

Article

Addressing Humanities Pre-Service and In-Service Teachers' Concerns in Integrating STEM Education—A Case Study of Geography Education

Sung Ho Cheuk  and Yun Fat Lam * 

Department of Geography, The University of Hong Kong, Hong Kong, China; sungcho@connect.hku.hk

* Correspondence: yunlam@hku.hk

Abstract: STEAM education has become a global agenda to integrate humanities subjects with STEM elements. With a lack of science-related teacher training, promoting STEM education under humanities curriculums faces challenges. However, limited research has been conducted to understand the concerns of humanities teachers in applying STEM education in their classrooms. In this study, we examined the concerns of pre-service and in-service geography (GEOG) teachers ($N = 49$) in Hong Kong (HK) secondary schools and evaluated the effectiveness of trainer workshops in alleviating their concerns. We applied an in-depth questionnaire analysis based on a 5-point Likert scale under a “Stages of Concern” model. The ordinal regression and t -test results suggested that (1) the pre-service and in-service GEOG teachers were highly concerned in most of the stages of concerns ($Mean = 4.06/5$); (2) unique yet different concerns about GEOG STEM education were identified from the pre-service teachers and in-service teachers; (3) teacher training workshops that offer scientific and STEM training could be effective in addressing the concerns of in-service teachers. As such, this study supports the development of geography STEM education and promotes the education community’s ability to address teachers’ concerns in embracing STEM education.



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1. Introduction

Science, Technology, Engineering, and Mathematics (STEM) education strengthens students’ ability to think critically, to be creative, and to solve contemporary problems. In recent years, arts subjects have been regarded as the latest suggested component to be incorporated into STEM, turning STEM into Science, Technology, Engineering, Art, and Mathematics (STEAM) (Kutnick et al., 2020; Hebebcı & Usta, 2022). What differentiates STEM from STEAM is that STEAM has progressed from STEM and integrates humanities subjects and arts design (e.g., visual arts) into the curriculum alongside science and technology. It connects technical concepts with humanities perspectives to allow students to approach problem-solving from multiple perspectives. In the last decade, STEM education has been increasingly regarded as a critical component of the global education agenda to prepare students with the knowledge necessary to face future challenges in international economic, scientific, and technological developments.

Geography (GEOG) is an example of a humanities subject (as defined in some countries) that diverged from the traditional STEM subjects in the high school/secondary school syllabus. Recent debates centered on whether GEOG is a STEM subject (now progressed

to and named STEAM). Countries view this proposal differently. In Britain's higher education, GEOG is recognized as a partial STEM subject based on the number and nature of scientific investments ([Royal Geography Society, 2011](#)). Germany also treats GEOG as STEM since it requires a substantial level of mathematics and logical reasoning ([Germany Academic Exchange Service, n.d.](#)). Further, GEOG is also included in the 2019 New Finnish National Core Curriculum as a STEM subject as it shares the same essential elements as other conventional STEM subjects ([Scientix, 2019](#)).

Some countries and regions, however, do not include GEOG in their STEM disciplines. In Australia, GEOG is viewed as a humanities subject despite its curriculum emphasizing numerous scientific concepts. The local community urges their government to develop and promote GEOG further as a partial STEM subject. Some foundation measures have been suggested, e.g., fostering collaboration with schools and universities and pursuing more research on how Australian geography is perceived and identified ([Caldis & Kleeman, 2019](#); [Australian Academy of Science and National Committee for Geographical Sciences, 2018](#)). In the United States, the federal government does not recognize GEOG as a STEAM discipline, which is adversely affecting the funding opportunities and attracting talented individuals to the field ([Al Mamun et al., 2015](#)). In recent years, a sub-stream of GEOG, Geoscience, has been separately recognized as a STEM subject by the U.S. National Science Foundation. In Hong Kong (HK), GEOG is also not considered a STEM subject in the secondary school syllabus, and it is placed under the branch of personal, social, health, and economic education by the HK Education Bureau (HKEdB). The recent government initiatives on a multidisciplinary approach for promoting STEM education have opened opportunities for GEOG, as an intradisciplinary subject, to revive its close relationship with other traditional STEM subjects (i.e., physics, chemistry, biology, and computer studies) under climate and environmental education ([Al Mamun et al., 2015](#); [Kerski, 2015](#); [Caldis & Kleeman, 2019](#)). The requirement of fieldwork study in the curriculum and inquiry-based learning with a strong STEM flavor also promotes GEOG-based STEAM, such as spatial data inquiry and analysis ([CDC & HKEAA, 2017, 2020](#); [LegCo, 2021](#)). It is notable that scientific concepts of physics, chemistry, biology, GIS, and environmental science are thoroughly used in GEOG, regardless of whether human, physical, or cultural topics. Hence, there is a growing consensus that GEOG should be considered a STEM field, and more countries and regions are now considering it, especially for those treating GEOG solely as an arts component in STEAM education.

Various challenges and obstacles to including GEOG as a STEM subject remain unsolved. These include (1) inadequate science-related training for humanities-based GEOG teachers; (2) a lack of resources for training GEOG teachers to address their concerns; and (3) an unclear funding approach, including whether GEOG could receive STEM-related funding support from the science division. These have hindered the development of GEOG education with STEM ([Acar & Büyüksahin, 2021](#); [Roehrig et al., 2021](#); [Hanifah et al., 2021](#); [Knie et al., 2022](#)). Recent studies show that teachers' concerns and self-efficacy in STEM education are influenced by their skills and multidisciplinary knowledge. In their study of STEM education in HK, [Geng et al. \(2019\)](#) applied a Stages of Concern (SoC) model, which included a questionnaire regarding teachers' concerns and self-efficacy. Based on the model, it was found that HK was not well prepared to promote STEM education, as teachers have different concerns and are not confident in their ability to teach STEM subjects. Similarly, [Lau and Jong \(2023\)](#) implemented SoC in HK and found deep concerns regarding STEM education at all five stages. Among these concerns was the lack of existing teaching materials and practical examples of managing class hours for STEM education. In a study conducted by [Acar and Büyüksahin \(2021\)](#), teachers from diverse disciplines were asked to describe their viewpoints and attitudes after receiving STEM training. Teachers

were concerned about whether they had adequate skills, knowledge, and resources for conveying effective STEM education.

