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RESEARCH ARTICLE

The Impact of Experiential Learning Program for Advanced Science on the Students' Science Career Orientation

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첨단과학 체험 프로그램이 학생의 과학 진로 지향도에 미치는 영향

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ABSTRACT

The purpose of this study aims to analyze the effectiveness of experiential learning programs in advanced science, which were conducted as a community engagement program organized by the STAR Bridge Center (School Teacher And Research Institute) at K University. To do this, the one group pretest–posttest research was conducted to examine the science career orientation among 194 participants who agreed to take part in the research. The research findings are as follows: First, students who participated in the experiential learning program for advanced science showed an improvement in their science career orientation. Second, depending on the school level, the science career orientation has improved for the elementary and middle school students. Among the elementary school students, both boys and girls saw an increase in the science career orientation scores, while among the middle school students, the science career orientation increased for boys more. Third, within the group of the participating students, those aspiring to non-STEM (Science, Technology, Engineering, and Mathematics) field careers, both male and female students, showed an increase in the science career orientation. Among the students with aspirations for the STEM field careers, the science career orientation scores showed specifically an improvement for the female students.

Key words: Experiential learning program for advanced science, science career orientation, school level, future career field, gender

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Introduction

With the advent of the untact times caused by COVID-19, with little human contact, and the development of science and technology, which can be called the in the era of the 4th Industrial

Revolution, there have been continuous changes in the job types needed by society (Di Battista et al., 2023). Particularly, with the emergence of a multitude of new jobs based on advanced science and technology, there is a global increase in the demand for science and technology personnel. However, due to the decreasing school-age population caused by the low birth rate, it is projected that the shortage of STEM (Science, Technology, Engineering, and Mathematics) personnel in South Korea will worsen (KISTEP, 2021) in the near future. Regardless of the demands for the science and technology personnel being strong, the "scientist" is always ranked low by the Korean elementary, middle, and high school students (Kim et al., 2022), when they talk about their aspirations. Furthermore, the majority of the students aspiring to follow STEM careers often lean toward the medical fields (Go, 2023). To adapt to the future society, the ever-changing terrain of science and technology, it is crucial to cultivate the STEM talents that can respond to the changes in the scientific and technological advancements. To achieve this, it is necessary to stimulate the students' interest and enthusiasm in the field of science.

Given the shortage of manpower in science and engineering fields, several studies have been conducted on the students' choice of the science-related career paths. In a study that investigated the factors affecting the science-related career choices among elementary, middle, and high school students, the main factors affecting the science career choice appeared in the following order: participation in a science-related activity, preference for science learning, and perceptions about the science-related career (Yoon, 2002). Specifically, a study by Lee & Lim (2020), which investigated the elementary school students' awareness of science-related careers and career education, argued that educational efforts are needed to increase the students' interest and enthusiasm for science to encourage STEM career choices (Lee & Lim, 2020). Additionally, the research reveals a close correlation between the students' experiences with science inside and outside of school and their motivation for science learning, particularly among the middle school students (Bong & Lee, 2012). In the case of female high school students, the factors affecting the science-related career choices were found to be influenced directly or indirectly by the science-related educational activities, highlighting the importance of recognizing the value of careers in science (Ahn et al., 2017). It has been revealed that that science career choices have been impacted by the participation in science-related activities and that it also plays a crucial role in shaping the students' interest in science-related careers and in science as a whole.

Young adults who have been exposed to informal science-related activities in their school years are more likely to choose STEM-related careers (Bischoff et al., 2008; Dabney et al., 2012). Previous studies on out-of-school education programs in science-related career education emphasize experiences in informal learning that improve the students' scientific reasoning skills, and increase scientific interactions outside the classroom (Gerber et al., 2001). Indeed, visits to science centers are positively associated with the development of scientific reasoning abilities of students (Sasson, 2014), and experiences such as conducting experiments outside the school, as in a science education center, increases interest in science (Glowinski & Bayrhuber, 2011; Zoldosova & Prokop, 2006). Students who participated in STEM camps showed improvement in their STEM career awareness (Gossen et al., 2021). Science outreach labs can have positive effects on students' affective domains related to science even though through short-term programs (Molz et al., 2022). In addition, students who participate in science experience programs exhibit a significantly higher interest in field related to STEM as future career compared to those who do not (Kong et al., 2014; Kitchen et al., 2018). Given that science experience programs have been found to have a positive impact on the students' preferences for science and their

