Brain, Digital, & Learning

pISSN : 2384-2474
eISSN : 2586-7490

RESEARCH ARTICLE

A Study on the Science-Affective Domain of Students Participating in a Chemistry Experience Camp

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ABSTRACT

The purpose of this study is to conduct an in-depth analysis of the affective domain of science among students who participated in a chemistry experience camp. To this end, a survey was conducted on students who participated in the camp to draw graphs related to the affective domain of science and their attitudes toward chemistry. The results of the study are as follows: first, students who participated in the chemistry camp generally showed an increasing interest in science as they advanced in grade levels. This trend was closely related to an improvement in their confidence in science. Participatory experiences, such as experiments and achievements in science, had a positive impact on their interest in and confidence regarding science. Second, the students' interest in science, confidence in science, career interests, and career choices were found to be closely interconnected. Third, students perceived chemistry as both satisfying and challenging, but also complicated. They responded that mathematical calculations, such as the quantitative relationships in chemical reactions, and various laws could contribute to negative feelings toward chemistry.

Keywords: Chemistry experience camp, science-affective domain, interest in science, confidence in science, career path

Brain, Digital, & Learning
2024, Vol. 14, No. 4, 597-612
https://doi.org/10.31216/BDL.20240034

Received: November 21, 2024
Revised: December 13, 2024
Accepted: December 13, 2024

Introduction

Elon Musk has proposed the Mars colonization project, which can enable humanity to live beyond Earth and eventually inhabit other planets (Musk, 2017). Throughout history, human civilization has rapidly advanced through science, and the future brought about by scientific progress is evolving so quickly that it cannot be accurately predicted. As uncertainty about the future grows, there is an increasing demand for individuals capable of flexibly adapting to environmental changes. Consequently, school education is shifting toward fostering future-oriented competencies. To help students develop the skills needed to adapt successfully to the ever-changing society and continue learning, South Korea introduced a revised curriculum in 2015 that emphasized core competencies (MOE, 2015). This initiative aligns with the direction of future education outlined by OECD Education 2030, which focuses not only on knowledge and skills but also on attitudes and values. This approach continues with the 2022 revised curriculum, which emphasizes the holistic development of students to meet future challenges (MOE, 2022a).

South Korea has experienced rapid growth in the fields of science and technology due to talented individuals, with the country achieving recognition as a global leader in technological competitiveness. In 2023, South Korea ranked 10th in the Global Innovation Index, further underscoring its world-class status in technological innovation (WIPO, 2023). However, the nation faces significant challenges such as a declining birthrate and a decreasing school-age population. These trends have led to a substantial reduction of new talent in the fields of science, technology, engineering, and mathematics (known as STEM fields), which exacerbates the gap between supply and demand and raises concerns about the future of the STEM workforce (MSI, 2021). This decline in scientific competence and interest also fuels concerns about the future national competitiveness of South Korea. To address these challenges and maintain competitive edge in the face of uncertainty, fostering talent in the science and technology sector has become a universally acknowledged priority (MOE, 2023). Since the Talent Cultivation Strategy Meeting, the government has been planning comprehensive and systematic measures for fostering talent in advanced fields at a national level (MOE, 2023). However, aside from driving innovation centered around universities to nurture talent for advanced industries, it is also important to strengthen science education at the primary and secondary levels, which forms the foundation for STEM education. Various initiatives have been implemented to achieve this, such as providing advanced technology-based teaching and learning support, strengthening infrastructure, and organizing camp programs centered around various fields to promote experiential and inquiry-based activities outside of school (MOE, 2020).

Intrinsic motivation refers to a form of motivation wherein the act of performing a task itself is the reward and source of enjoyment. Students with high intrinsic motivation toward science find studying science enjoyable, wherein the act of learning becomes a reward in itself, leading them to continuously engage in self-directed study (Kim, 2024a). The educational curriculum emphasizes values and attitudes, which are closely linked to intrinsic motivation (MOE, 2022a). Similarly, the primary goal of the science curriculum is to foster positive attitudes toward science, embedding values and attitudes in achievement standards (MOE, 2022b). However, the affective achievement in science among students in South Korea is one of the lowest compared to participating countries in international academic assessments such as the Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA) (MSI, 2021; MOE, 2023). Since science is a discipline dealing with abstract concepts, students can find it challenging to comprehend scientific phenomena. Therefore, fostering intrinsic motivation toward science is critical. Having a low affective achievement can lead to decreased learning motivation for science, and the relatively low performance of South Korea in this area compared to other countries is concerning. Thus, there is great interest in variables related to the affective domain of science and affective achievement, leading to ongoing research in these areas. To enable students to excel in science, it is essential to encourage genuine interest and enjoyment in studying the subject. Accordingly, studies have been conducted to identify variables that foster intrinsic motivation toward science and analyze their relationship with cognitive achievement.

