

# Promoting STEM Interest through Empathy and Creative Thinking in a STEM-based Community Service Program

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**Abstract:** Students' interest in science, technology, engineering, and mathematics (STEM) tends to decline as they reach high school. Among the factors to which this decline is attributed are the perceptions about the lack of communality and creativity in STEM. To address this problem, we implemented an 8-week STEM-based community service program where high school students learned about STEM and community service. The students were asked to design possible solutions to problems faced by people from disadvantaged groups (e.g., visually impaired people). Using the post-test data from 275 high school students who participated in the program, we examined a model of empathy predicting STEM interest via creative thinking. Results of mediation analysis showed that empathy predicted STEM interest through creative thinking. The findings provided support for the important roles of empathy and creative thinking in the promotion of STEM interest. This information can be used as a basis for designing STEM-based community service programs for the enhancement of students' interest in learning STEM.

**Keywords:** STEM-based community service program, STEM interest, empathy, creative thinking

## 1. Introduction

Science, technology, engineering, and mathematics (STEM) education has been a globally important educational initiative (Jong et al., 2021; Lau & Jong, 2022; Nalipay et al., 2022); nevertheless, there is declining interest in STEM as students reach high school (Gok, 2022), especially among girls (Valenti et al., 2016). Among the reasons cited for this are the perceptions of lack of communality (e.g., Belanger et al., 2020) and creativity (Valenti et al., 2016) in STEM. STEM fields are often viewed as providing little opportunity for collaboration and helping others (Fuesting et al., 2021). Moreover, traditional STEM teaching tends to employ teacher-centered approaches that do not provide much opportunity for students to imagine, explore, and make mistakes, and hence, students tend to be less creative and engaged in their learning (Amran et al., 2021). To address this, we implemented a crossover program of STEM and community service education (Huang et al., 2022; Huang & Jong, 2020) that provided students with an opportunity to empathize and understand the problems of the people in the community, as well as practicing creative thinking in helping them find a solution to these problems. We proposed that empathy would be associated with creative thinking, and subsequently, interest in learning STEM among the high school students who participated in the STEM-based community service program.

### 1.1 STEM-based Community Service Program

We developed a STEM-based community service program based on the integrated STEM-based community service learning model (Huang et al., 2022). The integrated STEM-based community service learning model illustrates the key elements that should be emphasized to support students' development of creativity (Amabile & Pratt, 2016) and other twenty-first century skills in the design thinking process (Hasso Plattner Institute of Design, 2010). In the 8-week program, students were taught about STEM knowledge and community service, interacted with participants from disadvantaged groups, and designed possible solutions for the problems faced by them (Huang et al., 2022). We hypothesized that among the program participants, empathy would be related to increased creative thinking, and in turn, creative thinking would be associated with greater STEM interest.

## *1.2 Empathy and Creative Thinking*

Empathy refers to one's efforts to comprehend other people's actions and motivations, physical and emotional needs, and their meaning-making. It allows designers to get to know and care about the product users and the context in which they live, and thus, create meaningful innovations (Hasso Plattner Institute of Design, 2010). There is evidence that STEM programs that facilitate empathy could promote STEM interest. Burns and Lesseig (2017) found that empathy-based lessons in STEM could increase students' sense of belongingness and interest in STEM careers. We proposed that empathy is linked to STEM interest via creative thinking. Creativity entails the development of new, novel, interesting, and effective ideas that have aesthetic sensibility (Smith & Henriksen, 2016). The National Academy of Engineering (2008) suggested that students must begin to associate the need for creativity and real world problem-solving skills with the opportunities in STEM fields. Previous studies have supported the link between empathy and creative thinking. For example, in an experiment by Anderson et al. (2023), participants who were instructed to be more empathic toward a subject demonstrated greater creativity.

## *1.3 Creative Thinking and STEM Interest*

Students are usually highly interested in science and math in the primary grades, but their interest starts to decline as they approach high school. Although this is true for both genders, the decline is more apparent among girls (Valenti et al., 2016). To maintain students' interest in STEM, it has been suggested that STEM education should allow more room for creativity (Wieselmann et al., 2020). The relationship between creativity and STEM interest has been widely supported in the literature. Cooper and Heavenlo (2013) found creativity as a positive predictor of girls' STEM interests. In a study by Knezek et al. (2015), self-reported creative tendencies were found to predict STEM career aspirations in both males and females. These provide support for the likelihood that in the present study, students who demonstrate greater creative thinking would also be more interested in STEM.