perceptions of science careers (Im & Kim, 2019; Markowitz, 2004), it is necessary to conduct specific research on the effectiveness of the experiential learning program for science that can positively influence the students' choices of STEM careers in the future. However, there is still a lack of specific research on the effects of science experience programs on the students' aspirations to follow science careers. Therefore, this study aims to analyze the impact of an experiential learning program for advanced science on the students' science career orientation. The research problem of this study is as follows,

1. Does an experiential learning program for advanced science influence the students' career orientation?

2. How does an experiential learning program for advanced science affect the students' science career orientation based on the school level and gender?

3. What impact does an experiential learning program for advanced science have on the students' science career orientation based on their interest in the STEM careers and gender?

Research Methods

Participants

This study concentrated on the students who participated in the "Open Science" and "STAR Bridge camp," which are science experience programs which contribute to the communities, organized by the STAR Bridge Center (School Teacher And Research Institute) at K University in Chungcheongnam-do. The participants voluntarily took part in the program, and the research was conducted on the students who were explained its purpose in advance and agreed to participate. The study included a total of 194 participants from the elementary, middle, and high school levels. The proportion of male students was higher than that of female students, and there were slightly fewer students aspiring to follow STEM careers compared to non-STEM career choices, as shown in Table 1.

Table 1. Backgrounds of participants

Category		Frequency(%)		
		Male	Female	Total
School level	Elementary	25(61.0)	16(39.0)	41(21.1)
	Middle	61(66.3)	31(33.7)	92(47.4)
	High	39(63.9)	22(36.1)	61(31.4)
Future career field	STEM	51(56.0)	40(44.0)	91(46.9)
	non-STEM	57(55.3)	46(44.7)	103(53.1)
Total		108(55.7)	86(44.3)	194(100.0)

Experimental Setup

The schedule and methods of the "Open Science" and "STAR Bridge camp" at STAR Bridge Chungcheong Center were provided to the schools in an official document. Furthermore, after seeing the notice, the Open Science program was applied for at the school level, while students were allowed to participate individually in the STAR Bridge camp. Open Science took place on September 20th and 21th, 2023, and the STAR Bridge camp was held on October 7th and 28th

of the same year. The research was designed using the one group pretest-posttest design.

The participating students experienced two educational programs based on advanced science and technology developed through the Starbridge Chungcheong Center. There were two types of advanced science and technology education in the program: a hydrogen energy experience program and a new drug development experience program. For each program, two teachers and one professor collaborated to develop the program, and it underwent two review processes to supplement the developed products. In the hydrogen energy experience program, students are engaged in hands-on activities, and they experienced the process of electrolyzing water to produce hydrogen through experiments. An entry program was also used in order to determine the fuel efficiency of hydrogen cars and gain an understanding of contributing to sustainable development. The difficulty was adjusted by simplifying explanations using diagrams and examples for students who had not learned the concepts of chemical formulas and electrolysis at school level.

The overall flow of the drug development process was introduced in the new drug development experience program. Students then screened substances through their structures in order to understand how they would function as new drugs. A practical session wherein students utilized artificial intelligence to examine the 3D structure and active site of target enzymes was also part of the program. To accommodate lower-grade students, usage procedures of the program were simplified, and easy proteins were introduced to address differences in difficulty according to school grades of students. To assess the impact of the programs on the students' science career orientation, paper-based questionnaires were administered both before and after the programs.