Studies have focused on objectively assessing the affective achievement of Korean students in the field of science by analyzing their performance in the affective domain through national tests such as the TIMSS and PISA. These studies aim to provide insights for future science education policies (Kim, 2022; Kim & Choi, 2021). Although South Korea has been implementing various strategies within and beyond schools to improve affective achievement in science (MOE, 2020), Korean students still exhibit relatively lower affective achievement in science compared to major countries in America and Europe. To address this issue, studies have explored the causes of low affective achievement by investigating the attitudes of Korean elementary, middle, and high school students toward science using the Science Positive Experience Index (Kim et al., 2022). Additionally, ongoing research continues to investigate the teaching and learning methods that effectively enhance students' interest in and attitudes toward science. An analysis of 228 studies conducted over 12 years by Potvin and Hasni (2014) revealed that students' interest in science decreases as they progress through school levels, noting a particularly sharp decline in interest and motivation during middle school. Traditional teacher-centered lectures were found to accelerate this decline in interest, whereas student-centered methods, such as experiment-based classes, improved their attitudes toward science.

Providing concrete, hands-on experimental experiences can enhance affective achievement in science. For instance, students who participated in chemistry experience programs showed significant improvement in their attitudes toward chemistry (Kim, 2024b). Similarly, science classes that utilize computer-based science inquiry programs can enhance both core competencies in science and affective achievement in the subject (Kim & Kim, 2022). However, assessments of affective achievement in science, including the PISA and TIMSS, often involve students selecting answers from predetermined options or self-reported evaluations. Since not all aspects of the affective domain are consciously accessible to students, the information obtained through surveys can be limited. In response, the affect graphing method was introduced; this can visually represent aspects of the affective domain through graphs (Jeong et al., 2022; Satyam et al., 2022). Recent qualitative studies have used this to investigate the causes of low affective achievement in science among elementary, middle, and high school students. Students were asked to draw graphs depicting changes in their interest and confidence in science classes, as well as to verbally describe the changes reflected in these graphs (Jeong et al., 2022).

The science subjects can be broadly divided into physics, chemistry, biology, and earth science. Among these, chemistry deals with the microscopic world of atoms and molecules, which students cannot observe with the naked eye, making it known as a subject where students often struggle to understand its concepts (Chiu et al., 2015). The chemistry subject of the College Scholastic Ability Test (CSAT) in Korea has consistently been considered difficult, making Chemistry II the least chosen subject among the science exploration subjects and Chemistry I the subject with the fewest test-takers even among the more commonly selected science exploration I subjects (KICE, 2023). Students' subject choices in the CSAT reflect the areas and subjects they are currently interested in, which are also linked to their career aspirations. The lack of preference for chemistry among students negatively impacts the cultivation of talent in the field of chemistry, emphasizing the need to focus on affective achievement in chemistry. Research on the affective domain of science sub-subjects such as chemistry has recently been conducted to investigate attitudes toward physics (Kang, 2018; Song & Choi, 2017), but little research has been conducted on attitudes toward chemistry. However, studies on attitudes toward chemistry remain scarce. Therefore, it is meaningful to examine attitudes toward chemistry in depth even within the field of scientific definition research.

Students who voluntarily participate in a chemistry experience camp likely have a high affective achievement in chemistry. This study aims to examine their affective achievement in science through methods such as graph drawing and surveys. Through this study, we hope to analyze the characteristics exhibited by these students in the affective domain of science and derive implications for improving students' affective achievement in science.

The research questions of this study are as follows:

What characteristics are observed in the graphs of students' interest, confidence, and career choices related to science participating in the chemistry experience camp?

What attitudes did students toward chemistry participating in the camp, and what causes their negative perceptions toward chemistry?

