The Influence of Online STEM Education Camps on Students’ Self-Efficacy, Computational Thinking, and Task Value

Feng-Kuang Chiang1,2 · Yicong Zhang2,3 · Dan Zhu2 · Xiaojing Shang2 · Zhujun Jiang2

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Abstract
As a result of COVID-19, various forms of education and teaching are moving online. However, the notion of an online STEM camp is still in its beginnings, and there is little relevant research and experience in this context. At the beginning of April 2021, the research team launched an online STEM charity camp with the theme of “Shen Nong Tastes Herbs.” Participants included 113 third- and fourth-grade primary school students ranging from 8 to 12 years of age from four schools in Karamay, Xinjiang Uygur Autonomous Region with weak educational capabilities. The camp lasted for 3 days and included 7 activities, while remote teaching was accomplished through Dingtalk. Pre- and post-test questionnaires and interviews were used to explore the impact of this camp on students. We found that online STEM camps could improve students’ self-efficacy, computational thinking, and task value, and there is a significant improvement in the self-efficacy ($p = 0.000$) and task value ($p = 0.001$) dimensions. In addition, students with high self-efficacy had higher scores in the other two dimensions. Finally, we summarized the experiences and gains of students and teachers and proposed suggestions for developing online camps based on this experience.

What Is Already Known About this Topic
• STEM and robotics education have a positive impact on student development.
• Students’ self-efficacy, computational thinking, and task value are very important and popular research areas in STEM education.
• STEM education camps can promote students’ teamwork skills and other abilities. However, due to the influence of the COVID-19 pandemic, there is little research concerning online STEM education.

What this Paper Contributes
• An online STEM education charity camp was launched for schools with weak educational capabilities.
• Against the backdrop of the COVID-19 pandemic, the online camp effectively integrated traditional Chinese herbal medicine culture, LEGO robots, and STEM knowledge.
• This paper explored the relationship among students’ self-efficacy, computational thinking and task value.

Implications for Practice and/or Policy
• This paper developed an online STEM course with multidisciplinary integration to provide ideas for instructional designers.
• This paper summarized the experience of online STEM education camps and provided suggestions for the implementation of online camps in the future.
• This paper encouraged more educators to pay attention to students living in areas with weak educational capabilities and to actually promote the balanced development of education.

Keywords  STEM education · Online camps · Self-efficacy · Computational thinking · Task value

Introduction
The sudden outbreak and continuing spread of COVID-19 have caused large-scale interruptions to education around the world (UNESCO, 2020). Traditional teaching in schools is usually difficult to carry out, and educational methods require urgent change. Online learning, with its advantages of flexibility, convenience, and timely interaction at a distance between teachers and students (Santos et al., 2021), has become an
essential solution for teaching and learning during the pandemic period (Asare et al., 2021) and has guaranteed students’ continuing education (Yan et al., 2021). In China, educational methods differ between urban and rural students (Li & Zhao, 2021), and COVID-19 has exacerbated this educational imbalance. Due to the uneven distribution of education funds and teachers, rural schools often lag behind urban schools, and teachers lack digital experience and training (Goudard et al., 2020). STEM education is the interdisciplinary integration of science, technology, engineering, and mathematics, which can not only stimulate students’ interest in learning (Mathers et al., 2012) but can also improve students’ self-efficacy (Wilson et al., 2018), computational thinking (Grover & Pea, 2013), and other diversified abilities. STEM education has been important in the UK, Germany, Japan, Finland, and other countries and has been implemented at the stage of K–12 education. The research team effectively integrated traditional Chinese medicine culture, LEGO robots, and STEM education and launched the STEM education charity camp “Shen Nong Tastes Herbs” (神农尝百草). Based on the effects of and experiences with offline implementation of this camp during the winter vacation of 2021, we launched an online STEM camp in early April of 2021 to transfer bountiful resources from Shanghai to disadvantaged schools in Xinjiang in order to narrow gaps in educational equity.

