

INNOVATION WITH SOCIETAL VALUES: THE IMPACT OF CITIZEN SCIENCE ON FEMALE STUDENTS' STEM CAREER ASPIRATIONS

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Abstract

This study employed a quantitative survey methodology to explore the relationships between self-efficacy, creativity, and intentions to pursue science careers among 170 female university students participating in a Citizen Science Project. The students were engaged in activities such as guiding science-related literature and films, conducting science tours, and promoting science knowledge in underprivileged areas. The study examined how engagement in the Citizen Science Project influenced changes in self-efficacy, creativity, and career intentions across students from science-related and non-science-related departments. Additionally, Structural Equation Modeling (SEM) was used to assess the direct and indirect effects, with mediation analysis revealing that creativity fully mediates the relationship between self-efficacy and career intentions. The results indicate that both self-efficacy and creativity positively predict intentions to pursue science careers.

The findings underscore the critical roles of self-efficacy and creativity in shaping female students' career intentions in science, offering valuable insights for initiatives aimed at enhancing women's participation in STEM fields. The study highlights the importance of integrating creativity into STEM education, fostering mentorship, improving career counseling, promoting female representation, and establishing industry collaborations. By addressing these factors, educational institutions and policymakers can create a more inclusive environment for female students in STEM. This research provides a foundation for further exploration and emphasizes the need for ongoing efforts to dismantle barriers and promote gender equity in STEM careers.

Keywords: Citizen Science; Creativity; Science careers; Mediating Effect; Self-efficacy

The gender gap in STEM (Science, Technology, Engineering, and Mathematics) fields continues to be a significant global challenge, despite efforts to promote gender equity. Women remain underrepresented in various STEM careers, which is influenced by numerous factors, including entrenched societal stereotypes, a lack of female role models, and limited mentorship opportunities (Dos Santos et al., 2022). These barriers often result in lower levels of engagement and career aspirations for women in science and technology fields. Moreover, traditional gender norms and societal expectations further deter women from pursuing STEM careers (El-Hout et al., 2021). Addressing these barriers requires innovative educational strategies that can enhance key psychological constructs, such as self-efficacy and creativity, which have been shown to influence career intentions in STEM fields.

Self-efficacy, defined as an individual's belief in their ability to perform tasks and achieve goals (Bandura, 1989), is a critical predictor of both academic and career success, particularly in STEM fields (Chen et al., 2022). Higher levels of self-efficacy are associated with increased motivation, persistence, and resilience, all of which are essential traits for success in STEM, where challenges and competitive environments are common (Quinlan et al., 2022). Creativity, on the other hand, is the ability to generate novel ideas and solutions, and it plays an equally important role in fostering innovation in science, engineering, and technology (Baer, 2015). Creative thinking allows individuals to approach problems from different angles and is vital for advancing knowledge and practices in STEM fields (Tierney & Farmer, 2004).

Citizen Science Projects have emerged as a promising educational tool for fostering both self-efficacy and creativity in STEM education. These projects involve the participation of the public in scientific research, allowing individuals to engage in meaningful, real-world scientific tasks (Chang et al., 2023). For women, such projects offer a unique opportunity to challenge the stereotypes that have traditionally limited their participation in STEM, while simultaneously building confidence in their scientific abilities (Wong et al., 2022). Previous studies have shown that participation in Citizen Science can significantly boost both self-efficacy and creativity, which in turn, are linked to increased career aspirations in STEM (Lu et al., 2023).

This study employed a quantitative survey methodology to explore the relationships between self-efficacy, creativity, and intentions to pursue science careers among 170 female university students participating in a Citizen Science Project. The students were engaged in various science-related activities, including guiding discussions on science-related literature and films, conducting science tours, and promoting science knowledge in underprivileged areas. These activities were designed to provide participants with real-world experience and to foster

self-efficacy and creativity, which were hypothesised to influence their STEM career intentions. The study also compared the outcomes between students from science-related and non-science-related academic backgrounds to identify any potential differences in the impact of these activities.

Table 1 presents the descriptive statistics (mean and standard deviation) and correlations between the key variables of self-efficacy, creativity, and STEM career intentions. The mean score for self-efficacy was 5.79 with a standard deviation of 0.92, indicating that participants generally reported moderate to high levels of confidence in their abilities. The mean score for creativity was 5.26 with a standard deviation of 1.12, suggesting relatively strong creative self-assessments among the participants. Lastly, the mean for STEM career intentions was 4.73 with a standard deviation of 1.38, reflecting varying levels of interest in pursuing STEM careers.

In terms of correlations, self-efficacy showed a strong positive correlation with creativity ($r = 0.663$, $p < 0.01$), indicating that participants with higher self-efficacy also tended to exhibit higher creativity. Self-efficacy was moderately correlated with STEM career intentions ($r = 0.480$, $p < 0.01$), suggesting that greater confidence in abilities is associated with stronger intentions to pursue careers in STEM.

Additionally, creativity was strongly correlated with STEM career intentions ($r = 0.672$, $p < 0.01$), implying that participants who rated themselves higher in creativity were also more likely to express a desire to pursue careers in STEM fields.

