RESEARCH ARTICLE

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# Civic Engagement in the STEAM Classroom: Taking "Teaching of Sewage Purification System" as an Example

Sin F. E. Ng and Tak W. Man

**ABSTRACT**

**Civic engagement is more and more critical in this modern society since it can promote the development of society. In Hong Kong, the Education Bureau allows schools to implement civic education through multiple approaches. In this background, the authors' school tries to develop a curriculum to cultivate students' sense of citizenship, which increases students' care and participation in the community. We try to integrate STEAM education and citizenship teaching and let students explore society's responsibility through an integrated curriculum approach. This article shares the practical experience of using STEAM education to facilitate junior high school students' understanding of citizenship and suggests coping with the challenges. The study found that students could construct the value and meaning of STEAM education. Also, students could develop a sense of citizenship after the lessons. Finally, students with low academic achievement could build learning confidence through the integrated curriculum.**

**Keywords:** Civic Engagement, Civic Education, Integrated Curriculum, STEAM Education

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## I. Introduction

The primary role of civic education is to prepare our students to be good citizens in our country and let them actively participate in the development of the community (Dewantara *et al.*, 2019). Civic engagement is vital to the development of society, and we can eliminate the negative factors to it if we can provide civic education to the students (Galston, 2007). Many researchers have discovered that classroom teaching, extracurricular activities, school atmosphere, and service-learning are the most effective ways to promote civic education (Campbell, 2019). Therefore, schools should develop an appropriate civic education policy and lead teachers to design suitable curriculums and activities to build students' sense of citizenship and civic engagement.

STEAM education is an interdisciplinary approach (science, technology, engineering, arts, mathematics) to increase students' problem-solving ability, creativity, and learning interest in STEM knowledge (Perignat & Katz-Buonincontro, 2019). STEAM education also can stimulate students to think actively instead of waiting for teachers' answers (Mahmudovnaet *et al.*, 2022). The main objectives of STEAM education are to educate students with critical thinking and innovation since our world needs this kind of thinkers to solve global problems, like climate change, social inequality, etc. (White & Delaney, 2021). In practice, STEAM teachers must teach students about design thinking (empathize, define, ideate, prototype, and test) to guide them to understand the need of people and plan how to satisfy their needs (Jantakun *et al.*, 2021). Hence, we can see that STEAM education can train students to think and solve real-world problems, and it is in line with the spirit of civic education.

In recent years, the HKSAR government has vigorously pushed the development of civic education and required schools to provide different teaching activities for students to learn how to act as good citizens (Curriculum Development Council, 2021). Researchers found that civic engagement could assist Hong Kong students in building meaning in life (Fong & To, 2022). Since helping students find their purpose in life is crucial in holistic education, teachers should design the program to help students find the meaning of living (Yuen, *et al.*, 2021). Under this background, the authors try to integrate STEAM education into civic education to provide opportunities for students to participate in the community. However, there are many difficulties in the implementation of the program. Thus, this article analyzes the effectiveness of the integrated curriculum (STEAM education and civic education) to learn STEAM knowledge and develop a sense of citizenship (let the students understand the meaning of learning and their roles in the community).

## II. Conceptual Framework

STEAM education can provide a way to develop a sense of citizenship for students and guide students to help the community's people. There are three principles for the implementation of civic education, including discussing critical issues of society with students, offering extracurricular and students government activities, providing opportunities of services learning (Youniss, 2011). STEAM education emphasizes cooperation among students, and it can help students solve the problem by creating the actual product prototypes during the lessons (Eshbekovich, 2020). Furthermore, STEAM education can let students change society by transforming knowledge into practice (Singh, 2021). The research study finds that when teachers integrate STEAM education with civic education, students can increase their civic engagement since they can know more about their community in the learning process (Condon & Wichowsky, 2018). Also, maker activities are the core element of STEAM education, and students can achieve the goal of helping disadvantaged people through maker activities (Timotheou & Ioannou, 2021). Therefore, civic education in schools is essential to students since they can understand the role of a good citizen. Suppose we combine civic education with STEAM education, in that case, students can explore the community issues (what are the needs of the people) and use STEAM as a medium to solve these problems. As a result, students can develop their sense of citizenship.

Fig. 1. shows the conceptual framework of the integrated curriculum (STEAM education and civic education). The integrated curriculum includes knowledge (students learn STEAM knowledge to solve the problem), skills (students use "design thinking" to think of a problem-solving solution for the difficulties of the people in need), and attitudes (students care about their community and increase the civic participation). We can see that STEAM can as a tool for the students to participate in the community.