## *1.4 The Present Study*

In the present study, we investigated a model in which empathy is associated with creative thinking, and in turn, creative thinking is related to STEM interest among students who participated in a STEM-based community service program. Although past studies have mostly focused on the relationships of empathy and creativity to STEM career interest (e.g., Burns & Lesseig, 2017; Knezek et al., 2015), the present study looked into learning interest in STEM, which is more proximal to high school students and indicative of intrinsic motivation (Wigfield & Eccles, 2000). Specifically, we intended to address the following research questions:

- Does empathy predict STEM interest?
- Does creativity mediate the relationship between empathy and STEM interest?

We proposed empathy and creativity as contributing factors to STEM interest. In particular, we hypothesized that empathy would predict STEM interest, and this relationship

is mediated by creativity. The study could contribute valuable information for designing STEM-based community service programs that nurture students' interest in STEM.

## 2. Method

### 2.1 Participants and Procedures

The participants were 275 high school students from three schools in Hong Kong; 52% were boys and 48% were girls; and most were 12-13 years old (76%). They attended the STEM-based community service program described in Section 1.1. For the STEM knowledge aspect of the program, among the key topics covered were coding skills and computational thinking; Internet-of-Things concepts and applications; and smart home devices. For the community service knowledge, among the contents included were foundational knowledge in community services; community housing residents and their needs; and presentation of design solutions and collection of feedback. The participants completed a survey measuring various twenty-first century skills and STEM learning outcomes, including the main variables of the study. The findings presented and discussed in this paper are based on the post-test data that were gathered from the program.

### 2.2 Measures

We used adapted scales to measure the main variables of the study. For empathy, we used a 5-item scale adapted from Vossen et al. (2015). For creative thinking, we used a 5-item scale adapted from Chai et al. (2020). For STEM interest, we used a 4-item adapted scale from (Paul et al., 2020). The three measures were rated from 1 = *strongly disagree* to 6 = *strongly agree*, and demonstrated adequate internal consistency, with Cronbach's  $\alpha = .903$ ,  $.921$ , and  $.879$ , respectively. Schools 1 and 2 were coded 0 (*no*) or 1 (*yes*) (a response of 0 in both means they were from School 3). Gender was coded 1 (*boy*) or 2 (*girl*), while age was coded 1 (*12-13 years*), 2 (*14-15 years*), or 3 (*16-17 years*). We used the Chinese version of the questionnaires.

### 2.3 Data Analysis

To find out whether empathy predicts STEM interest via creative thinking, we performed regression-based mediation analysis using the PROCESS macro for SPSS (Hayes, 2018). Empathy was entered as the independent variable, STEM interest as the dependent variable, and creative thinking as the mediator. We also included schools, gender, and age as covariates. The sample was bootstrapped to 5000, with a 95% confidence interval.

## 3. Results

Table 1 shows the mean, standard deviation, and correlations of the study variables. The main variables empathy, creative thinking, and STEM interest were significantly and positively associated with each other. As for the covariates, those from School 1 tend to have higher levels of empathy, creative thinking, and STEM interest relative to those from other schools. Boys tend to have higher levels of creative thinking and STEM interest, whereas age did not correlate with the main variables of the study. Results of the mediation analysis showed direct ( $\beta = .261, p < .001$ ) and indirect ( $\beta = .388, p < .001, 95\% \text{ CI} = .302, .476$ ) relationships between empathy and STEM interest via creative thinking (see Figure 1; note: all coefficients reported are standardized). Empathy predicted STEM interest, and creativity mediated the relationship between empathy and STEM interest, hence confirming the hypotheses of the present study.

Table 1. Mean, Standard Deviation, and Correlations of the Study Variables

	Mean	SD	1	2	3	4	5	6
1. Empathy	4.64	0.89	---					
2. Creative thinking	4.36	0.99	.676***	---				
3. STEM Interest	4.23	1.06	.672***	.790***	---			
4. School 1	---	---	.125*	.142*	.174**	---		
5. School 2	---	---	.110	.088	0.056	-.608***	---	
6. Gender	---	---	.032	-.131*	-.126*	-.030	.062	---
7. Age	---	---	-.003	.080	.065	.123*	-.261***	-.075

Note: \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$

#### 4. Discussion

The study investigated whether empathy would be associated with creative thinking, and subsequently, STEM interest among high school students who participated in a STEM-based community service program. Results showed that empathy positively predicted STEM interest directly and indirectly via creative thinking. This indicates that students who try to better understand the people in the community and their needs and problems tend to be more interested in learning STEM, specifically, design principles of STEM products. Moreover, this relationship can be attributed partially to creative thinking, where they come up with new and diverse ideas and combine different subject knowledge to solve problems.