Table 1: Descriptive Statistics and Correlations Between Key Variables

Variable	Mean	SD	1	2	3
1. Self-efficacy	5.79	.92	1		
2. Creativity	5.26	1.12	.663**	1	
3. STEM Career Intentions	4.73	1.38	.480**	.672**	1

*** $p < .001$ ** $p < .01$

To investigate potential differences in the effects between students from science-related and non-science-related departments, independent t-tests were conducted on the pre- and post-survey scores for self-efficacy, creativity, and STEM career intentions.

As shown in Table 2, significant differences were found between the two groups. Students from non-science-related departments reported significantly higher self-efficacy scores ($M =$

5.91) compared to their counterparts in science-related departments ($M = 5.54$), with a t -value of -2.43 ($p < 0.01$). This suggests that non-science students exhibited greater confidence in their abilities.

For creativity, no significant difference was observed between the two groups ($t = -1.49$, $p > 0.05$), although students from non-science-related departments had slightly higher mean scores ($M = 5.35$) compared to science-related students ($M = 5.08$).

In terms of STEM career intentions, the non-science group also reported marginally higher scores ($M = 4.83$) than the science-related group ($M = 4.58$), but this difference was not statistically significant ($t = -1.11$, $p > 0.05$).

These results suggest that students from non-science-related departments may exhibit higher self-efficacy and slightly stronger intentions to pursue STEM careers, although the differences in creativity and career intentions were not significant.

Table 2: Group Comparisons of Science-related and Non-science-related Departments

Variable	Science-related (n=69)	Non-science-related (n=101)	t-value	
Self-efficacy	5.54	5.91	-2.43**	Non-Science > Science
Creativity	5.08	5.35	-1.49	<0.01
STEM Career Intentions	4.58	4.83	-1.11	<0.01

*** $p < .001$ ** $p < .01$

Model 1 examines the predictive role of self-efficacy in shaping intentions to pursue careers in science among women participating in STEM initiatives. The analysis revealed that self-efficacy significantly predicts career intentions, with a path coefficient of 0.41, indicating a strong and positive relationship between self-efficacy and aspirations to pursue careers in science. This suggests that individuals with higher levels of self-efficacy are more likely to aspire to scientific careers. The fit indices for Model 1 demonstrate a good fit to the data ($\chi^2 = 121.38$, $df = 42$, $\chi^2/df = 2.89$, $NFI = .929$, $RFI = .907$, $IFI = .952$, $CFI = .952$, $SRMR = .056$, $RMSEA = .106$, $TLI = .937$), confirming the model's structural soundness. These findings

underscore the importance of self-efficacy in driving career intentions within STEM fields, as illustrated in Figure 1.

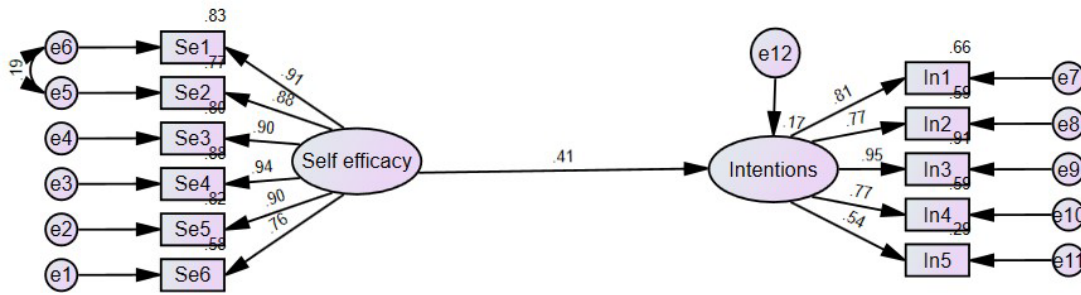


Figure 1. Predicting the power of self-efficacy in STEM career intentions

Model 2 explores the mediating role of creativity in the relationship between self-efficacy and STEM career intentions. Following Preacher and Hayes (2008) mediation framework, the analysis shows that creativity partially mediates this relationship. While the direct effect of self-efficacy on career intentions remains significant, its effect size diminishes when creativity is included in the model, indicating that creativity carries part of the influence of self-efficacy on career aspirations. Notably, when controlling for creativity, the direct relationship between self-efficacy and career intentions was reduced to non-significance, suggesting that creativity is a key mediator in this dynamic. The fit indices for Model 2 also indicate a good fit ($\chi^2 = 189.254$, $df = 86$, $\chi^2/df = 2.20$, $NFI = .930$, $RFI = .914$, $IFI = .960$, $CFI = .959$, $SRMR = .056$, $RMSEA = .084$, $TLI = .951$), validating the model's robustness. Figure 2 illustrates the direct and indirect effects, highlighting how creativity enhances the impact of self-efficacy on students' STEM career intentions.