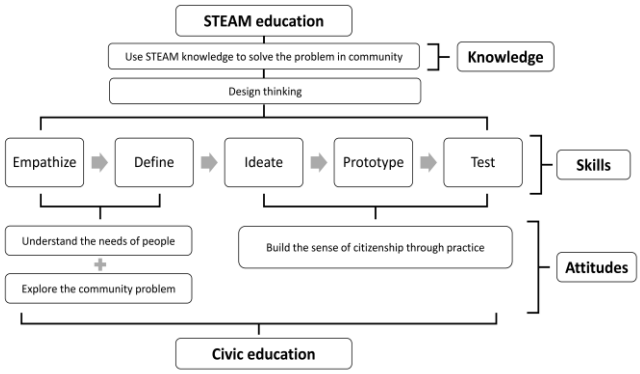


Fig. 1. The conceptual framework of using STEAM education to increase students' sense of citizenship.

## III. Objectives of the Study

a) To evaluate the teaching effectiveness of the integrated curriculum (STEAM education and civic education).

b) To investigate the evaluation of students on the integrated curriculum (STEAM education and civic education).

## IV. Methodology

### *A. Research Method*

Twenty-seven students participated in this study. They were seventh-grade students. They had a good relationship with the authors, which facilitated the development of this research. After the invitation from the authors, they were willing to take part in this study. Most of them were lively and liked to have activities during the lesson.

At the end of lessons, the authors interviewed five students to learn more about their evaluation and feelings of the integrated curriculum. These five students had a good relationship with the authors and were willing to tell us their true feelings and views. It enabled the authors to obtain accurate research data and present the results more objectively. In addition, the authors conducted the interviews with the following questions: 1. What is your evaluation of the integrated curriculum (STEAM education and civic education)? 2. What learning activities or content impressed you most? 3. Could this teaching approach improve your understanding of STEAM? 4. Are you willing to have relevant teaching in the future? The authors asked students follow-up questions to understand their views more comprehensively during the interview.

The authors made a questionnaire to study the effectiveness of the integrated curriculum. To enhance the quality of the questionnaire, we invited a middle school teacher with qualitative research experience to review it. After that, the research group revised the questionnaire format and items. We used the pattern of the Likert scale to design the questionnaire (ten questions in total). After collecting the questionnaires from the students, the authors analyzed the data to explore the effectiveness of the integrated curriculum.

The authors used teacher observation to study students' learning performance. The authors wrote down the words (field notes) based on the observation after each lesson. These field notes could let the authors understand the learning process and changes of students. Also, it could help the authors to do the teaching reflection and enhance the teaching effectiveness.

To increase the credibility and validity of the research, the authors invited an experienced teacher with an educational research background to assist in analyzing the qualitative data. If there were inconsistencies in the data analysis, we would discuss them until we reached a consensus. Also, the authors adopted triangulation (collecting three primary data sets to confirm the results mutually) to reduce the researchers' personal bias. Lastly, the authors adopted the "member check" to ask the students to read the data analysis script and ensure the investigation did not misunderstand their views.

### *B. The Teaching Design of the Integrated Curriculum (Civic Education and STEAM Education)*

STEAM knowledge and skills are essential to developing a country, and they are the necessary qualities of citizens in the 21st century (de Roock & Baildon, 2019). STEAM education can help us construct a civic society with social justice (Ortiz-Revilla *et al.*, 2020). Therefore, the educators can use STEAM education as the base to develop students' sense of citizenship (using STEAM knowledge and skills to help people and promote the development of society). With

this background, the authors implemented the teaching of the sewage purification system.

The authors' school was in Yuen Long (New Territories of Hong Kong) and next to Shan Pui River (Figure 2), and it was polluted and smelly. This problem seriously affects the quality of people's living environment. For this problem, the authors led the students to explore the causes of pollution and formulate solutions to improve residents' living environment. The authors designed different learning activities for the students as follows: 1. Lesson teaching: The students learned the related scientific knowledge (the methods to filter water, the causes of water pollution, etc.) through lectures and group discussion. 2. Picture book appreciation: The teachers and students read the "river" picture book and discussed the function and meaning of the river to the human beings (such as economy, agriculture, culture, religion, environment, ecology, etc.). 3. Newspaper reading: The teachers discussed the related news (the water pollution problem of the community) with the students. 4. Watching video: The students watched the video about water pollution worldwide and discussed its harmful effects. 5. Field trips: The teachers took students to inspect Shan Pui River (exploring the water pollution problem of the river and understanding the difficulties of the residents nearby). 6. Writing activities: The students wrote a letter to the director of the Water Supplies Department to introduce the pollution problem of Shan Pui River and made suggestions. 7. Water filter design competition: The students designed the water filter and compared filtering effects. 8. The maker workshop: The students learned the concept of design thinking and the reasons for innovation. 9. Research and development activities: The students designed and made the model of the sewage purification system (filtered the polluted river water and used purified river water for toilet flushing). 9. Press conference: The students introduce their sewage purification system to the teachers and classmates. 11 Media interview: The reporter interviewed the student inventors.