Questionnaire

To measure the students' science career orientation, the science career orientation questionnaire utilized in a previous study by Yoon et al. (2006) was employed, which has been continuously used in recent studies that investigate science career orientation. The science career orientation questionnaire is divided into four categories: preference for science learning, preference for science career, awareness of science career value, and need for science career information. It consists of a total of 20 items rated on a 5-point Likert scale. In order to give specific examples of categories, preference for science learning is based on six questions asking which are concerned with whether science classes are interesting, among other things. Preference for a science career consists of four questions that ask whether students want to major in science-related fields at university, among other inquiries. Awareness of science career value is composed of six questions that deal with the future prospects of a career in science. Need for science career information is composed of four questions that ask whether there is a significant need for information about careers related to science. The Cronbach's α of the assessment tool was 0.87 to 0.93 in the pretest, 0.93 to 0.97 in the posttest, and 0.96 overall in the pretest and 0.98 in the posttest. Specific details can be found in Table 2.

Table 2. The reliability of the science career orientation questionnaire

Domain	Category	Items	Cronbach's α	
			Pretest	Posttest
Science career orientation questionnaire	Preference for science learning	6	0.90	0.97
	Preference for science career	4	0.93	0.93
	Awareness of science career value	6	0.87	0.95
	Need for science career information	4	0.90	0.96
Total		20	0.96	0.98

Data Collection and Analysis

To examine the changes in the science career orientation of all the students who participated in the science experience-based education program, a paired t-test was conducted. Changes in science career orientation based on the school level and future career field were analyzed, using paired t-tests for each group. Additionally, paired t-tests based on gender were conducted for each group to investigate the gender differences in the science career orientation. In addition, the effect size for areas that show significant changes in the t-test results were calculated as Cohen's d. Based on Cohen's guidelines, effect sizes around 0.20 were interpreted as small, around 0.50 as medium, and around 0.80 as large effect sizes (Cohen, 2013). This allowed to compare the effects in science career orientation across different areas or with previous research. The analysis of the gender differences in elementary school, where the number of participating students was small and the normality assumption was not met, makes it difficult to analyze with parametric statistics. Therefore, a non-parametric statistic called the Wilcoxon signed-rank test was used to compare the pretest and posttest results. The options in the questionnaire were coded from 1 (not at all) to 5 (very much). The respondents were also asked to specify their desired occupation in the survey, which was used to categorize the career aspirations into the STEM and non-STEM fields. The response data were analyzed using the SPSS 27.0.

Results

Table 3 shows the results of the science career orientation responses of all the students who participated in the experiential learning program for advanced science.

Table 3. Response results of science career orientation for all students

Category	M(SD)		t	*p*	Cohen's d
	Pretest	Posttest			
Preference for science learning	4.13(0.78)	4.24(0.96)	−1.56	0.12	-
Preference for science career	3.47(1.18)	3.90(1.04)	−5.11	0.00	1.20
Awareness of science career value	3.93(0.71)	4.11(0.95)	−2.78	0.01	0.88
Need for science career information	3.79(0.97)	4.10(1.04)	−3.86	0.00	1.13
Total	3.87(0.78)	4.10(0.93)	−3.55	0.00	0.92

Compared to the pretest, the participating students achieved statistically significant increase in the overall average response of science career orientation in the posttest($t = -3.55, p < 0.01$). The effect size, calculated with Cohen's d, was 0.92, which indicates a large effect size. Specifically, when examining each category, there was no significant difference in the post-preference for science learning. However, there was a significant improvement in the post-response with all Cohen's d values above 0.80, which indicates a large effect size for the other three categories.

Science Career Orientation by School Level

Table 4 shows the results of analyzing the impact of the experiential learning program for advanced science on the science career orientation by school level.