In addition, research also sheds light on the practical aspects of teacher training for integrating STEM education. According to [Margot and Kettler \(2019\)](#) and [Ampartzaki et al. \(2022\)](#), teachers, including those with rich humanities backgrounds, are more comfortable teaching STEM when institutional support, quality in-service instruction, and training are provided. In a Malaysian university, [Hanifah et al. \(2021\)](#) analyzed the skills and knowledge of prospective teachers with humanities backgrounds in GEOG. The research found that teachers need STEM knowledge and skills, such as the ability to design suitable STEM group activities for students and an understanding of their relevant applications, to teach STEM effectively. [Knie et al. \(2022\)](#) recognized the importance of an in-service teacher training program in raising teachers' awareness and acquiring knowledge of computational thinking. In this way, they could combine computational thinking with STEM to inspire their students. A study conducted in HK by [Cheng et al. \(2023\)](#) examined teachers' professional development in STEM education. It concluded that teachers' abilities to provide STEM education could be strengthened effectively if multiple teaching professional development models were combined. In order to accommodate teachers' varying needs and the school-based STEM curriculum, various teaching methods and trainer training at central locations were implemented along with small-scale investigations in the classrooms.

However, the needs and concerns of pre-service teachers with humanities backgrounds have not been adequately addressed in STEM education ([Li et al., 2019](#); [Boice et al., 2021](#); [He et al., 2022](#)). [Sutaphan and Yuenyong \(2021\)](#) argued that pre-service teachers had positive perceptions of STEM education and strong mindsets when preparing their lessons, which indicated the importance of training for pre-service teachers. It is similar to the case of integrating STEM into GEOG education, in which pre-service GEOG teachers possess a higher level of STEM knowledge, skills, and values ([Najib et al., 2020](#)). The pre-service teachers were also proactive in their efforts to become STEM teachers in the future. Despite this, many teachers lacked confidence in teaching STEM at schools ([Sutaphan & Yuenyong, 2021](#); [Erdogan & Ciftci, 2017](#)). Under such circumstances, they should be well-informed and trained with more STEM practices and training in the universities so that their knowledge can be applied in their teaching ([Erdogan & Ciftci, 2017](#); [Kurup et al., 2017, 2019](#)). Therefore, future teachers who may teach STEM-related knowledge must acquire fundamental skills and knowledge, such as problem-solving, forecasting future opportunities and threats, and innovation in dealing with complex sustainability issues ([Khadri, 2022](#)).

To meet the future upsurge of education needs in STEM education, especially when arts are integrated with STEM, pre-service and in-service teachers must develop their skills and remedy their concerns with support ([Park et al., 2016](#); [Boice et al., 2021](#)). The successful integration of STEAM within education relies heavily on competent teachers who possess the necessary knowledge and skills ([Romero-Ariza et al., 2021](#)). Throughout this paper, understanding the teachers' concerns in GEOG STEM education is the major focus, primarily from the perspective of a rich background in humanities education. With this approach, future obstacles to recruiting and nurturing sufficient and qualified future teachers may be addressed with practical and feasible solutions. As a result, with a case study of GEOG education, this paper seeks to understand the differences in the needs and concerns of in-service and pre-service teachers about GEOG education with STEAM and whether teacher training workshops can alleviate the concerns of GEOG teachers toward GEOG STEAM education.

2. Materials and Methods

2.1. Study Area

In HK, STEM and STEAM education were emphasized in the Government of HK's 2016 and 2023 Policy Address, respectively. As part of the government goals, secondary school (grades 7–12) students are expected to be exposed to a variety of STEAM activities. Designated STEM disciplines include mathematics, integrated science, biology, chemistry, physics, combined science, and information and communication technology (ICT), while GEOG is excluded (CDC, 2017; Chan & Cheung, 2018; HKEAA, 2021; LegCo, 2021; GovHK, 2023). Due to the emphasis on STEM, the science proficiency of HK students ranked relatively high globally. According to the Programme for International Student Assessment (PISA) by the Organization for Economic Co-operation and Development (OECD), 15-year-old HK teenagers are performing much better than students from the other OECD members, with an average score of 517 points (OECD, 2023).

Notably, the multidisciplinary GEOG syllabus of the HK Diploma of Secondary Education (HKDSE) covers both physical and human environments, and global challenges, showing a high potential for integrating GEOG with STEAM in HK. Therefore, more voices have urged the government to categorize GEOG as a partial STEAM subject. However, GEOG is not officially regarded as a STEAM subject, as STEAM elements are rarely incorporated into the existing GEOG syllabus. It has been observed that most GEOG teachers who graduated under the HKDSE syllabus are only equipped with limited knowledge of science and technology. This is due to the fact that more focus was given to factual information rather than the science concepts and mathematics from the relevant STEM disciplines. As GEOG is hosted under the branch of personal, social, health, and economic education, limited in-depth science concepts and theories have been incorporated into the current curriculum. This differs from some countries (e.g., Germany) that place GEOG as a science-relevant subject. At the university level in HK, GEOG has also been categorized as a social sciences and humanities subject at the top-ranked universities (AASOHKU, 2023; CUHK, 2023a). Due to these circumstances, most teachers come from a humanities education background rather than a science education background. This has resulted in a limited amount of science-related training for these pre-service GEOG teachers at the university. It is important to note that teachers' skills and knowledge are crucial to the success of GEOG fieldwork and lessons for students to enrich their STEAM interests and knowledge. Hence, equipping GEOG teachers with STEAM skills is a prerequisite for promoting STEAM education. In this study, GEOG is used as an example to demonstrate the integration of a humanities subject with STEM (STEAM).