Research Methods

Participants

This study was conducted among students who participated in the chemistry experience camp organized by the Starbridge Center in the Chungcheong region in 2024. The participants were middle and high school students from the Chungcheong, Daejeon, and Sejong areas, who voluntarily attended the camp. The camp was conducted on Saturdays in June and October, with separate sessions for middle school and high school students. The research subjects were 51 students who voluntarily expressed interest in participating in the study. The future career fields of the students are as follows: 32 in science and engineering, 8 in medicine, 2 in the humanities, and 9 not decided. Detailed information about the research subjects is provided in Table 1.

Table 1. Participant background data

Frequency (%)

School level		Future Career Field			Total
Middle school	High school	STEM	Non-STEM	Not Decided	
36(70.6)	15(29.4)	40(78.4)	2(3.9)	9(17.7)	51(100.0)

Research Design

The chemistry experience camp in this study was conducted as a community outreach program at the Starbridge Chungcheong Center. It was held on Saturdays in June, September, and October 2024, with students voluntarily registering through the website to participate. Each program consisted of a career lecture in the field of chemistry followed by a 90-minute hands-on chemistry experiment. For middle school students, the experiment involved producing hydrogen by electrolyzing water and then building hydrogen rockets, while for high school students, it involved producing hydrogen through electrolysis and using it to power hydrogen cars as part of their activities.

Questionnaire

Assessment tools were developed to facilitate an in-depth examination of the affective domain in science among students participating in the chemistry experience program. The tools are divided into two parts:

1. Affective Domain in Science: This section includes three types of graphing activities corresponding to the affective domain of science.

2. Attitudes Toward Chemistry: This section investigates students' attitudes toward chemistry.

Figure 1 illustrates some of the items included in the questionnaire used in this study.

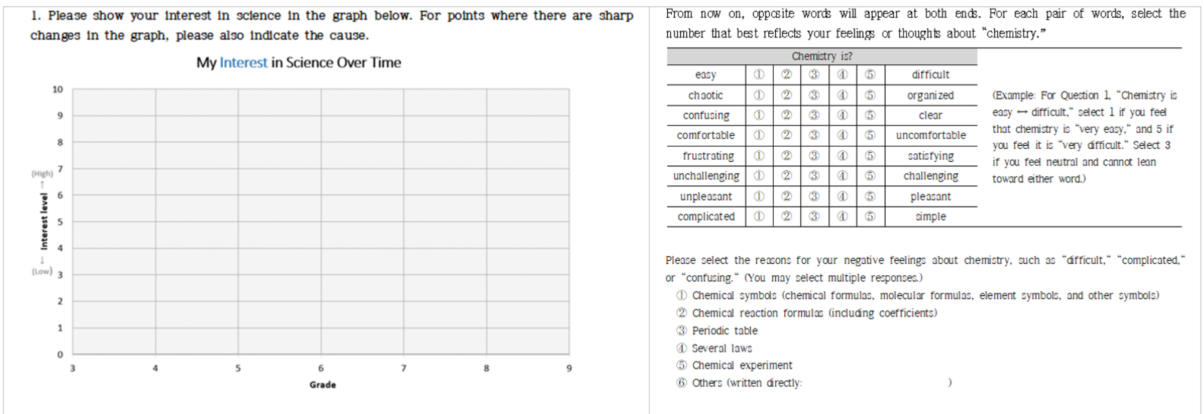

Fig. 1. Example of the questionnaire items

To investigate students' interest in science, confidence in science, and changes in career interest and selection, affective domain graphs were utilized based on the storyline research method proposed by Jeong et al. (2022). These graphs represent the flow of time on the x-axis, starting from the third grade of elementary school up to the present, while the intensity of each variable is described on the y-axis. Students were asked to describe the specific reasons for any significant changes in the graphs. Additionally, since the study participants were students in a chemistry experience program, the research focused specifically on attitudes toward chemistry within the broader scope of science attitudes. The items for assessing attitudes toward chemistry were adapted from Xu & Lewis (2011) and Bauer (2008), who refined a set of 20 attitude items into a representative 8-item scale with validated reliability. These items were further modified to suit Korean students, based on the methodology proposed by Kim (2024b); the scale was adjusted from a 7-point to 5-point Likert scale. The attitude assessment included eight items related to chemistry, which reflect prior research on attitudes toward chemistry. Additional items were included to investigate the factors contributing toward the negative perceptions of chemistry. The attitude assessment consisted of eight items related to chemistry, reflecting prior research on attitudes regarding chemistry, including additional items for the factors contributing toward negative perceptions of chemistry. The overall Cronbach's alpha for the 8-item scale assessing attitudes toward chemistry was 0.786, indicating a high level of reliability.