Literature Review

Robot-Based Education

With the rapid development of science, economics, and technology, robots are gradually being integrated into people’s work and daily lives, a change which also affects the educational environment (Johnson et al., 2016). Robots play a role in assisting educational practice. In teaching, they can be used as teachers or tutors to provide direct curriculum support through prompts, teaching, and supervision. In learning, the introduction of robots can lead to innovations in the teaching of traditional subjects and improve students’ interest in learning (Brand et al., 2008; Caron, 2010). As early as 2016, EDUCAUSE Horizon Report: Higher Education Edition listed robotics technology as one of six key technologies. Robot-based education facilitates students’ development and encourages students to cooperate (Yuen et al., 2014). It can not only help students to learn scientific knowledge and understand the concepts of STEM disciplines, but it can also be of use in cultivating students’ interest in learning and improving their computational thinking ability (Hsiao et al., 2022). Affected by the COVID-19 pandemic, traditional offline teaching has shifted towards online teaching, and robot-based teaching has moved from offline to online. Using the network to guide theoretical knowledge and coding, Benitez et al. (2020) performed construction activities with respect to a robot’s arm based on this project. The famous WRO (World Robot Olympiad) also announced that the 2021 International Finals were conducted online, and competition rules were altered to encourage the construction and competition of virtual robots.

STEM Education Camp

The STEM education camp is a common and important form of informal learning and plays an active role in promoting the development of students’ interests in and attitudes towards STEM (Binns et al., 2016), as well as their practical ability (Roberts et al., 2018), creativity (Falk & Meier, 2021), teamwork awareness (Mohr-Schroeder et al., 2014), and future career aspirations (Bindis, 2020). According to previous research, the thematic content of STEM education camps is rich. In addition to ordinary topics in science (Todd & Zvoch, 2019) or engineering, there are summer camps dedicated to subjects such as astronomy (Plummer et al., 2016), meteorology (Barrett et al., 2014), and LEGO robots (Üçgül & Altiok, 2021). Moreover, various camp activities are carried out for students of different ages and educational levels. It is worth noting that under the influence of COVID-19, many courses or training programs have been transformed into online distance education (Hu et al., 2021; Watermeyer et al., 2021; WHO, 2020), but online camps, especially STEM education camps, are still an underdeveloped aspect of teaching reform. At present, the most common solution to this challenge is to change an offline camp into an online course. For example, Bergsman and Chudler (2021) studied the Virtual REACH Program, which transformed the neural engineering summer camp into an online course. This program provided synchronous and asynchronous curriculum resources, which were fully available online, and promoted teaching interaction through real-time video conferences, lectures, and discussions.

Self-Efficacy, Computational Thinking, and Task Value in STEM Education

Self-efficacy refers to students’ judgement concerning their ability to complete tasks or learning objectives, which is driven by cognition, emotion, and choice. Students’ belief that they can complete tasks prompts them to take the actions needed to achieve their goals (Bandura & Albert, 1993). In the STEM education context, self-efficacy has
been used to measure student change with respect to science (Bryan et al., 2011), technology (Shank & Cotten, 2014), engineering (Brown & Burnham, 2012), and mathematics (Rozgonjuk et al., 2020), and it has also played a vital role in students’ career development (Luo et al., 2021b). Computational thinking uses computer science to solve a range of cognitive activities, such as problem-solving and system design, and it is a must-have skill for everyone, just like reading, writing, and arithmetic (Wing, 2006). CT has received increasing attention from countries and has been included in K–12 education (Angeli et al., 2016; Webb et al., 2017). In addition, studies have shown that engineering skills (Jou et al., 2021) and programming experience (Sun et al., 2021) have an impact on students’ computational thinking. Based on the theory of expectation value, task value refers to students’ cognition and interest in importance. Students may focus on tasks that they deem important while ignoring tasks that they do not value (Wigfield & Eccles, 1992). Task value affects students’ attitudes towards STEM (Ball et al., 2017) and their career choices related to STEM (Wang et al., 2017).

Although there are many studies focusing on the self-efficacy, computational thinking, and task value dimensions in STEM education, few scholars have explored the correlation between them. From the perspective of the social cognitive theory of Bandura and Albert (1993), self-efficacy affects students’ assessment of the value and importance of tasks. When students realize that assessment tasks are essential and valuable, they may develop a strong sense of self-efficacy (Mcmillan & Workman, 1998; Wigfield & Eccles, 1992). In addition, studies have shown that self-efficacy has a strong influence on coding achievement and computational thinking ability (Baek et al., 2019).