2.2. Research Framework

This study aims to (1) compare the concerns of pre-service and in-service GEOG teachers regarding GEOG STEAM education and (2) correlate the alleviation of their concerns with STEAM trainer workshops. A trainer workshop was conducted to train some in-service GEOG teachers according to the proposed framework (see Figure 1). Initially, a trainer workshop was held for in-service teachers who are from various secondary schools, which led to the completion of the onsite questionnaire survey through an online platform. Next, students majoring in GEOG-relevant education programs were recruited from local universities along with other in-service GEOG teachers from the secondary schools (as control) for the online survey. The online survey was designed according to the SoC model and the 5-point Likert scale. The survey results were analyzed using ordinal logistic regression. Note that the study has passed the ethical approval of the human ethics committee at the university that the authors are serving (EA230411).

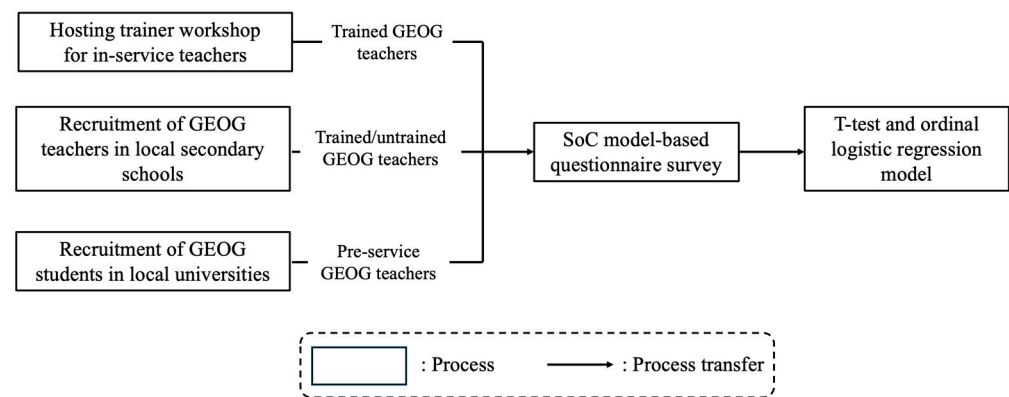


Figure 1. Research framework of the study.

2.3. Data Collection

The questionnaire survey was distributed separately to three groups: (1) trained and (2) untrained in-service teachers and (3) pre-service teachers from universities (demographic profile in Table A1). The survey, modified based on Yip and Cheung (2005) and Lau and Jong (2023), was applied to examine teachers' and pre-service teachers' concerns about GEOG STEAM education. Please note that Yip and Cheung (2005) examined school-based assessments (SBA) under the Teacher Assessment Scheme (TAS) in the Hong Kong Advanced Level Examination (HKALE), which HKDSE has substituted for the University Entry Examination (HKACE) for secondary school students, while TAS is not part of the assessment in HKDSE GEOG syllabus. Table 1 summarises the categories of the SoC model in the survey, which formed the basis of the questions. In these questions, respondents rated the SoC items on a Likert scale from 1 to 5 (1 = not at all concerned and 5 = highly concerned). Next, the 5-point Likert scale was processed to three latent classes, with scales 1–2 indicating moderate concerns, scale 3 indicating considerable concerns, and scales 4–5 indicating extreme concerns. In addition, the responses to the questions on teachers' support in GEOG STEAM were also divided into moderately supportive (scales 1–2), considerably supportive (scale 3), and extremely supportive (scales 4–5).

Table 1. The categories of the SoC questionnaire survey.

Categories of SoC	The Respondent Is Concerned About. . .
Evaluation	The issues in evaluating the feasibility and effectiveness of GEOG STEAM education.
Information	Information sufficiency in terms of support, training programs, and feedback of GEOG STEAM education.
Management	The time management and other soft skills related to GEOG STEAM education.
Consequence	The impacts on teachers and students in the GEOG syllabus of public examinations, students' career choices, and teachers' professional development.
Refocusing	The future development of GEOG STEAM education, such as whether teachers and students can refine themselves to cope with the changes.

2.4. GEOG STEAM Trainer Workshop

Unlike untrained teachers who have never attended STEAM training, trained teachers refer to participants in a trainer workshop held by the Community Weather Information Network (Co-WIN) and participants in other related STEAM training programs in HK. Co-WIN is a community network that connects secondary schools by hosting GEOG STEAM-related activities for local teachers and students. It utilizes real-time street-level

meteorological data collected by low-cost environmental sensors installed in participating schools (Co-WIN, 2023). Through the workshops, teachers can extend their collaborations with colleagues. The program has also provided them with the necessary soft skills to deliver STEAM knowledge to students. As a result of the workshop, teachers could experience the integration of relevant STEAM knowledge to the current HKDSE GEOG syllabus (see Table A2), enabling them to gain an understanding of GEOG STEAM education and showing them how they can address related classroom questions to the future real-world problems.

Furthermore, using the data collected from Co-WIN's monitoring network at schools, these workshops provided in-service teachers with hands-on opportunities for analyzing, visualizing, and modeling geospatial data related to urban heat islands in the compact urban environment using STEM-related software (version 2023) with the latest versions in 2023, including 3D Builder, Google Earth, RenderDoc, and others (see Figure 2). It is an excellent opportunity to examine the effectiveness of training workshops in teachers' adaptation to STEAM in regions where relevant trainer workshops are absent, and the integration of GEOG with STEAM education is just beginning because of the workshop's innovative and interactive learning environment.