Table 4. T-test results by school level

Category	School level	M(SD)		t	*p*	Cohen's d
		Pretest	Posttest			
Preference for science learning	Elementary	3.93(0.90)	4.33(0.74)	−3.22	0.00	0.80
	Middle	4.06(0.78)	4.22(1.02)	−1.50	0.14	-
	High	4.39(0.64)	4.22(1.00)	1.47	0.15	-
Preference for science career	Elementary	3.09(1.17)	3.69(0.94)	−3.95	0.00	0.98
	Middle	3.26(1.28)	3.93(1.10)	−4.80	0.00	1.34
	High	4.04(0.77)	4.01(1.00)	0.20	0.84	-
Awareness of science career value	Elementary	3.79(0.61)	4.10(0.73)	−3.25	0.00	0.61
	Middle	3.92(0.74)	4.15(1.00)	−2.22	0.03	1.01
	High	4.04(0.71)	4.04(1.00)	0.03	0.98	-
Need for science career information	Elementary	3.40(1.00)	3.90(0.95)	−3.25	0.00	0.98
	Middle	3.68(1.00)	4.13(1.08)	−3.41	0.00	1.27
	High	4.21(0.73)	4.19(1.02)	0.18	0.86	-
Total	Elementary	3.61(0.80)	4.05(0.73)	−3.84	0.00	0.72
	Middle	3.78(0.82)	4.12(0.99)	−3.20	0.00	1.03
	High	4.18(0.61)	4.12(0.96)	0.59	0.56	-

At the school level, there was a statistically significant increase in the average science career orientation response for the elementary($t = -3.84$, $p < 0.01$) and middle($t = -3.20$, $p < 0.01$) school students compared to the pretest, while there was no significant difference for the high school students. For the elementary school students, the science career orientation showed significant improvement in all the four categories, with Cohen's d being 0.60 or higher, mostly exceeding 0.80, which indicates a medium to large effect size. The posttest scores for middle school students were statistically much higher than the pretest scores in the three categories, that is, preference for science career($t = -4.80$, $p < 0.01$), awareness of science career value($t = -2.22$, $p < 0.05$), and need for science career information($t = -3.41$, $p < 0.01$). In addition, the effect size, as calculated by Cohen's d, was 1.00 or higher, which indicates a large effect size.

Table 5 presents the analysis results of science career orientation based on gender in elementary school.

Table 5. Wilcoxon signed-rank test results by gender for students in elementary school(continued)

Category	Gender	Rank	N	Mean rank	Sum of ranks	Z	*p*
Preference for science learning	M	Negative ranks	3[a]	10.67	32.00	−2.74[d]	0.01
		Positive ranks	17[b]	10.47	178.00		
		Ties	5[c]				
		Total	25				
	F	Negative ranks	2[a]	6.75	13.50	−2.46[d]	0.01
		Positive ranks	12[b]	7.63	91.50		
		Ties	2[c]				
		Total	16				
Preference for science career	M	Negative ranks	5[a]	8.10	40.50	−2.81[d]	0.00
		Positive ranks	17[b]	12.50	212.50		
		Ties	3[c]				
		Total	25				
	F	Negative ranks	3[a]	4.00	12.00	−2.76[d]	0.01
		Positive ranks	12[b]	9.00	108.00		
		Ties	1[c]				
		Total	16				

Table 5. Wilcoxon signed-rank test results by gender for students in elementary school

Category	Gender	Rank	N	Mean rank	Sum of ranks	Z	*p*
Awareness of science career value	M	Negative ranks	5[a]	10.10	50.50	−2.27[d]	0.02
		Positive ranks	16[b]	11.28	180.50		
		Ties	4[c]				
		Total	25				
	F	Negative ranks	3[a]	4.83	14.50	−1.93[d]	0.05
		Positive ranks	9[b]	7.06	63.50		
		Ties	4[c]				
		Total	16				
Need for science career information	M	Negative ranks	7[a]	7.71	54.00	−1.67[d]	0.10
		Positive ranks	12[b]	11.33	136.00		
		Ties	6[c]				
		Total	25				
	F	Negative ranks	2[a]	4.50	9.00	−3.10[d]	0.00
		Positive ranks	14[b]	9.07	127.00		
		Ties	0[c]				
		Total	16				
Total	M	Negative ranks	4[a]	8.38	33.50	−3.02[d]	0.00
		Positive ranks	18[b]	12.19	219.50		
		Ties	3[c]				
		Total	25				
	F	Negative ranks	2[a]	7.25	14.50	−2.77[d]	0.01
		Positive ranks	14[b]	8.68	121.50		
		Ties	0[c]				
		Total	16				