Fig. 2. The picture of Yuen Long Shan Pui River.

Fig. 3. shows the relationship between different teaching activities and promoting learning. Those teaching activities aimed to educate students to reach the learning objectives: caring for the community problem, participating in the community, and learning STEAM knowledge in practice.

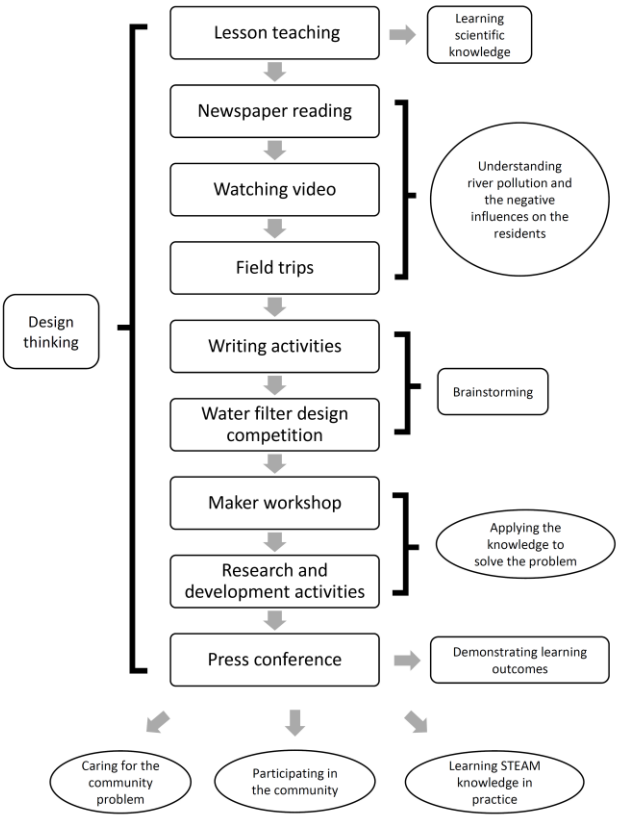


Fig. 3. The relationship between teaching strategies and promoting learning.

The most significant innovation of this program is that the authors used the community problem as the teaching topic to lead the students to understand their local society problems more. Also, they could apply the STEAM knowledge learned in the lessons in the process to understand the meaning of STEAM education: helping the people in need and building a better future for our community. Moreover, the students could comprehensively understand the community issue through interdisciplinary learning (Chinese language, STEAM education, social study, and civic education). This teaching approach could help the students develop the thinking of solving the problem using different disciplinary knowledge.

## V. Result and Discussion

### *A. Constructing the Values and Meaning for Learning*

The students reported that they liked the program since they could apply the STEAM knowledge to solve the community problem. Student A and Student B indicated that they did not know the reason for learning STEAM in the past, and they found the values of learning STEAM education after the lessons. Student C and Student E clearly stated that STEAM education could help people solve the problem in reality, and it was the most important value of learning knowledge. Under the authors' observation, most of the students were active during the lessons (some low-motivation students changed their learning attitude and actively took part in every activity), showing that they loved this learning approach. The authors asked them the reason for the change of the learning attitude. They all indicated that they could show the learning outcome by making the model instead of

finishing many written tests and exercises. The most impressive thing was that Student D told the authors, "I did not know why I was learning in the past, but now I know what I am doing. The meaning of STEAM learning is to make a better society by technological innovations." Indeed, it is the most critical learning outcome (understanding the meaning of learning) of this program.

Fig. 4. A student showed the sewage purification system (his group and teachers invented it).

Table I presents the mean and standard deviation for each question in the pre-test and post-test (items related to STEAM education). The mean scores and standard deviation were used to explain the students' confidence using STEAM knowledge. The results showed that the students increased their confidence in using STEAM knowledge. We can see that the mean scores of each question in the pro-test rose compared with the pre-test.