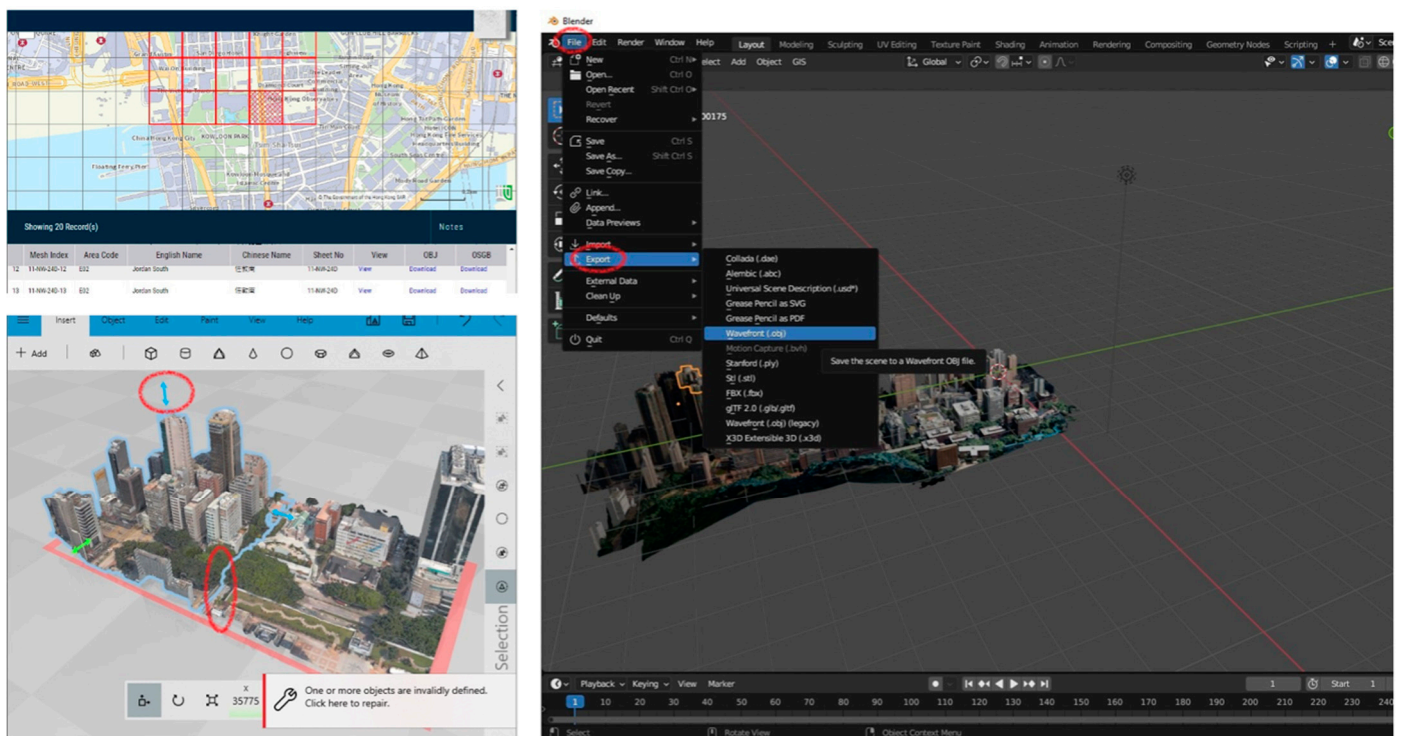


Figure 2. 3D modeling of street maps in the workshop (Co-WIN, 2023).

2.5. T-Test and Ordinal Regression

Following the data collection from the survey, ordinal logistic regression was used to examine the statistical relationship between demographic variables and issues related to GEOG STEAM. The topics are teachers' SoC, support for GEOG STEAM education, and perceptions of the importance of training workshops. Demographic items, such as respondents' age, education, and teaching background, are summarized in Table 2. Multi-collinearity, chi-square, and deviance tests were also conducted to ensure the regression models fit well.

Table 2. Descriptions of demographic variables involved in the study.

Independent Variables	Description
Types of teachers	In-service and pre-service teachers for GEOG may hold different concerns.
Preparedness of teachers	Whether the teachers have undergone any GEOG STEAM training programs or not.
History of teaching	Whether they have taught HKDSE or HK Advanced Level Examination or not.
Age of teachers	Differences in the age of teachers may lead to different views.
Education background	The type of fields in which the teachers were educated in the university may lead to different levels of concern.
Current workload	Teachers currently teaching more than one subject other than geography may have a higher level of concern.
Supportiveness in GEOG STEAM education	Teachers who support and oppose GEOG STEAM education may have different views.

There may also be correlations among the five SoCs. It was, therefore, necessary to perform correlation tests as well. Additionally, we conducted an independent *t*-test to compare the mean scores of respondent groups regarding the issues of GEOG STEAM education discussed earlier to determine whether there are differences in concerns and perceptions among responding groups. By also analyzing respondents' comments in the survey, this study involves both qualitative and quantitative approaches to examine teachers' concerns and the workshop's effectiveness.

3. Results

In this study, the following issues of GEOG in STEAM education were examined: (1) the concerns of pre-service and in-service GEOG teachers in secondary schools and (2) the effects of trainer workshops on addressing the teachers' needs and concerns. The results and implications of these questions are demonstrated and discussed in Sections 3 and 4.

3.1. Demography

Having obtained the informed consent of our respondents and removing invalid responses, 29 in-service GEOG teachers in HK secondary schools and 20 pre-service GEOG teachers currently enrolled in HK universities were selected. Among the in-service teachers, 14 had previously attended GEOG-related STEAM workshops, including workshops conducted by Co-WIN and by other hosts. The remainder of the group ($N = 15$) had never participated in any training. More than half of the in-service teachers are between the ages of 21 and 40 ($N = 16$), while all pre-service teachers are between the ages of 21 and 30. Only 13 teachers, aged 41–60, had previously taught HKALE geography, while most teachers began their careers after switching to HKDSE.

All in-service teachers studied GEOG and other social science subjects in university, with only two students studying science concurrently. Only four pre-service teachers are studying science-related subjects, while all others are studying GEOG and other social science subjects. The current educational background of our respondents is consistent with our observation that most GEOG teachers in HK secondary schools are from a GEOG background but has limited science background at the university level.

3.2. Supportiveness in GEOG STEAM Education

Generally, GEOG STEAM education is well supported ($M = 3.939$, $SD = 0.988$). In the case of pre-service teachers specifically, approximately 75% are extremely supportive of the promotion of GEOG STEAM education in HK, while approximately 66% of in-service teachers are extremely supportive. Using an independent sample t -test, it is determined whether there is a difference in supportiveness between pre-service and in-service teachers. As a result of the t -test, no statistically significant difference is found between the mean scores of pre-service ($M = 4.15$, $SD = 0.875$) and in-service teachers ($M = 3.79$, $SD = 1.048$), [$t(47) = -0.666$, $p = 0.256 > 0.05$] regarding their level of support for GEOG STEAM learning.