[a]: posttest < pretest, [b]: posttest > pretest, [c]: posttest = pretest, [d]: based on negative ranks

The results indicated that both male($Z = -3.02$, $p < 0.01$) and female($Z = -2.77$, $p < 0.05$) students in elementary school demonstrated a statistically significant increase in the science career orientation category in the posttest compared to the pretest. Specifically, male students demonstrated a posttest improvement in three categories, that is, preference for science learning($Z = -2.74$, $p < 0.05$), preference for science career($Z = -2.81$, $p < 0.01$), and awareness of science career value($Z = -2.27$, $p < 0.05$), while female students exhibited posttest improvement in three categories, that is, preference for science learning($Z = -2.46$, $p < 0.05$), preference for science career($Z = -2.76$, $p < 0.05$), and need for science career information($Z = -3.10$, $p < 0.01$).

Table 6 presents the analysis results of science career orientation based on gender in middle school.

Table 6. T-test results by gender for students in middle school

Category	Gender	N	M(SD)		t	*p*	Cohen's d
			Pretest	Posttest			
Preference for science learning	M	61	4.18(0.74)	4.35(1.01)	−1.42	0.16	-
	F	31	3.82(0.82)	3.95(1.00)	−0.62	0.54	-
Preference for science career	M	61	3.49(1.24)	4.18(1.02)	−4.17	0.00	1.29
	F	31	2.80(1.24)	3.44(1.09)	−2.43	0.02	1.46
Awareness of science career value	M	61	3.95(0.80)	4.21(1.05)	−2.00	0.05	-
	F	31	3.86(0.61)	4.03(0.90)	−0.99	0.33	-
Need for science career information	M	61	3.78(1.08)	4.20(1.15)	−2.51	0.01	1.31
	F	31	3.49(0.82)	4.00(0.94)	−2.35	0.03	1.20
Total	M	61	3.89(0.84)	4.25(1.01)	−2.72	0.01	1.02
	F	31	3.56(0.73)	3.88(0.91)	−1.67	0.10	-

The overall science career orientation response average for male students in middle school demonstrated a statistically significant increase in the posttest compared to pretest($t = -2.72$, $p < 0.05$), with a Cohen's d exceeding 1.00, which indicates a large effect size. Male and female students exhibited statistically significant improvements in the categories of preference for science career and need for science career information.

No statistically significant difference was observed in the results of the high school students' science career orientation responses by gender.

Science Career Orientation Based on The Aspiration for STEM Career

Table 7 presents the results of the analysis on the impact of the experiential learning program for advanced science on the science career orientation by the aspiration for future career field, between a STEM and a non-STEM career.

Table 7. T-test results by aspiration future career field

Category	Future career field	M(SD)		t	*p*	Cohen's d
		Pretest	Posttest			
Preference for science learning	STEM	4.45(0.62)	4.44(0.84)	0.22	0.83	-
	non-STEM	3.85(0.80)	4.07(1.03)	−1.88	0.06	-
Preference for science career	STEM	4.16(0.81)	4.19(0.90)	−0.37	0.71	-
	non-STEM	2.85(1.11)	3.65(1.09)	−5.90	0.00	1.37
Awareness of science career value	STEM	4.11(0.67)	4.22(0.86)	−1.75	0.08	-
	non-STEM	3.78(0.71)	4.00(1.01)	−2.20	0.03	1.04
Need for science career information	STEM	4.19(0.75)	4.29(0.94)	−1.30	0.20	-
	non-STEM	3.43(1.00)	3.94(1.10)	−3.73	0.00	1.37
Total	STEM	4.24(0.63)	4.29(0.82)	−0.88	0.38	-
	non-STEM	3.55(0.77)	3.94(0.98)	−3.61	0.00	1.10