Research Questions

This research integrated Chinese medicinal knowledge into the LEGO STEM camp and relied on the internet to conduct synchronized teaching across regions. The research questions were as follows:

**After participating in the online STEM education camp — “Shen Nong Tastes Herbs,”**

**RQ1:** What changes occur to students’ sense of self-efficacy, computational thinking, and task value?

**RQ2:** How did the engineering and programming experience influence students’ computational thinking?

**RQ3:** What is the relationship among students’ self-efficacy, computational thinking and task value?

**RQ4:** What experiences and suggestions do students and coordinating teachers have?

Research Design

This research was conducted through a combination of quantitative and qualitative methods. Quantitative methods included using pre- and post-test questionnaires to explore changes in students’ abilities and qualitative methods included using interviews to obtain teachers’ and students’ evaluations of the camp.

Context

The “Shen Nong” (SN) project was a charity camp that fostered primary school students’ interest in STEM learning and promoted balanced education. The first camp of the project was officially implemented in the winter vacation of 2021. The study focused on the second camp in the spring of 2021 as follows. We have reached cooperation with the Karamay Education Bureau of Xinjiang Uygur Autonomous Region in western China to introduce the theme and schedule of online STEM summer camp, and the main participants – grades three and four primary school students. The Education Bureau publicized the STEM Education project, and in the response of many schools, four weak schools were finally identified. With the consent of their parents, students signed up after self-recommendation or teacher recommendation. And students could only participate in this online camp after comprehensive evaluation by the school.

Participants

A total of 113 third- and fourth-grade pupils, ranging from 8 to 12 years of age (male: 81; female: 32), volunteered to participate in the study. Researchers speculated that male students were more interested in STEM themes, so the number of male students was higher than that of female students in the case of voluntary enrollment. Since the parents of the students were ordinary workers, farmers, or self-employed workers, the time and financial support available to educate the students was limited. Therefore, in addition to receiving traditional education in school, most students were not exposed to additional STEM-related skill tutoring. Among these students, 63.3% had no experience with engineering activities and competitions, while 70.6% had experienced programming education previously.

Camp and Curriculum Implementation

Considering safety requirements during the pandemic, the SN STEM Camp was launched online in early April 2021. After evaluation and testing, the camp teachers finally chose Dingtalk as a distance teaching platform to assist teaching. Dingtalk is a distance learning platform...
recommended by UNESCO (UNESCO, 2020). It not only supports real-time video communication and delivers a smooth and stable platform network environment but also has rich and robust functions. The SN STEM camp took the form of remote synchronous teaching (Fig. 1). The main port was in Shanghai, and 10 camp teachers (as teaching assistants to each other) were in a dedicated classroom, and the main teaching meeting was broadcast live by Dingtalk. Remote ports were four schools in Xinjiang Uygur Autonomous Region. Each school was equipped with a number of coordinating teachers, who were responsible for the synchronous connection of online teaching ports, classroom order management, and real-time teaching communication and feedback with Shanghai assistant teachers through Dingtalk Teaching Group. The students from the same school and remote coordinating teachers were in the same classroom face to face.

The curriculum adopted 6E teaching model: (1) Engage: Teachers created situations to attract students’ interest; (2) Explore: Students were guided by teachers to search for information and design various solutions; (3) Explain: Students discussed and communicated to choose the best solution; (4) Engineer: Students collaborated to build models, tested and evaluated the functionality of the work; (5) Enrich: Students perfected their models for different application scenarios; (6) Evaluate: Students demonstrated and reported the models, and teachers made objective evaluations. The camp mainly selected rural schools which are remote and lack of resources, so it emphasized the gradual progress of curriculum design. Teaching activities guided students to combine software with hardware to improve their practical and cooperative abilities.