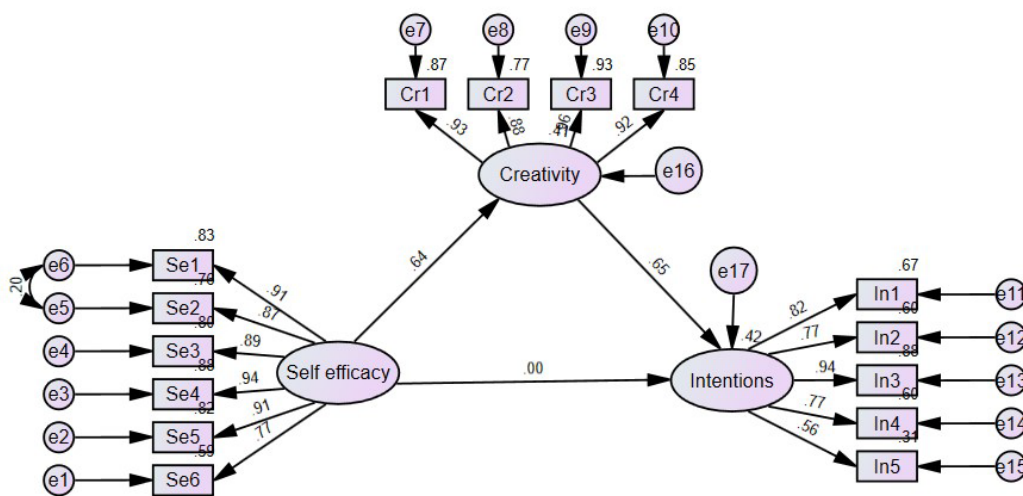


Figure 2. The Mediating Role of Creativity in the Relationship between Self-efficacy and

To analyse the data, Structural Equation Modelling (SEM) was employed to assess both the direct and indirect relationships between self-efficacy, creativity, and STEM career intentions. SEM is a powerful statistical technique that allows researchers to examine complex relationships between multiple variables, including mediation effects. In this study, SEM was used to determine whether creativity acted as a mediator in the relationship between self-efficacy and career intentions. The results of the mediation analysis revealed that creativity fully mediates the relationship between self-efficacy and career intentions, indicating that the influence of self-efficacy on career intentions occurs primarily through its effect on creativity.

The findings of the study highlight several important points. First, both self-efficacy and creativity were found to positively predict intentions to pursue STEM careers. This suggests that enhancing these psychological constructs through educational initiatives, such as Citizen Science Projects, can play a significant role in encouraging women to consider careers in STEM. Second, the results of the mediation analysis underscore the critical role of creativity in shaping STEM career intentions. While self-efficacy is important for building confidence and motivation, it is the development of creative thinking skills that ultimately drives students' aspirations to pursue careers in science, technology, engineering, and mathematics.

Moreover, the study found notable differences between students from science-related and non-science-related academic backgrounds. Interestingly, students from non-science-related departments reported higher levels of self-efficacy compared to their counterparts in science-related fields. This finding suggests that Citizen Science Projects may provide a novel and empowering experience for students with less exposure to STEM disciplines, helping to boost their confidence in their ability to engage with scientific tasks. However, no significant differences were observed in creativity or STEM career intentions between the two groups, indicating that the impact of the Citizen Science Project on these outcomes was relatively consistent across academic backgrounds.

These findings offer valuable insights for educators and policymakers seeking to design effective STEM engagement programmes. The study suggests that integrating Citizen Science Projects into STEM curricula can be an effective strategy for enhancing self-efficacy and creativity among female students, which in turn, can increase their interest in pursuing STEM careers. By providing real-world, hands-on experiences, these projects help students build confidence in their scientific abilities while fostering the creative problem-solving skills that are essential for success in STEM fields.

In addition to the practical implications for STEM education, the findings of this study also have broader implications for gender equity in STEM. Women remain significantly

underrepresented in STEM careers, and addressing this gender gap requires targeted interventions that address the specific barriers women face in these fields. The results of this study highlight the importance of fostering both self-efficacy and creativity as a means of encouraging more women to pursue careers in STEM. Initiatives that focus solely on building technical skills may overlook the critical role that creativity plays in shaping career aspirations. Therefore, it is essential that educational programmes aimed at promoting gender equity in STEM also focus on developing creative thinking skills alongside technical competencies.

Furthermore, the study emphasises the importance of mentorship and career counselling in supporting female students' STEM career aspirations. Providing female students with role models and mentors who can guide them through the challenges of STEM education and careers can help to break down the barriers that have traditionally limited women's participation in these fields. Additionally, improving career counselling services to better address the specific needs of female students in STEM can help them navigate the often complex and competitive landscape of STEM careers.

In conclusion, this study provides important insights into the relationships between self-efficacy, creativity, and STEM career intentions among female university students participating in a Citizen Science Project. The findings underscore the critical role of both self-efficacy and creativity in shaping career aspirations in STEM and highlight the potential of Citizen Science Projects as an effective educational tool for promoting women's participation in these fields. By addressing the psychological and societal barriers that have traditionally limited women's engagement in STEM, educational institutions and policymakers can create more inclusive environments that support women's career aspirations in science, technology, engineering, and mathematics.

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