The students who wanted to follow STEM careers did not show a statistically significant differences in the science career orientation. However, the students who responded that they wanted to pursue non-STEM careers exhibited statistically significant differences($t = -3.61$, $p < 0.01$). Specifically, the students that aspire non-STEM career exhibited significant posttest improvements in the three categories, that is, preference for science career($t = -5.90$, $p < 0.01$), awareness of science career value($t = -2.20$, $p < 0.05$), and need for science career information($t = -3.73$, $p < 0.01$). In addition, Cohen's d was 1.00 or higher, which indicates a large effect size.

Table 8 presents the analysis results of science career orientation based on gender among students who aspire to a STEM career.

Table 8. T-test results by gender for students wishing to pursue a STEM career

Category	Gender	N	M(SD)		t	*p*	Cohen's d
			Pretest	Posttest			
Preference for science learning	M	51	4.39(0.71)	4.35(1.04)	0.31	0.76	-
	F	40	4.53(0.48)	4.55(0.46)	−0.30	0.77	-
Preference for science career	M	51	4.11(0.95)	4.14(1.07)	−0.22	0.83	-
	F	40	4.23(0.59)	4.26(0.61)	−0.42	0.67	-
Awareness of science career value	M	51	4.05(0.73)	4.15(1.00)	−0.91	0.37	-
	F	40	4.18(0.59)	4.31(0.63)	−3.19	0.00	0.26
Need for science career information	M	51	4.10(0.86)	4.17(1.12)	−0.50	0.62	-
	F	40	4.30(0.58)	4.44(0.63)	−2.19	0.03	0.42
Total	M	51	4.17(0.73)	4.21(1.00)	−0.35	0.73	-
	F	40	4.32(0.45)	4.40(0.49)	−2.52	0.02	0.20

Among the students aspiring to follow STEM careers, female students showed a statistically significant increase in the science career orientation category($t = -2.52$, $p < 0.05$). Specifically, statistically significant improvements in awareness of science career value($t = -3.19$, $p < 0.01$) and the need for science career information($t = -2.19$, $p < 0.05$) were observed in the posttest. In the category the awareness of science career value, Cohen's d exceeded 0.20, which indicates a small-sized effect, while for the need for science career information, Cohen's d exhibited a medium-sized effect.

Table 9 presents the analysis results of science career orientation based on gender among students aspiring to a non-STEM career.

Table 9. T-test results by gender for students wishing to pursue a non-STEM careers

Category	Gender	N	M(SD)		t	*p*	Cohen's d
			Pretest	Posttest			
Preference for science learning	M	57	4.00(0.72)	4.23(0.96)	−1.67	0.10	-
	F	46	3.67(0.87)	3.87(1.08)	−1.02	0.31	-
Preference for science career	M	57	3.09(1.10)	3.88(1.02)	−4.83	0.00	1.23
	F	46	2.55(1.06)	3.36(1.11)	−3.56	0.00	1.54
Awareness of science career value	M	57	3.83(0.75)	4.09(1.00)	−1.98	0.05	-
	F	46	3.71(0.65)	3.89(1.02)	−1.12	0.27	-
Need for science career information	M	57	3.56(1.05)	4.00(1.14)	−2.49	0.02	1.33
	F	46	3.28(0.93)	3.86(1.04)	−2.78	0.01	1.42
Total	M	57	3.68(0.77)	4.07(0.96)	−2.93	0.00	1.01
	F	46	3.38(0.74)	3.77(0.99)	−2.18	0.03	1.22

Students aspiring to pursue non-STEM careers, both male($t = -2.93$, $p < 0.01$) and female($t = -2.18$, $p < 0.05$), showed statistically significant improvement in the science career orientation. Specifically, both male and female students who aspire a non-STEM career exhibited a significant posttest increase in the preference for science career and the need for science career information, with effect sizes exceeding 1.00, which indicates a large impact.