Supportiveness among trained and untrained teachers is also similar. Regarding trained teachers, approximately 80% expressed strong support for GEOG STEAM education. A t -test was used to analyze the mean score for the supportiveness of trained ($M = 3.93$, $SD = 1.072$) and untrained teachers ($M = 3.67$, $SD = 1.047$). Once again, the results indicate that the difference between trained and untrained teachers is insignificant [$t(27) = -1.251$, $p = 0.217 > 0.05$]. The results demonstrate that the types of teachers defined in the survey are not statistically significant factors affecting teachers' supportiveness of STEAM education in GEOG.

In addition, the factors affecting pre-service teachers' supportiveness are regressed, including age, importance of training, and educational background. As a result of a deviance [$\chi^2(9) = 1.802$, $p = 0.994$] and likelihood ratio chi-square tests [$\chi^2(3) = 9.038$, $p = 0.029$], the regression model is found to be a good fit. Interestingly, pre-service teachers who believe training is crucial have higher support for GEOG STEAM education than those who believe it is less important ($p = 0.033$). The importance of pre-service teacher training can be seen in this example. Other reasons for their support of GEOG STEAM education are also revealed in their alternative comments:

"Science—Learn about rock, climate; technology- using VR (Virtual Reality) to learn map and cities; there are many multidisciplinary elements". (Excerpt 1: A pre-service teacher who extremely supported geography STEAM education)

"This subject is very similar to the science subject and has a lot of applied science components". (Excerpt 2: A pre-service teacher who extremely supported geography STEAM education)

The multidisciplinary nature of GEOG, as indicated in Excerpts 1 and 2, is another primary reason for the support of pre-service teachers, involving science applications and concepts to be studied in different chapters of the GEOG syllabus. Despite this, some pre-service teachers are still conservative when it comes to GEOG STEAM education:

"I don't know what geography STEAM education is". (Excerpt 3: A pre-service teacher who considerably supported geography STEAM education)

"Only humanities students study geography in our school". (Excerpt 4: A pre-service teacher who moderately supported geography STEAM education)

Based on Excerpts 3 and 4, some pre-service teachers are held back by the social stereotype that GEOG is a humanities discipline only and a lack of knowledge of its STEM components. Similarly, the demographic variables and their perception of the importance of training were regressed with a deviance [$\chi^2(57) = 39.915$, $p = 0.958$] and likelihood ratio chi-square tests [$\chi^2(7) = 14.129$, $p = 0.049$] regarding the supportiveness of in-service teachers in GEOG STEAM education. There is also a similar result in the regression model of in-service teachers, with in-service teachers who believe that training is essential being more supportive of GEOG STEAM education than those who believe training is less critical

($p = 0.025$). The following reasons are also cited as reasons for a high level of support among in-service teachers:

“As there are lots of geographical technologies related to geography, such as GIS, AR (Augmented Reality) and sandbox”. (Excerpt 5: An in-service teacher who extremely supported geography STEAM education)

From Excerpt 5, in-service teachers who support GEOG STEAM education share the same view as the pre-service teachers that the application and comprehensiveness of geographical technologies in GEOG education have distinguished it from other subjects in humanities and social science as well as its approach to STEAM education. However, when compared to pre-service teachers, in-service teachers can view GEOG STEAM education from a different perspective:

“Syllabus in AL (HKALE) is more STEM than HKDSE”. (Excerpt 6: An in-service teacher who extremely supported geography STEAM education)

In Excerpt 6, an experienced in-service teacher who previously taught HKALE GEOG acknowledged that the current GEOG syllabus of HKDSE contains fewer STEAM elements than HKALE GEOG.

“More helpful to student’s career development and university programme selections”. (Excerpt 7: An in-service teacher who extremely supported geography STEAM education)

In Excerpt 7, the benefits and development of students are also the key reasons for in-service teachers to support GEOG STEAM education. Despite its benefits to students, some in-service teachers are not in favor of GEOG STEAM education:

“In HK, geography is treated as a social science subject”. (Excerpt 8: An in-service teacher who moderately supported geography STEAM education)

“Not enough lesson time”. (Excerpt 9: An in-service teacher who considerably supported geography STEAM education)

In Excerpt 8, in-service teachers also expressed the stereotype that GEOG belongs to the social sciences; it is difficult to change this perception in a short time. However, some provided another valid reason for not supporting GEOG STEAM education in Excerpt 9: their tight teaching schedule under the current HKDSE GEOG syllabus. The concern about lesson time is further examined in the next section.

3.3. Concerns of Teachers

According to Lau and Jong (2023), the SoC model consists of 5 main categories of teachers’ concerns, namely “management”, “information”, “evaluation”, “consequence”, and “refocusing”. In this study, the SoC model was refined to fit this study better. Table 3 presents the descriptive statistics and results of the correlation test. The most common concerns of GEOG teachers are evaluation ($M = 4.173$, $SD = 0.669$) and refocusing ($M = 4.163$, $SD = 0.693$), while information received the least concern ($M = 3.871$, $SD = 0.846$). The correlation test reveals a significant correlation between most pairs of categories. Among the correlated pairs, evaluation and information are the most highly correlated [$r(49) = 0.443$, $p = 0.001$], while management and consequence show the least correlation [$r(49) = 0.330$, $p = 0.021$]. There is no correlation between consequence and information.

The demographic variables were regressed to the SoC category of evaluation, which was the most serious among the SoC. The deviance test [$\chi^2(107) = 47.998$, $p = 1.000$] and a likelihood ratio chi-square test [$\chi^2(18) = 30.883$, $p = 0.030$] show that the model is significant. A significant statistically positive relationship exists between evaluation concerns and in-service geography teachers who taught language subjects simultaneously ($p = 0.009$).