To investigate the causes of negative perceptions of chemistry, additional items were developed based on findings from Kim (2024b), who identified that students had a predominant negative image of chemistry as being "complex and difficult." These items aimed to identify the experiences that contributed to such perceptions. We designed multiplechoice questions which allowed students to select the reasons that led them to view chemistry as "difficult," "complex," or "confusing" (Figure 1). To construct this question, an open-ended survey of 339 students from three middle schools and 265 students from one high school was conducted in March 2024. This survey asked students to describe experiences that made them perceive chemistry negatively, using terms such as "difficult," "complex," or "confusing." The responses were categorized by school level, and the most frequently mentioned reasons were used to create the response options for the question. This method ensures that the questions accurately reflected the students' experiences and perceptions. For middle school students, the frequently cited reasons were: chemical symbols (chemical formulas, element symbols, and other symbols), chemical equations (including coefficients), periodic table, various laws, chemistry experiments, and others (write-in response). For high school students, these were: chemical symbols (chemical formulas, molecular formulas, and other symbols), chemical equations (including coefficients), periodic table, mole, quantitative relationships in chemical reactions, and others (write-in response).

Data Collection and Analysis

In June and October 2024, students participating in the chemistry experience camp hosted by the Starbridge Center in the Chungcheong region were informed of the research objectives, and volunteers were asked to complete paper-based surveys. These surveys included graph drawing related to the affective domain of science, questions on attitudes toward chemistry, and items regarding the causes of negative perceptions of chemistry.

Students were asked to draw three graphs representing their interest in science, confidence in science, and career interest/career selection over time. The overall trends in these graphs were analyzed, particularly focusing on points of significant change. Additionally, the interrelationships among the three graphs were examined to identify patterns. For attitudes toward chemistry, adjectives selected by students were coded on a 5-point scale, with negative and positive adjectives assigned scores of 1 and 5, respectively. The overall mean and item-specific averages were calculated and compared with the pretest scores of students who participated in the previous years's chemistry experience camp. Additionally, to identify the primary experiences or factors contributing toward studentss' negative perceptions of chemistry, a multiple-response frequency analysis was conducted, categorized by school level (i.e., middle school and high school). By analyzing these responses, the study sought to uncover patterns and potential areas for intervention to improve students' attitudes toward chemistry.

Results

Characteristics observed in the affective domain of science

Table 2 shows the results of analyzing the graphs pertaining to studentss' interest in science from the third grade in elementary school up to the present.

Table 2. Changes in students' interest in science from the third grade up to the present

Frequency (%)

Increase		Increase and then decrease		Decrease		No variation		Total	
Middle school	High school	Middle school	High school	Middle school	High school	Middle school	High school	Middle school	High school
31 (86.1)	12 (80.0)	3 (8.3)	0 (0.0)	1 (2.8)	1 (2.8)	1 (6.7)	2 (13.3)	36 (100.0)	15 (100.0)

An increasing interest in science from the third grade up to the present was noted by 38 students (29 middle school, 9 high school) out of 51 who participated in the camp. On the one hand, many students demonstrated a gradual increase or maintained a steady level of interest for a period, followed by an increase at certain grades, resulting in an overall upward trend. On the other hand, a smaller number of students noted a decline in their interest in science after a certain grade, a steady decrease, or a maintained level of interest. For students whose interest in science sharply changed, the grades at which these shifts occurred are summarized in Table 3.