Discussion

The research results show that the experiential learning program for advanced science was effective in enhancing the students' orientation toward science careers. This result is in line with a study by Wahono et al. (2021) that investigated the effects of an SSI-based class through STEM-6E. In their research, the posttest results of the program demonstrated a significant improvement and large effect sizes of 0.80 or more, which is similar to the results observed here. The response average for preference for a science career, a component of the science career orientation, significantly increased, and Cohen's d indicated a large effect size. This is similar to the findings of Bischoff et al. (2008) and Kitchen et al. (2018), where the students participating in the science-related activities showed positive changes toward choosing STEM careers. Thus, science activities, such as science camps, as noted by Markowitz (2004), play a crucial role in elevating the students' orientation toward the STEM career choices, stressing the importance of the students' participation in the science activities to increase their interest in science careers.

In addition, the results of this study indicated a significant increase in the post-science career orientation among both elementary and middle school students. According to Gossen et al. (2021), after participating in science camps,

elementary students showed a moderate increase in the STEM-related values and aspirations, with a moderate effect size. Notably, in this study, the participation showed a moderate to high effect size. Similarly, the enhancement in the affective domain relating to science among middle school students following outreach lab activities(Molz et al., 2022) was observed in our research. However, there was no significant increase in the science career orientation among high school students, which could be interpreted as due to their already high level of science career orientation before the program, resulting in no significant difference.

When comparing the responses by gender across the school levels, it was found that the science career orientation among the elementary school students significantly increased for both boys and girls. For as to the middle school students, a significant difference in the science career orientation was observed only in boys. This is similar to the research by Kong et al. (2014), which found that the middle school boys participating in science camps were significantly more likely to choose STEM careers than girls. The results showing lower science career orientation among the middle school girls compared to boys support the findings that more men prefer careers in the STEM fields than women (Makarova et al., 2019), and it seems that this result is seen in the differences in the effects of the program on the participants depending on gender, to a certain extent.

As indicated in Table 7, students who aspired to pursue the STEM careers had significantly higher pretest scores in the science career orientation category than those interested in the non-STEM fields, resulting in no significant differences in the posttest scores. This phenomenon is referred to as the ceiling effect. Similar observations of a ceiling effect were noted in a study conducted by Weinberg et al. (2011), which investigated the impact of an experiential learning program on middle school students' motivation in mathematics and science. Significant measurements of change in the posttest were restricted when a high level of motivation and understanding of the importance of mathematics and science was reported in the pretest. In contrast, students who aspired to pursue non-STEM careers showed a significant increase in the post-science career orientation with a large effect size. Science activities, such as science camps, appear to enhance the interest in science of the students who were previously not interested in science careers (Markowitz, 2004). Given that experiencing the science experiential activities, such as those described in this study, influences future science career choices (Bischoff et al., 2008), these findings are considered important

When the students aspired to pursue STEM careers, the pretest scores were all above 4.00, indicating very high levels of science career orientation scores and as a result, many did not show significant posttest increases. The pretest and posttest scores for boys were similar, whereas girls showed a small effect size in significant increase only in the posttest results. The positive outcomes observed for the female students in this study are similar to the findings that girls who experienced out-of-school science activities showed more positive attitudes about choosing careers in the science-related fields (Fadigan & Hammrich, 2005). This is different than for the students, both male and female, who aspired to pursue the non-STEM careers, who had pretest scores between 2.55 and 4.00 and showed a large effect size increase in the science career orientation. In terms of the preferences for science learning and the awareness of science career value, the pretest scores were relatively high compared to the preference for science career and the need for science career information, indicating that the students needed more information and experience to form science career preferences. The significant positive change in the students aspiring to pursue non-STEM careers after participating in the activities, those who had relatively lower pretest scores, in preference for science career and the increase in their need for science

career information is a meaningful result. Considering the decline in the number of students planned to pursue STEM careers or persisted in fields (Rosenzweig et al., 2021), efforts to make positive changes that would increase the interest in those careers must continue.