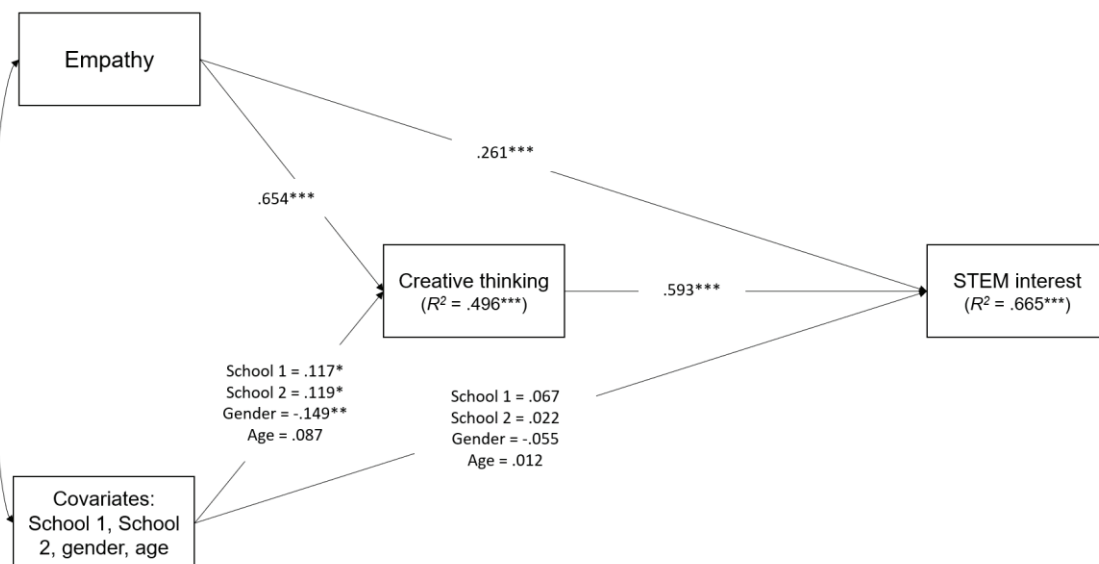


Figure 1. Results of mediation analysis (Note: \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$ ).

The findings align with the idea that empathy is associated with an increased interest in learning STEM, as shown in past studies (e.g., Burns & Lesseig, 2017) and demonstrated that this could be due to creative thinking. Empathizing with the people for whom one designs a product for allows designers to gain a better understanding of their context, views, and needs, and hence, facilitate the creation of more meaningful innovations (Hasso Plattner Institute of Design, 2010). Trying to understand the needs of the people in the community could have facilitated the students to generate ideas to address their problems (Weng et al., 2022). Consequently, coming up with new and different ideas could have made the students more

interested to learn about STEM knowledge which empowered them to solve the problems of the people in the community. This is consistent with past studies linking creativity with greater interest in STEM (e.g., Knezek et al., 2015; Wieselmann et al., 2020). The underlying psychological mechanism is likely to be associated with the self-determination theory (Ryan & Deci, 2020). It is noteworthy that in the model, gender did not significantly predict the STEM interest of the students who participated in the STEM-based community service program ( $\beta = -.055$ ,  $p = .129$ ), providing support for the possible roles of empathy and creativity in addressing the gender gap in STEM (e.g., Wieselmann et al., 2020).

The study provided a better understanding of how the integration of STEM and community service learning promotes STEM interest among students through empathy and creative thinking. These findings can be utilized in designing STEM-based community service programs to improve students' interest in learning STEM. The study has some limitations. The use of cross-sectional data prevents cause-and-effect relationships from being inferred, and the use of self-report measures makes it prone to certain biases, e.g., social desirability. Despite its limitations, the study supported the importance of empathy and creativity in the promotion of students' interest in STEM learning.

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