Shen Nong was a famous person in ancient China. To cure people, he travelled around looking for various herbs and recorded the characteristics and medicinal properties of herbs by personally tasting them, which had a significant and positive impact on the development of Chinese medicine. The curriculum took Shen Nong Taste Herbs as its main storyline and used LEGO WeDo1.0 as the building tool to carry out seven teaching activities (Fig. 2), which took place from 10:00 am to 6:00 pm. In the first six activities, the students worked in pairs. Each group had a set of WeDo1.0 and at least one computer available. Activity 1 was mainly a preliminary understanding of Lego and programming software. From Activity 2 to Activity 6, after learning the basic knowledge, students designed and built group of LEGO robots works to solve the problems encountered during Shen Nong’s journey (Chinese traditional story): although teaching team provided simple drawings for reference, students could and were encouraged to play freely and create freely. In the seventh activity, students usually worked in groups of four and made creative planning and scene construction based on the theme of “Shen Nong Tastes Herbs.” Students’ creative works can be consulted in supplementary materials. To enrich students’ spare time and enhance their understanding of traditional Chinese culture, 20 min per day were

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**Fig. 1** The implementation form of the online SN STEM education camp
dedicated to reading classical Chinese studies and encouraging interest in ancient medical scientists. In addition, we distributed a 10-min online questionnaire before and after the camp and interviewed certain teachers and students from each school for 20 min after the camp.

Research Instruments

The questionnaires explored the impact of the online SN STEM education camp on students’ self-efficacy, computational thinking, and task value. There were 19 questions scored on a 5-point Likert scale (5, strongly agree; 4, agree; 3, uncertain; 2, disagree; and 1, strongly opposed). Self-efficacy refers to an individual’s self-evaluation of his or her ability to master a task, which includes judgement concerning and confidence in his or her ability to complete the task. This study referred to the self-efficacy scale developed by Luo et al. (2021a) (α = 0.9) and used seven questions according to the situation. Computational thinking refers to solving problems by using ideas and methods in the field of computer science. Researchers have summarized and categorized relevant scales for computational thinking (Dias et al., 2016; Luo et al., 2019; Sklar et al., 2003), and nine topics were retained after expert screening. Task value represents students’ evaluation of the interest and importance of the task. Researchers selected three questions from Nugent et al. (2009) in the robot dimension (α = 0.83) to measure the impact of student’s building of robots on task value. Four researchers and one expert repeatedly revised all the questions to conform to the theme of this study and to ensure that primary school students could understand the meaning of the questions.

In addition to students’ basic information and scale content, the pre-test questionnaire added multiple-choice questions to obtain the reasons for and expectations of students participating in the online SN STEM education camp. The content of the post-test questionnaire included students’ basic information, dimension scale with varying order, 5-point Likert scale for camp curriculum evaluation, and an open question that can be answered voluntarily, “What are your feelings, experiences or suggestions after participating in the online STEM camp?” The pre- and post-test questionnaires were distributed online, and students filled them in online. It should be noted that some students did not participate in the 3-day project in its entirety, so invalid data were excluded from the pre-test, and a total of 109 valid questionnaires were ultimately collected. The researchers evaluated the reliability of the pre-test and post-test values of the questionnaire and obtained Cronbach’s α values of 0.894 and 0.893, indicating sufficient consistency between the results of the two tests in this study. At the end of the camp, we interviewed a number of teachers and students from
the four schools to obtain curriculum evaluations and suggestions.

**Data Analysis**

A total of 113 students signed up for this camp. After excluding invalid data, the researchers ultimately analyzed and discussed 109 students. For quantitative data, the researcher used SPSS 20.0 to conduct paired sample t tests for students. The ANCOVA method was used to exclude the influence of pre-test scores, and K-means clustering analysis was used to classify students with different levels of self-efficacy. For qualitative data, the content analysis method was used. Two educational technology researchers used open coding to code the interview data of students and teachers. For uncertain information in the data, researchers engaged in discussion to reach consensus and determine the internal consistency of the data.

**Results**

**Changes in Students’ Self-Efficacy, Computational Thinking, and Task Value**

We first tested the normality of the pre-test and post-test data and used the Kolmogorov–Smirnov (K-S) test to ensure that all dimensions followed a normal distribution ($p > 0.05$). We performed a paired-sample $t$ test on the scores of 109 students before and after the test. Table 1 shows that the scores of the students improved in the three dimensions discussed. For the self-efficacy dimension, the scores of students in the post-test were significantly higher than those of students in the pre-test ($t = −4.622, p < 0.05$). Although variation in students’ computational thinking was not significant between pre-test and post-test, the post-test results were higher than the pre-test results (the mean in the pre-test = 4.76, and the mean in the post-test = 4.83). In addition, there were significant differences in the task value of students, and the post-test results were significantly higher than were the pre-test results ($t = −3.301, p < 0.05$).