Conclusion and Implication

This study analyzed the effectiveness experiential learning program for advanced science offered to the students in a community engagement program of the STAR Bridge Chungcheong Center, with a focus on the impact of the program on the science career orientation. The research results are as follows:

First, the students who experienced the experiential learning program for advanced science showed a statistically significant improvement in their science career orientation scores, with a large effect size. Specifically, there was an increase in the categories of the science career orientation, such as preference for a science career, awareness of the science career value, and need for science career information. Even if improving the students' scores in the preference for science learning category was challenging, it was evident that the students could be positively influenced in terms of their preference for and perception of science-related careers, even just through a short duration program.

Second, the impact of the experiential learning program for advanced science varied depending on the school level, with mostly medium to large effect sizes in the categories. The elementary and middle school students showed statistically significant improvements, while no difference was observed among high school students. Enhancing the students' interest and excitement about science through science experience programs proved beneficial (Glowinski & Bayrhuber, 2011; Zoldosova & Prokop, 2006), especially for elementary school students, one of the main reasons being that elementary school students do not choose science-related careers due to their negative perception of science, which many find not interesting (Lee & Lim, 2020). Additionally, since "participation in activities" is the most crucial factor (Yoon, 2002), which influences the middle school students' science-related career choices, providing experimental based science programs, such as the one examined by this study, is expected to help to improve science career orientation for middle school students.

Third, the effect of the science experience-based program varied depending on whether the students aspired to STEM or non-STEM careers. Students wishing to pursue non-STEM careers showed a statistically significant improvement in the science career orientation, with a large effect size. On the contrary, the students who aspired to follow STEM careers did not show a statistically significant difference. The results suggest that the students aspiring to pursue non-STEM careers can experience improvements in their preference for science career, awareness of science career value, and need for science career categories through science experience programs. That indicates that the students who frequently participate in science experience programs (Molz et al., 2022; Zoldosova & Prokop, 2006) may undergo changes in their career aspirations.

Fourth, the impact of the science experience-based program on the students' science career orientation differed depending on their gender. The science career orientation of both male and female students in elementary school and of male students in the middle school improved statistically in a significant way. Regardless whether their desired career field was STEM or non-STEM, the science career orientation of the female students had improved, having mostly a

medium to larger effect size. Since in STEM-related occupations, the proportion of men tends to be consistently high, thus making Girl-friendly science efforts are very important to positively change the female students' career orientation in science (Fadigan & Hammrich, 2005). It was confirmed by our research that science experience-based education programs also have a positive effect on the female students' science career orientation.

To enhance the students' science career orientation, the following suggestions are proposed based on the research results:

Foremost, there is a need to reactivate various science experience programs, such as science festivals and science fairs, which may have switched to being conducted online or interrupted due to the COVID-19 pandemic. Schools should continue to provide diverse science experience, as they have in the past during such events as the Science Month in April. Additionally, science experience programs that allow the students to experience science outside of school should also be reinstated to provide more opportunities for the students to engage in science.

Second, the science experience programs should be actively offered to the students who aspire to follow non-STEM careers. The study shows that the students aspiring to follow non-STEM careers experience an improvement in the science career orientation through. Therefore, in the school science class, experiential activities should be implemented to enable a positive career exploration and provide opportunities for the students to recognize the value of the science-related fields and careers.

Third, further research is needed to develop specific programs that can enhance the science career orientation among the high school students. Many high school students may have already chosen a career path at an earlier school level. Considering that among the scientists, the most likely time to decide on a science-related career was the third year of high school (Jang, 2004), high school research is needed on specific programs that can improve the students' science career orientation scores.

Finally, it's essential to acknowledge that this study applied a program conducted at the STAR Bridge Chungcheong Center and was specific to a certain region only. Additionally, there were differences in the number of the elementary, middle, and high school students, which may be a limitation to the generalizations of the research findings. Future research should aim to increase the sample size by the school level and further analyze the differences based on grade within each school level.

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Conflicts of Interest

The authors declared no conflicts of interest.

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