TABLE I: THE RESULT OF THE QUESTIONNAIRE (ITEMS RELATED TO STEAM EDUCATION)

| | Pre-test | | Pro-test | |
|---|---|---|---|---|
| Questions | Means | SD | Means | SD |
| 1. I understand the learning meaning and value of STEAM knowledge. | 2.81 | 0.48 | 4.04 | 0.81 |
| 2. I can use the STEAM knowledge to fix the problem. | 2.74 | 0.71 | 4.44 | 0.75 |
| 3. I can apply the theory of STEAM in practice. | 2.81 | 0.56 | 4.37 | 0.74 |
| 4. I understand the concept of design thinking. | 3.15 | 0.60 | 4.22 | 0.75 |
| 5. I can use design thinking to invent a product. | 2.85 | 0.72 | 4.19 | 0.74 |

### *B. Developing a Sense of Citizenship*

After the program, the students could understand the community problems more. Student A said that although he usually walked near Shan Pui River, he did not know why it became smelly. Also, he did not have the intention to explore the problem. After learning, he knew the reasons and understood more about his living community. In the future, he would like to explore more community issues since he was responsible for making our living place better. Student E indicated that she would be more aware of her community since she was one of the family members of the community. Student B said there were many problems in the school's community, such as feral pigeon nuisance. He hoped that the authors would arrange the next module to teach them to solve other community problems. The authors were happy that students could find the importance of knowing their living community and solving the community problem. It meant that they could build up a sense of citizenship (having duties to make this place better) and enhance their engagement in society (willingness to take action to change the community).

Fig. 5. The students had a field trip on the Shan Pui River.

Table II presents the mean and standard deviation for each question in the pre-test and post-test (items related to civic education). The mean scores and standard deviation were used to explain the students' beliefs in developing a sense of citizenship. The results showed that the students built a sense of citizenship after the lessons. We can see that the mean scores of each question in the pro-test increased compared with the pre-test.

TABLE II: THE RESULT OF THE QUESTIONNAIRE (ITEMS RELATED TO CIVIC EDUCATION)

| | Pre-test | | Pro-test | |
|---|---|---|---|---|
| Questions | Means | SD | Means | SD |
| 1. I am concerned about community issues. | 3 | 0.73 | 4.04 | 0.75 |
| 2. I am willing to participate in the community affairs. | 3.19 | 1.00 | 4.15 | 0.66 |
| 3. We should be responsible for community development. | 3.59 | 0.80 | 4.41 | 0.50 |
| 4. We should play an active role in community development. | 3.11 | 0.85 | 4.52 | 0.51 |
| 5. I wish I could help the residents solve the community problem. | 2.67 | 0.83 | 4.11 | 0.85 |

### *C. Building the Learning Confidence of Students with Low Academic Achievement*

The unexpected thing is that many students with low academic achievement told the authors that they became more confident after this program. Student D, with learning difficulties, indicated that traditional education (emphasizing the written exam result) defeated him in primary school. However, this program provided a chance for him to demonstrate the learning outcome by performance evaluation, and he got a higher mark. After this program, he thought he could succeed if he made an effort. Another student reported that the authors offered many opportunities (interviewed with the media reporter, conducted the competition, and invited them to speak to the classmates) to recognize their contribution, making them more confident. Therefore, the hands-on course can provide students with

learning difficulties another way to succeed and build their learning confidence. Also, it is helpful to cater to the needs of learners with different levels.

Fig. 6. The Radio Television Hong Kong reporter interviewed the students.

## VI. Conclusion

To sum up, this study found that the integrated curriculum (STEAM education and civic education) could allow the students to apply the STEAM knowledge and develop a sense of citizenship. More importantly, the students could build up the meaning of learning STEAM: to solve the community problem. Despite this, there are some challenges to this program. Firstly, the teaching content of the program included the knowledge of different disciplines, and the authors needed to spend much more time preparing the lessons, such as designing the learning activities, making the teaching materials, etc. Secondly, the authors were not science teachers. Thus, the authors needed to consult other science educators outside the school to study the relevant STEAM knowledge. Thirdly, due to the spread of COVID-19 in Hong Kong, the Education Bureau only allowed the school to offer half-day lessons to the students. In that case, the teaching hours were not enough for the authors to discuss and consolidate the knowledge with students in the learning process. Fourthly, the authors could not invite different community stakeholders to join the program, such as district council members, government officers, etc. Therefore, the learning was not comprehensive enough for students to explore the water pollution problem of Shan Pui River.

In the future, the authors will take the following actions to solve the challenges mentioned above. 1. The authors will form a professional teaching community in the school and invite different subject teachers to join the community. With their help, the authors can have more human resources to develop a higher-quality curriculum. 2. The authors will try to invite professors or lecturers with science education backgrounds. Then they can provide professional sharing or training to the members of the professional teaching community, and the members, including the authors, can expand the horizon in STEAM education. 3. The authors will develop the flipped classroom to save time and spend more time discussing and consolidating the knowledge in the face-to-face lessons. 4. The authors will contact the district council members, the person in charge of the district organization, the government officers, the convener of the resident organization, etc., and ask them to help in the lessons. They may give lectures to the students, lead them to have a field trip, discuss civic or community issues with them, etc. The students can comprehensively understand the community issues with their practical sharing.

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## Conflict of Interest

The authors declare no potential conflicts of interest concerning the publication of this article.

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