| Factors               | Pre-test Mean | SD | Post-test Mean | SD | Gain score | p     |
|-----------------------|---------------|----|----------------|----|------------|-------|
| Self-efficacy         | 4.70          | 0.35| 4.83           | 0.30| 0.13       | 0.000***|
| Computational thinking| 4.76          | 0.32| 4.83           | 0.31| 0.07       | 0.053  |
| Task value            | 4.79          | 0.34| 4.89           | 0.26| 0.10       | 0.001***|

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

**Influence of Engineering and Programming Experience on Students’ Computational Thinking**

This research used the ANCOVA method to evaluate students’ changes in computational thinking between pre-test and post-test. The researchers first established the interaction type of the pre-test data. The homogeneity test of the regression coefficient showed that the regression line of the covariate and the dependent variable was parallel. The interaction between students’ engineering experience and programming experience on the post-test score was insignificant ($p > 0.05$). The ANCOVA analysis could be performed. The pre-test scores concerning engineering and programming experience are shown in Table 2 below. After excluding the influence of pre-test scores concerning computational thinking, we found a significant difference between students with engineering (F = 5.20, $p = 0.025$) and programming experience (F = 4.53, $p = 0.036$) and those without engineering or programming experience. This result shows that students who had previously studied engineering or programming could improve their computational thinking ability more than could those who had not. In addition, students with engineering and programming experience had higher pre- and post-test scores in the dimensions of self-efficacy and task value than did students who had not been previously exposed to engineering and programming.

**The Relationship among Students’ Self-Efficacy, Computational Thinking, and Task Value**

To explore the impact of self-efficacy on computational thinking and task value, this research used cluster analysis to classify students with different levels of self-efficacy and to evaluate students’ scores in computational thinking and task value. Cluster analysis is usually called unsupervised learning. It can divide data into groups without preset classification, thus effectively avoiding the subjectivity and randomness of classification. The $K$-Means method is the most used algorithm in cluster analysis. Its initial cluster center has a more significant impact on clustering results, so the number of cluster families $K$ in the clustering algorithm must be determined first. This research first used SPSS to perform systematic clustering analysis and
then used the intergroup link method to cluster, setting the Pearson method as the metric, generated a pedigree diagram, and classified 109 students in terms of self-efficacy. The systematic clustering analysis determined that the \(K\) value = 3. The researchers divided 109 students into 3 groups through the \(K\)-Means clustering algorithm. Self-efficacy scores, listed from high to low, identified the following groups: G1, G2, and G3. The specific classification situation was as follows: There were 58 students in G1 (M = 4.97, SD = 0.06), 37 students in G2 (M = 4.54, SD = 0.13), and 14 students in G3 (M = 4.00, SD = 0.11). Among these groups, the number and average score of students in G1 were higher than those of students in the other two teams, while the number and average score of students in G3 were the lowest.

Table 3 shows that the post-test scores of G3 were significantly higher than those of the pre-test (gain score = 0.41), and the pre-test scores of G2 were much lower than those of the post-test (gain score = 0.26). There were significant differences between G2 and G3 (\(p < 0.05\)). In G1, students had higher pre-test scores.

In order to further explore the relationship among self-efficacy, computational thinking, and task value, we conducted a descriptive statistical analysis (Fig. 3). The X-axis represented the three groups of students with high, medium, and low self-efficacy, and the Y-axis represented the mean values of students in computational thinking and task value. It can be seen from the figure that the post-test scores for the different dimensions were higher than scores for the pre-test dimensions (the scores of computational thinking in G1 remained unchanged), and the scores of computational thinking and task value for G1 and G2 were higher than those for students in G3. This result may indicate that self-efficacy was related to personal computational thinking and task value. Students with high self-efficacy tended to have higher scores on computational thinking and task value, and those with low self-efficacy also had relatively low scores in the other two dimensions. Positive self-efficacy may produce better computational thinking and task value.