Notably, lesson time is the largest concern ($M = 4.306$, $SD = 0.619$) compared to other concerns, which are students' supportiveness and learning efficiency within the same SoC.

Table 3. Descriptive statistics and zero-order correlations among the concern variables.

Stages of Concern	Mean	SD	1	2	3	4	5
1. Evaluation	4.177	0.669	-				
2. Information	3.871	0.846	0.443 **	-			
3. Management	4.075	0.663	0.420 **	0.391 **	-		
4. Consequence	4.026	0.675	0.461 **	0.089	0.330 *	-	
5. Refocusing	4.163	0.693	0.713 **	0.473 *	0.495 *	0.772 **	-

* $p < 0.05$. ** $p < 0.01$.

Another SoC with a high level of concern shared by the teachers is refocusing, which refers to their concerns related to the future development of GEOG STEAM education, such as whether teachers and students could refine themselves to cope with the upcoming changes. In this SoC, concerns related to teachers' and students' stress under GEOG STEAM education in the future are at the highest level ($M = 4.204$, $SD = 0.735$), among other concerns within the same SoC. Notably, no demographic items are significant in the regression model for this SoC, with deviance [$\chi^2(29) = 5.972$, $p = 1.000$] likelihood tests [$\chi^2(7) = 38.815$, $p < 0.001$]. The mean scores of pre-service and in-service teachers regarding their SoC were also compared in Table 4. In general, in-service teachers ($M = 4.188$, $SD = 0.636$) scored higher than pre-service teachers ($M = 4.027$, $SD = 0.749$), showing greater concern in GEOG STEAM education among in-service teachers.

Table 4. Quantification of teachers' concerns of SoC in GEOG STEAM education.

Stages of Concern	Pre-Service Teachers		In-Service Teachers		Trained Teachers		Untrained Teachers	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1. Evaluation	4.117	0.804	4.356	0.609	4.190	0.505	4.356	0.609
2. Information	3.917	0.944	4.044	0.638	3.619	0.854	4.044	0.638
3. Management	3.950	0.622	4.222	0.560	4.095	0.790	4.222	0.560
4. Consequence	4.117	0.691	4.100	0.630	3.875	0.715	4.100	0.630
5. Refocusing	4.033	0.637	4.244	0.712	4.000	0.624	4.244	0.712
6. Overall	4.027	0.749	4.188	0.636	3.951	0.729	4.188	0.636

All survey items were scored on a 5-point Likert scale, with higher scores indicating greater concerns about GEOG STEAM education.

In general, in-service teachers have a higher level of concern than pre-service teachers, but trained in-service teachers ($M = 3.951$, $SD = 0.729$) have a lower level of concern than pre-service teachers ($M = 4.027$, $SD = 0.749$). The comparison of the mean scores of trained teachers ($M = 3.619$, $SD = 0.854$) with untrained teachers ($M = 4.044$, $SD = 0.638$) is statistically significant in the category of information [$t(27) = 2.082$, $p = 0.023$], in which teachers are concerned about whether receiving adequate information regarding GEOG STEAM education.

3.4. Responses to Training Workshops

The SoC section reveals the importance of trainer workshops in addressing teachers' concerns, with trained teachers having fewer concerns than untrained teachers. To further validate the effectiveness of training workshops for teachers in GEOG STEAM education,

the in-service teachers were also asked about their views of the workshop organized by Co-WIN and their likelihood of attending similar workshops in the future. Generally, most of our responders who had participated in the Co-WIN's workshop agree that the workshop is effective in addressing their concerns about GEOG STEAM education in HK ($M = 4.33$, $SD = 0.67$). In addition, in-service teachers, including both trained and untrained educators, are highly likely to attend training workshops sponsored by government agencies or educational institutions to adapt to GEOG STEAM education ($M = 4.10$, $SD = 0.84$). Pre-service and in-service teachers were also asked about their perceptions of the importance of training. There is a slightly higher level of importance attached to training for pre-service teachers ($M = 4.30$, $SD = 0.56$) than for in-service teachers ($M = 4.28$, $SD = 0.58$), [$t(46) = 0.074$, $p = 0.471$], whereas trained teachers ($M = 4.33$, $SD = 0.67$), [$t(27) = -1.364$, $p = 0.092$], viewed training as more important than the untrained teachers. However, neither pair of comparisons shows statistically significant differences in mean scores. Furthermore, the deviance and likelihood tests are used to regress the demographic variables to teachers' perceptions of the importance of training, and the results are statistically significant. Teachers' age is significantly associated with their perception of the importance of training, with lower-age teachers having higher perceptions that training is important to their adaptation to GEOG STEAM education ($p < 0.001$).

4. Discussion

4.1. Teachers' Concerns in STEAM Education

As shown in the findings, in-service teachers from humanities backgrounds expressed high levels of concern in all SoCs. This is within our expectations as integrating STEAM elements into humanities subjects (GEOG, in this case) creates a variety of uncertainties for the teachers. One of the uncertainties shared by the teachers is the unfamiliarity of STEAM. This is because these in-service teachers were trained in the humanities during their university pre-service training (Geng et al., 2019; Lau & Jong, 2023). When GEOG, a conventional humanities/social science subject, is integrated with STEAM, they are worried that they might be unable to adapt to such changes and deliver their lessons effectively, such as whether they can adequately convey the STEAM knowledge to their students within limited lesson time, and whether they have adequate STEAM knowledge to inspire their students (Herro et al., 2019; Boice et al., 2021).

Another primary concern that teachers reflected on is the pressure and anxiety exerted on teachers and students. The teachers are worried that integrating STEAM in GEOG education would exert additional stress and stress-related issues for teachers, such as fatigue and depression, especially when about 45% of the in-service teachers in the survey are also teaching other subjects concurrently. This can reduce students' perceived teacher caring and satisfaction with schools and GEOG STEAM education (Ramberg et al., 2020). As an example, when more STEAM elements are added to the syllabus, more pressure will be exerted on teachers to reorganize their lessons and arrange supplementary lessons to complete the syllabus on time, which burdens the students simultaneously. This also creates stress and other negative implications for students, which are unbeneficial when they are refocusing on the future of GEOG STEAM education, making GEOG STEAM education counterproductive.