Table 3. Points of significant change in interest in science

Frequency (%)

School level	Grade									Total
	3	4	5	6	7	8	9	10	none	
Middle school	2 (5.6)	6 (16.7)	8 (22.2)	7 (19.4)	7 (19.4)	-	-	-	6 (16.7)	36 (100.0)
High school	-	1 (6.7)	1 (6.7)	1 (6.7)	4(26.7)	3 (20.0)	1 (6.7)	2 (13.3)	2 (13.3)	15 (100.0)
Total	2 (3.9)	7 (13.7)	9 (17.6)	8 (15.7)	11 (21.6)	3 (5.9)	1 (2.0)	2 (3.9)	8 (15.7)	51 (100.0)

As shown in Table 3, students' interest in science changed the most during their first year of middle school, with many students reporting a significant shift in interest between the fourth and sixth grades of elementary school. When examining Tables 2 and 3 together, students who participated in the chemistry camp often experienced significant changes in their interest in science between the fourth grade of elementary school and the first year of middle school, with most of these changes reflecting an increase in interest. An example of a case where the reason for this sharp increase in interest in science was explicitly stated is shown in Figure 2. Middle school students who participated in the chemistry camp reported that their interest in science grew through enjoyable experiences with science, specifically stating, “I became interested by participating in science experiments.” and “I became interested by frequently watching science-related videos.” On the other hand, high school students indicated that their interest in science increased due to intrinsic motivation, such as “I became interested in investigating the causes of familiar phenomena.” and “I became interested in science by thinking about my career path and setting my future academic direction.”

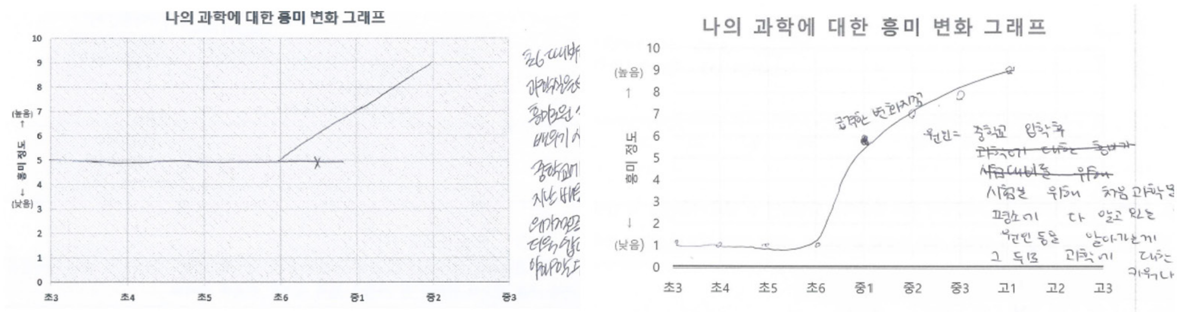

Fig. 2. Reasons for the points of significant change regarding interest in science

Table 4. Changes in students' confidence in science from the third grade up to the present

Frequency (%)

Increase		Increase and then decrease		Decrease		No variation		Total	
Middle school	High school	Middle school	High school	Middle school	High school	Middle school	High school	Middle school	High school
26 (72.2)	11 (73.3)	4 (11.1)	0 (0.0)	3 (8.3)	3 (20.0)	3 (8.3)	1 (6.7)	36 (100.0)	15 (100.0)

Similar to their interest in science, students' confidence in science also showed an upward trend, with 37 out of 51 students (26 middle school, 11 high school) having an increasing confidence in science from the third grade to their current grade. In many students, their confidence gradually increased or remained constant, then increased after certain grades, resulting in an overall upward trend. Comparatively, less students showed a decline in confidence after a certain grade, a steady decrease, or maintained a consistent level without change. For students who experienced sharp changes in terms of confidence in science after a certain grade, the grades at which these shifts occurred are shown in Table 5.

Table 5. Points of significant change in confidence in science

Frequency (%)

School level	Grade									Total
	3	4	5	6	7	8	9	10	none	
Middle school	1 (2.8)	4 (11.1)	5 (13.9)	7 (19.4)	7 (19.4)	2 (5.6)	-	-	10 (27.8)	36 (100.0)
High school	-	-	2 (13.3)	2 (13.3)	3 (20.0)	2 (13.3)	1 (6.7)	4 (26.7)	1 (6.7)	15 (100.0)
Total	1 (2.0)	4 (7.8)	7 (13.7)	9 (17.6)	10 (19.6)	4 (7.8)	1 (2.0)	4 (7.8)	11 (21.6)	51 (100.0)

Students' confidence in science most commonly showed significant changes in the 6th grade in elementary school and the 7th (Table 5). However, most students did not report any points of sudden change in confidence, indicating a more gradual or consistent trend for most participants.

The reasons for the sharp increase in confidence in science are specifically illustrated in Figure 3.