### Students’ and Coordinating Teachers’ Experiences and Suggestions Concerning Online SN STEM Education Camps

For explanatory convenience, students were coded as S1-S109. After sorting out the qualitative data obtained from the open question voluntarily answered by the post-test questionnaire, and eliminating the blank and “none” answers, we obtained the valid answers from 57 students. Two researchers classified and coded the responses, and in cases of disagreement, a third researcher determined the final code (Table 4). Regarding their feelings and experiences concerning participation in the online SN STEM education camp, 12 students thought that it improved their abilities. Seven of them mentioned teamwork: “I know the importance of unity and cooperation” (S14, S27, S39, S52, S55, S89, S95), and some students reflected on themselves: “I have learned a lot, and I should practice my language skills more” (S35). Thirteen students gained emotional experience. Six students thought that the course was interesting and “challenging” (S72); 4 other students gained friendship (S1, S14, S96, S109). Eleven students thought that they had learned a great deal of knowledge from this online camp, such as knowledge concerning LEGO®s and programming (S46, S49, S53, S103, S107). They not only learned topics related to STEM but also broadened their horizons (S81, S101).

### Table 2  ANCOVA analysis of computational thinking in the context of students’ engineering and programming experience (\(N=109\))

| Factors                        | N  | Mean | Adjust M | Std error | F    | p     |
|--------------------------------|----|------|----------|-----------|------|-------|
| Engineering experience         | 40 | 4.93 | 4.91     | 0.05      | 5.20 | 0.025*|
| No engineering experience      | 69 | 4.77 | 4.78     | 0.04      |      |       |
| Programming experience         | 77 | 4.87 | 4.87     | 0.03      | 4.53 | 0.036*|
| No programming experience      | 32 | 4.72 | 4.74     | 0.05      |      |       |

* \(p < 0.05\)

### Table 3 Changes in self-efficacy among three distinct groups (\(N=109\))

| Group         | N  | Pre-test Mean | Pre-test SD | Post-test Mean | Post-test SD | \(p\)  |
|---------------|----|---------------|-------------|----------------|--------------|------|
| G1 (high)     | 58 | 4.97          | 0.06        | 4.96           | 0.17         | 0.507|
| G2 (medium)   | 37 | 4.54          | 0.13        | 4.80           | 0.27         | 0.000***|
| G3 (low)      | 14 | 4.00          | 0.11        | 4.41           | 0.42         | 0.003**|

** \(p < 0.01\); *** \(p < 0.001\)
Students’ suggestions concerning this camp mainly referenced two aspects. The first kind of suggestion addressed project practice: 10 students hoped to increase the number of activities and to experience more similar camp activities and curricula in the future; 4 students suggested adjusting the duration of teaching activities, such as including “a little more cooperation and hands-on time” (S32, S66) in order to enjoy playing and learning. In addition, because the distance learning equipment and network conditions affected online teaching, student S59 suggested that “the teacher can speak louder.” The second kind of suggestion pertained to curriculum design: 8 students suggested adjusting the course contents, with suggestions included “cancel classic reading” (S51, S65, S71, S106) and “hold more creative competitions” (S2); 2 students suggested improving the difficulty of activities (S23, S67); 2 other students hoped to increase the teaching scope (S73, S107) in order to learn more knowledge.

### Remote Coordinating Teachers’ Experiences and Suggestions Concerning Online SN STEM Education Camps

After the online SN STEM education camp, we sent structured interview documents to coordinating teachers in four schools and received interview videos or documents from six students. The relationship between the computational thinking and task value of three groups of students (The X-axis represented the three groups of students with high, medium and low self-efficacy, and the Y-axis represented the mean values of students in computational thinking and task value.)

![Graph showing the relationship between computational thinking and task value for three groups of students.](image)

### Table 4 Students’ experiences and suggestions concerning online SN STEM education camps

| Types          | Contents                              | Coding of students’ answers | Frequency* |
|----------------|---------------------------------------|----------------------------|------------|
| **Experience** | Ability improvement                   | Teamwork                   | 7          |
|                |                                       | Hands-on practice          | 3          |
|                |                                       | Observation and reflection | 2          |
|                | Emotional expression                  | Feel interesting           | 6          |
|                |                                       | Promote friendship         | 4          |
|                |                                       | Provide pleasure           | 3          |
|                | Knowledge acquisition                 | Basic knowledge of curriculum | 6          |
|                |                                       | LEGO programming knowledge | 5          |
| **Suggestions**| Project practice                      | Increase the number of activities | 10         |
|                |                                       | Adjust the duration of teaching activities | 4          |
|                |                                       | Improve the sound quality of distance teaching | 1          |
|                | Curriculum design                     | Adjust the curriculum content | 8          |
|                |                                       | Improve the activities’ difficulty | 2          |
|                |                                       | Expand the teaching scope  | 2          |