An interesting finding is also observed. In-service teachers expressed a higher level of concern than the pre-service teachers in the evaluation category of the SoC model. It is possible that in-service teachers express greater concerns regarding evaluation than the pre-service teachers, especially in the evaluation category of SoC, because pre-service teachers can possibly achieve a higher level of perception and level of GEOG STEAM knowledge through current GEOG education programs. In-service education is evolving

by incorporating more STEAM elements than it used to when the in-service teachers were trained (Sutaphan & Yuenyong, 2021; Najib et al., 2020). By receiving proper guidance and training from university instructors, pre-service teachers can implement their lesson plans and teaching materials more effectively during practicums or internships. In addition, in-service teachers may feel inferior and require more confidence when teaching GEOG STEAM than the pre-service teachers. However, this could also indicate that pre-service training for humanities teachers is evolving to meet the needs and challenges of STEAM education.

Apart from the teachers' concerns, the qualitative survey analysis also revives two other potential obstacles to integrating STEAM in humanities subjects: students' career opportunities and social stereotypes in humanities subjects. As for students' future development, in-service teachers have guided their students in choosing elective subjects and preparing them for public examinations. Thus, the impact on students' careers and academic development becomes their primary motivation for supporting GEOG STEAM education. Geographical studies are regarded as a social science subject at the top-ranked universities in HK. On the other hand, earth sciences and urban planning, closely related to GEOG, have been separated into science and architecture, respectively. Although GEOG in secondary schools helps students understand urban studies, and earth sciences, GEOG is not a requirement for admission to these undergraduate programs (CUHK, 2023a; AASOHKU, 2023; HKU, 2023). The present secondary school syllabus portrays GEOG as a subject that is hardly related to the universities' programs in urban studies, and earth sciences. Therefore, students are discouraged from studying GEOG as it does not benefit their future education and career path (Quinlan & Renninger, 2022).

Furthermore, the excerpts also reveal that the social stereotypes that GEOG is a subject of humanities and social sciences still exist. This perception is attributed to how geographical education is historically classified as a humanities or social science subject by the government and universities, and it is difficult to change this perception quickly. Such stereotypes can also be found in other humanities subjects, which might hinder their integration with STEAM (Sun et al., 2023).

4.2. Effectiveness of Workshops

Our results show that trained teachers have fewer concerns than the untrained teachers, indicating that trainer workshops are crucial in preparing teachers to embrace STEAM education. For instance, the trained teachers have lower concerns about receiving information regarding GEOG STEAM education, as our workshop or other workshops provided them with hands-on experiences in using geospatial modeling software, providing a platform for teachers to work together to mitigate various classroom problems they encountered while teaching STEAM knowledge in GEOG classes. As such, trainer workshops are essential for inspiring in-service teachers with the necessary information on lesson planning, classroom problem-solving, possible inter-school collaboration of GEOG STEAM activities, and the latest developments in GEOG STEAM education in HK. For pre-service training, pre-service teachers can evaluate their lesson plans and teaching materials more effectively during practicums or internships in secondary schools (Zholymbayev et al., 2022). This allows them to combine their humanities knowledge with STEAM knowledge in training. This integration not only enriches their teaching strategies but also enhances their ability to create interdisciplinary learning experiences for students. Hands-on experience in actual classroom settings helps them to develop practical skills and adapt to the dynamic educational environment.

4.3. Suggestions

Although humanities subjects have been urged to be integrated with STEAM in recent years in HK, it is difficult at the current stage. With geography as an example, a high potential exists for integrating STEAM in GEOG education based on the current HKDSE GEOG syllabus, which covers physical and human environments as well as global challenges. It is, however, rare for STEAM elements to be integrated into HKDSE Geography until fieldwork-based questions (FBQs) were introduced in 2019. By participating in fieldwork with teachers, students will equip with an initial level of spatial data inquiry and analysis. However, FBQs became optional for HKDSE in some years due to COVID-19, while none of the elective chapters are covered by FBQ (see Table A1 in Appendix A) (CDC & HKEAA, 2017; CDC & HKEAA, 2020, 2021a, 2021b, 2023; HKEAA, 2017, 2018, 2020). As a result, the diversity and intention of teachers and students to participate in STEAM-related fieldwork may be impeded. In addition, the desired outcomes for students in HKDSE GEOG, such as using Geographic Information Systems (GIS) and modeling, have not yet to be achieved. Therefore, there is a need to integrate STEAM into HKDSE GEOG, which is also beneficial for students' development.

The role of teachers in the development of STEAM syllabuses is crucial. Even though they have the passion to inspire their students, the majority of them are from humanities backgrounds, which hinders the development of GEOG STEAM education and students' learning experiences. Hence, suggestions are made to address this challenge.

A possible solution for GEOG STEAM education is to provide systematic training for GEOG teachers. However, the current institutional training, with limited training vacancies for training university graduates to GEOG teachers, found in HK is the postgraduate diploma in education (PGDE) organized by the Chinese University of Hong Kong, allowing the teachers to acquire teaching strategies and current trends in GEOG education (CUHK, 2023b). This aligns with the context of Singapore (Seow, 2016). As such, there is a need for other educational institutions to provide more training for in-service teachers, particularly for those teachers with only a humanities background. The same may be true for humanities teachers of other subjects if more collaboration between humanities and STEAM teachers is required in STEAM education.

According to our findings, training can significantly reduce concerns among in-service teachers, especially when it comes to lesson planning and what GEOG STEAM education is all about. It should also be noted that additional support should be provided to two SoCs, namely evaluation and refocusing, both of which are at critical levels compared to other SoCs. These concerns can be mitigated by offering workshops that provide guidance on how teachers may modify or structure their GEOG lessons to meet the needs of future GEOG STEAM education. Teachers will be able to evaluate GEOG STEAM education more positively after their lessons become smooth and effective. Training workshops may also provide teachers with manuals, notes, and examples of how to prepare and evaluate lesson materials that students can understand easily, especially when dealing with STEAM software for geospatial analytics. The teachers can work on their lesson materials in the future based on the notes taken during the workshop. Under such circumstances, teachers and students can both relieve their stress.

