Springer.

Appendix

Appendix 1: Transcript of Participant 2

背景資料: 選修生物和物理，副修 STEM，有 STEM 教學經驗

Q: 你認為「曾選修生物和物理」對你未來的 STEM 教學有沒有幫助？

A: 有幫助，因為 STEM 涉及理科。如果有科學知識及做實驗、發明的經驗，可以幫助教學。

Q: 你認為「曾副修 STEM」對你未來的 STEM 教學有沒有幫助？

A: 有幫助。因為主軸關於 STEM，同時涉及理論和實踐。其中一個課程，ART2207，更需要書寫教案，並體驗其他同學設計的教案活動，切身感受甚麼是 STEM 活動，從而幫助將來教學。

Q: 你認為「現時擁有的 STEM 教學經驗」對你未來的 STEM 教學有沒有幫助？

A: 有幫助。

Q: 你當時如何獲得 STEM 工作機會？

A: 參與教授的 STEM project 和朋友介紹。

Q: 上述三方面 (「曾選修 STEM 相關的科目」、「曾副修 STEM」和「現時擁有的 STEM 教學經驗」) 對你未來的 STEM 教學最有幫助？

A: STEM 教學經驗。

Q: 回顧當時填寫的問卷，為甚麼你有這些選擇？

A:「理解 STEM 和 STEM 教學法」方面選四分而不是五分的原因是，我只讀了一個 STEM course，相關的理論不敢稱得上太認識。其他方面均選五分是因為我有持續的 STEM 教學經驗。

Q: 如何增加香港準常識教師對 STEM 教學的自我效能感？

A: 現時常識的主修課程已嘗試加入 STEM 元素，同時學校也持續推廣各種 STEM 工作坊及介紹工作機會。我認為本科課程可安排學生實地參觀現時學校的 STEM 活動，甚至成為工作人員協助活動。另外，為提升準教師對 STEM 的興趣，學校可舉辦 Fun Day，讓準教師體驗到 STEM 的樂趣，讓他們漸漸主動接觸 STEM 教學。

Q: 你曾對 STEM 教學感到迷惘嗎？現在有沒有正面的改變？為甚麼？

A: 有，若當初只讀了一個 STEM minor course 就進行教學，我會覺得很沒信心。但經過導師指導、他人的經驗分享和累積實質的教學經驗，我現在有信心面對 STEM 教學。

Q: 你旁觀過其他人的 STEM 教學嗎？

A: 有。

Q: 若能旁觀其他人的教學，你認為這樣能幫助你未來的 STEM 教學嗎？

A: 有。可以學習他人的教學模式。

Appendix 2: Transcript of Participant 9

背景資料: 選修化學，副修 STEM，有 STEM 教學經驗

Q: 你認為「曾選修化學」對你未來的 STEM 教學有沒有幫助？

A: 沒有幫助，因為現時 STEM 大部分關於編程。

Q: 你認為「曾副修 STEM」對你未來的 STEM 教學有沒有幫助？

A: 有些。基本知道有甚麼教學工作可以運用。但不太 practical，大多是理論上知道甚麼是創意、如何展示創意，只有一個課程需要模擬教學。

Q: 你認為「現時擁有的 STEM 教學經驗」對你未來的 STEM 教學有沒有幫助？

A: 有幫助。

Q: 你當時如何獲得 STEM 工作機會？

A: 網上得悉。申請原因是因為職前有提供訓練。

Q: 上述三方面 (「曾選修 STEM 相關的科目」、「曾副修 STEM」和「現時擁有的 STEM 教學經驗」) 對你未來的 STEM 教學最有幫助？

A: 擁有 STEM 教學經驗。

Q: 回顧當時填寫的問卷，為甚麼你有這些選擇？

A:「理解 STEM 和 STEM 教學法」方面選四分而不是五分的原因是，我知道一些，但不敢說知道全部。「設計 STEM 活動」方面選三分是因為我曾和別人合

作設計，但沒有獨自一人設計過。「執行 STEM 活動」方面選三分至四分也是因為知道一些，但不敢說知道全部。「回答 STEM 問題」方面選三分是因為我沒有回答過，但我相信將來經過備課後能回答得上。「解決 STEM 技術問題」方面也是同樣原因。「啟發學生興趣」方面選四分是因為我曾用動畫提升他們的學習動機。「收到回饋」選四分是因為我曾派發問卷收集學生課後意見，反映正面。「找到更好的方法教授」選三分是因為經驗上算不足，擔心將來只憑已知的教學法及經驗度日。

Q: 如何增加香港準常識教師對 STEM 教學的自我效能感？

A: 更多試教機會，因為需要寫教案，讓學生有機會把 STEM 元素融入常識課程，並有老師和同輩評論教案和執行方面的問題。

Q: 你曾對 STEM 教學感到迷惘嗎？現在有沒有正面的改變？為甚麼？

A: 有迷惘過，也有正面改變，因為讀過大學的 STEM 課程，並擁有一些教學經驗。

Q: 你旁觀過其他人的 STEM 教學嗎？

A: 有，大學教授的。

Q: 若能旁觀其他人的教學，你認為這樣能幫助你未來的 STEM 教學嗎？

A: 有，我透過觀摩大學教授的課堂演繹，認識到有什麼方法可以引導小學生自主學習。

Appendix 3: Transcript of Participant 21

背景資料: 選修中史和經濟，沒有副修 STEM，沒有 STEM 教學經驗

Q: 你認為「不曾選修 STEM 相關的科目」對你未來的 STEM 教學有沒有影響？

A: 由於我副修中文，所以將來想主要教常識和中文。但現在常識科與 STEM 掛勾，所以現在也想多尋找 STEM 方面的兼職工作，我現在也有在坊間額外報讀 STEM 課程。

Q: 你甚麼時候意識到裝備 STEM 方面的知識很重要？

A: 兩年前，但由於其他副修科目和時間安排而令我沒有在大學裡面刻意裝備 STEM 方面的知識。

Q: 你認為「曾選修 STEM 相關的科目」、「曾副修 STEM」和「現時擁有的 STEM 教學經驗」三個選項中，哪一項對你未來的 STEM 教學最有幫助？

A: 副修 STEM，因為感覺更全面讓學生了解甚麼是 STEM，包括編程知識。就算曾選修過理科，例如物理、化學和生物，那些內容不全是小學 STEM 會接觸到的。

Q: 回顧當時填寫的問卷，為甚麼你有這些選擇？

A: 雖然我當時已有在外進修 STEM 知識，但課程內容沒甚麼自由發揮空間，只是一步一步跟著導師的指示編程，所以令我上完課也沒有太大信心教授 STEM。即使有個作業需要我模擬教學，但我也認為沒太大幫助，因為我特意挑選過我

熟悉的課題來教授。所以我也希望把握畢業前剩餘時間累積實質的 STEM 教學經驗。

Q: 如何增加香港準常識教師對 STEM 教學的自我效能感？

A: 實踐機會。如果常識常規課程中能有專門一課教授 STEM 就更好。現在編程在 STEM 中佔很大一部分，但除了教授基本編程，我希望課程內容更多展示常識融合科學、工程和數學的例子，強調 STEM 可以如何融合小學常識課程。例如授課講者展示如何將「四季」這個常識課題融合 STEM 教學，然後要求學生也設計一個常識 STEM 教案。另外，單純分享教學法沒有用。如果前線老師能拿著他們設計的教案來分享，講述當時的設計理念、執行困難和學生反應，相信這樣會有幫助。

Q: 若能旁觀其他人的教學，你認為這樣能幫助你未來的 STEM 教學嗎？

A: 有幫助。