*The numbers indicate the frequency of keywords mentioned by 57 students. One student may mention multiple keywords.*
teachers online. The six teachers were labelled from T1 to T6, and the interview questions and results were as follows:

**Question 1:** “What do you think of the implementation of the online SN STEM education camp?” The six teachers’ evaluation of the curriculum was positive, which was helpful to both teachers and students. Not only the key points were highlighted, the content was progressive (T2), but also the hands-on activities were rich (T1). “Students’ excitement and acceptance are high” (T1), and “doing while learning, playing while learning” (T3). “Teachers also benefited a lot” (T5).

**Question 2:** “What do you think of the learning effects on students in this activity?” The teachers provided good comments. Students “are willing to explore” (T1), “have learned to think” (T3), “have learned about Chinese herbal medicines and famous ancient doctors, stimulated love for Chinese traditional culture, and enhanced Chinese national pride” (T2), and “have played their own role in-group cooperation and gained self-confidence” (T6).

**Question 3:** “What have you found in the online SN STEM education camp?” Through classroom observation and communication with students, teachers have made diverse and rich discoveries. “Students’ interest is very important” (T1, T3); “The integration of Chinese medicine and LEGO knowledge systems has created a new idea for STEM education” (T2); “Students’ creativity requires external support and cultivation” (T4); “Students exercise their thinking in group activities” (T5). Teacher T6 highlighted a different side of the students: “…many children show a side that is rarely shown in their daily study and life. …I am very grateful to a classmate in our group. “I found that I could”, “This course is so interesting!” In the past three days, children have attained not only a level of interaction between knowledge and thinking but also an improvement in self-awareness.” (T6).

**Question 4:** “What do you think should be focused on in subsequent development of the online SN STEM education camp? What needs to be improved?” Many teachers initially expressed the hope that more such activities would be carried out in the future (T3, T4, T5, and T6). It was suggested that more online training could be performed in the preparation stage and that “it is better if the distance school can support real-time teacher-student voice interaction” (T2). During the course, “the theoretical explanation could be shortened” (T1), and after the camp “the experience can be shared and promoted” (T3).

### Discussion and Conclusion

#### Finding of Online SN STEM Education Camps

Based on practical activities involving robots and using traditional Chinese herbal medicine as context, this research developed and implemented an online SN STEM education camp to allow more students from areas with weak educational capabilities to access STEM education. The study found that STEM courses can improve students’ sense of self-efficacy and computational thinking, a finding which is consistent with previous research (Master et al., 2017; Nugent et al., 2009; Wu & Su, 2021). After a 3-day camp, students’ belief in the value of their tasks also improved significantly, a factor which may be related to teamwork and positive interaction during the activity (Senler & Sungur, 2009). Students with programming or engineering experience have significantly higher computational thinking than those without such experience. This might be related to higher problem-solving ability and enthusiasm (Jones et al., 2019). The study found that although boys had higher average scores in the dimensions of self-efficacy, computational thinking, and task value than did girls, there was no significant difference, which is consistent with the results of previous studies (Luo et al., 2021a; Master et al., 2017; Noh & Lee, 2020). However, some scholars have conducted experiments and found gender differences between boys and girls in the context of STEM activities (Lewis et al., 2017; Stringer et al., 2019). A reason for this difference may be differences in students’ grades and majors.

Researchers used a cluster analysis algorithm to divide students with different levels of self-efficacy into three categories. The data showed that students with a higher sense of self-efficacy have relatively higher scores in the dimensions of computational thinking and task value than do other students. It is worth noting that the group of students with the lowest sense of self-efficacy (G3) made the most progress. After students participated in STEM activities, computational thinking and task value improved significantly. On one hand, the online SN camp played a positive role in promoting the development of students; on the other hand, students might not have had confidence in themselves at the beginning, but they exercised their ability through constant group cooperation and ultimately made continuous progress in the process of learning and building. Previous researches have shown that self-efficacy has a positive effect on student performance (Kim, 2010; Supervía & Robres, 2021). Different from previous studies, this study analyzed students’ self-efficacy and the scores of Theme Creative Competition (Activity 7) and found that the mean value of students who won prizes in pre-test and post-test was lower than that of
Experiences and Suggestions for Online STEM Camps