Another possible strategy is to collaborate with teachers of other STEAM subjects, especially physics and chemistry. As of now, concepts in some HKDSE GEOG units intersect with those in HKDSE physics and chemistry, including "weather and climate", "building a sustainable city", "climate change", and "dynamic Earth" (CDC & HKEAA, 2017; CDC & HKEAA, 2020, 2021a, 2021b, 2023; HKEAA, 2017; HKEAA, 2018, 2020). GEOG teachers who are unfamiliar with STEAM concepts may collaborate with STEAM teachers at their schools to teach a few lessons related to STEAM concepts in GEOG STEAM education. By

sharing their knowledge of STEAM teaching with the GEOG teachers, the GEOG teachers will be able to learn from the STEAM teachers and relieve the pressure of teaching STEAM subjects. Future studies could investigate the feasibility and effectiveness of this suggestion.

5. Conclusions

With a case study of GEOG with STEAM education in HK, this study aims to (1) explore the concerns of pre-service and in-service humanities teachers regarding STEAM education and (2) the effectiveness of trainer workshops in mitigating their concerns. This study involves both qualitative and quantitative approaches to determine teachers' level of concern under the SoC model. After collecting the responses of in-service and pre-service teachers with a questionnaire survey and analyzing them with a regression model, it is found that the evaluation and refocusing categories of SoC have the highest level of concern. Regarding the first objective, in-service teachers express a higher level of concern than the pre-service teachers due to their limited previous knowledge and training in STEAM. This hints at the importance of hosting more trainer workshops for in-service teachers (objective 2), which shows that trainer workshops can effectively mitigate in-service teachers' concerns regarding information in GEOG STEAM education. In addition, a high level of recognition of the importance of trainer workshops is also expressed by the pre-service and in-service GEOG teachers, indicating that these teachers firmly believe that attending trainer workshops could better equip them, and they are eager to participate in more of these types of workshops in the future. Overall, this study encourages policymakers to formulate and implement specific suggestions regarding how to mitigate teachers' concerns and to promote STEAM education in a feasible and effective manner. Once GEOG teachers, primarily from humanities backgrounds, can be trained systematically to fit into STEAM education, the success of STEAM integration in GEOG could serve as a lesson for policymakers to conduct effective pedagogical strategies and establish a well-developed STEAM education system related to the integration of humanities and STEM.

While this study may seem to be limited to the context of HK, the results of the study, including the concerns of humanities teachers under GEOG STEAM education and the effectiveness of trainer workshops, are applicable to other Asian countries where GEOG and other humanities subjects are being integrated to promote STEAM education, such as Singapore, South Korea, and Japan (Dharmadhikari, 2025). It is, however, difficult for this study to obtain a sufficient sample data size. Even so, this study serves as a foundation for future research related to the mitigation of concerns in GEOG. Further research can be conducted to validate and elaborate on the conclusions of this study. Consequently, researchers should consider employing larger sample sizes and diverse methodologies to strengthen the validity of future studies. With the understanding of teachers' concerns and workshops' effectiveness in promoting STEAM education developed in this study, future research could explore how the integration of arts education impacts teacher training and student outcomes in similar contexts.

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Abbreviations

The following abbreviations are used in this manuscript:

STEM	Science, Technology, Engineering, Mathematics
STEAM	Science, Technology, Engineering, Arts, Mathematics
SoC	Stages of Concern
HKDSE	Hong Kong Diploma of Secondary Education
HKALE	Hong Kong Advanced Level Examination
HK	Hong Kong
FBQs	Fieldwork Based Questions
GEOG	Geography

Appendix A

Table A1. Demography of the respondents.

Demography	N
In-service geography teachers	29
Pre-service geography teachers	20
Total respondents with valid responses	49
Trained in-service teachers	14
Untrained in-service teachers	15
In-service teachers (Age 21–30)	8
In-service teachers (Age 31–40)	8
In-service teachers (Age 41–50)	7
In-service teachers (Age 51–60)	6
Pre-service teachers (Age 21–30)	20

Table A2. An overview of the geography HKDSE syllabus.

Chapters	Compulsory/Elective Chapter	Fieldwork Based Questions (STEAM-Related)
^a Opportunities and Risks—Is it rational to live in hazard-prone areas?	^a Compulsory	^b N/A (Not included as Fieldwork Based Questions)
^a Managing River and Coastal Environments: A continuing challenge	^a Compulsory	^c Compulsory for 2019 and 2022 DSE syllabus, with field study on river discharge and velocity
^a Changing Industrial Location—How and why does it change over space and time?	^a Compulsory	^d Compulsory for 2025 DSE syllabus

Table A2. Cont.

Chapters	Compulsory/Elective Chapter	Fieldwork Based Questions (STEAM-Related)
^a Building a Sustainable City—Are environmental conservation and urban development mutually exclusive?	^a Compulsory	^b Compulsory for 2019–2020 DSE syllabus, with field study on urban environmental quality measurements and impact assessment
^a Combating Famine—Is technology a panacea for food shortage?	^a Compulsory	^b Optional for 2021 DSE syllabus
^a Disappearing Green Canopy—Who should pay for the massive deforestation in rainforest regions?	^a Compulsory	^d Compulsory for 2025 DSE
^a Climate Change—Long-term fluctuation or irreversible trend?	^a Compulsory	^{d, e} Optional for 2024 DSE and compulsory for 2025 DSE
^a Dynamic Earth: The building of Hong Kong	^a Elective	N/A
^a Weather and Climate	^a Elective	N/A
^a Transport Development, Planning and Management	^a Elective	N/A
^a Regional Study of Zhujiang (Pearl River) Delta	^a Elective	N/A

Source. ^a (CDC & HKEAA, 2017); ^b (CDC & HKEAA, 2020); ^c (CDC & HKEAA, 2021a); ^d (CDC & HKEAA, 2021b); ^e (CDC & HKEAA, 2023).

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