From the implementation process of the online SN STEM education camp and the results of questionnaires and interviews, traditional Chinese medicine culture, LEGO programming, and subject knowledge were effectively integrated. Students loved the activities of the online SN STEM education camp, realized the importance of teamwork, and preferred creative and competitive activities with teams. The 3-day online camp not only enabled students to recognize their strengths and weaknesses through self-reflection and hands-on practice but also enabled teachers to gain rich and unique experiences, discover students’ unique bright spots, and see students’ potential.

Through review of and reflection on this online camp, we summarized many experiences and suggestions, hoping to provide references for the teachers and researchers who will carry out such activities in the future. First, when online camps need to connect with many schools, assistant teachers in the main port and coordinating teachers in each remote port are essential. Adequate human resources and professional teachers are a basic necessity of online camp development, so it is necessary to contact responsible teachers in advance and determine everyone’s roles. Second, the teaching platform determines whether an online camp can be carried out smoothly. This factor requires teams of teachers to evaluate and select a high-quality, convenient, and suitable distance teaching platform. Moreover, learning resources and materials should be backed up as necessary. Early equipment testing and teacher training should also be considered. Attention to this detail can not only uncover problems early and improve them in time, but it can also enable teachers in remote schools to acquire relevant experience and lay the foundation for subsequent traditional teaching. Finally, clear teaching instructions and timely learning feedback are also needed in the online STEM education camp. In distance learning, teachers should guide students to make full use of study manuals to carry out activities. Coordinating teachers should also pay attention to and encourage students and give timely feedback on the completion of group projects. These actions are critical to the success of the online camp.

Research Limitations and Future Prospects

This research adopted a combination of quantitative and qualitative methods. In order to avoid the subjective bias of researchers as much as possible, we not only collected research data through pre- and post-test questionnaires, the open question, interviews, teaching reflections and other sources but also conducted investigations on participating students, remote coordinating teachers, teaching teams, and researchers. Admittedly, this research still faced certain limitations. In the part of quantitative analysis, we only explored the influence of online STEM camp on students through pre- and post-tests. However, it is difficult for us to know exactly whether the changes of students in various research dimensions were due to the design of curriculum activities or their own dynamic experience. Although we had consciously strengthened the curriculum design through task-oriented activities, the exhibition of open works, the group final big project competition, etc. and set up a reward mechanism in the implementation of activities to improve students’ sense of participation and achievement, however, it cannot be ruled out that the changes of students’ self-experience during the activity would interfere with the research results. Similarly, the excitement of STEM that students may have before the activity would also have a certain impact. Future research may try to focus on the influence of curriculum design and students’ experience, especially the relationship between them and self-efficacy, and explore which factor will have more influence. In the part of qualitative analysis, we only got valid data from some teachers and students and only presented high-frequency and relatively representative answers. For those teachers and students whose qualitative data we failed to collect, we could not know what they really think.

In addition, there were some objective limitations in the implementation of online camp. Due to the relative lack of hardware and software equipment in some schools, teachers could not interact with students in real time. Teaching progress could only be adjusted through feedback from assistant teachers and remote coordinating teachers. The sense of distance between teachers and students affected students’ learning performance to a certain extent. The online SN STEM education camp lasted for 3 days. Some students experienced a strong sense of excitement and pleasure, but they felt that the work on LEGO robots could not be perfected in a short time and hoped to have more activities and time, which may have affected students’ learning experience. This research focused only on primary school students. Among the 113 students who participated in the online SN STEM education camp, only 28% were girls, which is worth considering. At the same time, no significant gender differences were found in the dimensions of the study, which may provide reference or direction for future research. As a whole, we think the online STEM education camp is a good attempt. Especially for students in schools with weak educational capabilities, this can provide them with access to STEM education under limited conditions. Of course, the development and research of online STEM education camps in the future deserve more exploration.
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Data Availability The dataset generated and analyzed for the current study is not publicly available due to privacy reasons but is available from the author on reasonable request.

Declarations

Ethics Approval This research was carried out according to ethical guidelines.

Conflict of Interest The authors declare no competing interests.

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