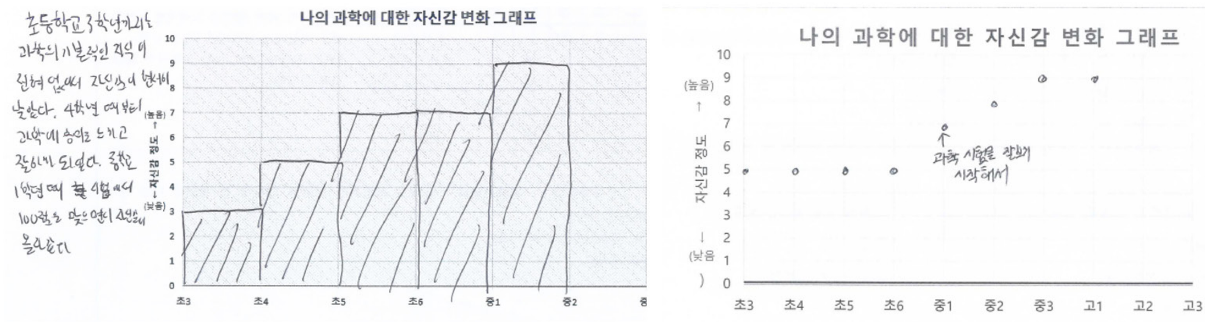

Fig. 3. Reasons for significant change regarding confidence in science

Students attributed this increase in confidence to several reasons, including “confidence rising after developing an interest in science,” “starting to feel confident after achieving good grades in science,” “gaining confidence by explaining learned material to friends,” and “boosting confidence by participating in science competitions.”

After analyzing the trends in students' interest and confidence in science, 39 students (76.4%) demonstrated similar tendencies in both areas. The most common pattern was a simultaneous increase in both interest and confidence in science, seen in 31 out of 51 students.

The analysis of career interests and choices among students participating in the chemistry camp is shown in Table 6.

Table 6. Students’ career interest and career choices

Frequency (%)

Middle school			High school			Total		
STEM	non-STEM	Not Decided	STEM	non-STEM	Not Decided	STEM	non-STEM	Not Decided
29 (80.6)	1 (2.8)	6 (16.7)	11 (73.3)	1 (6.7)	3 (20.0)	40 (78.4)	1 (3.9)	6 (17.6)

Among the participating students, 29 middle school students and 11 high school students expressed interest in STEM-related careers. Among these students, their interest and confidence in science tended to increase during periods when their career interest shifted. Conversely, among students whose interest and confidence in science declined, this decline was noted when their career interest shifted from STEM to other fields.

Attitudes toward chemistry and factors contributing to negative perceptions

The analysis of students’ attitudes toward chemistry is shown in Table 7.

Table 7. Students' attitudes toward chemistry

	Perceptions of chemistry	M(SD)		M(2024) - M(2023)
		2024	2023	
1	hard/easy	2.72(1.14)	2.61(1.06)	0.11
2	chaotic/organized	3.68(1.00)	3.73(0.89)	-0.05
3	confusing/clear	3.53(1.17)	3.25(1.16)	0.28
4	uncomfortable/comfortable	3.50(0.89)	3.32(0.91)	0.18
5	frustrating/satisfying	4.02(0.71)	3.93(0.87)	0.09
6	unchallenging/challenging	4.02(0.84)	3.90(0.98)	0.12
7	unpleasant/pleasant	3.73(0.76)	3.79(0.86)	-0.06
8	complicated/simple	2.33(1.05)	2.04(0.84)	0.29
	Total	3.44(0.61)		

Note: M=mean, SD=standard deviation

Students rated their attitudes toward chemistry using eight descriptive adjectives on a 5-point scale, with higher scores indicating a tendency toward positive adjectives and vice versa. Among these, the highest scores were observed for "frustrating/satisfying" and "unchallenging/challenging," whereas the lowest scores were recorded for "complicated/simple." In short, the participants generally perceived chemistry as a satisfying and challenging, yet complex field of study. These responses were similar to those observed in a study conducted with elementary, middle, and high school students who participated in the 2023 Chemistry Experience Camp (Kim, 2024b). The most positively and negatively perceived adjectives in both studies were consistent. However, Kim (2024b) used a more comprehensive 20-item to evaluate attitudes toward chemistry and also included responses from elementary school students. Thus, the variations in the average scores for specific items between the two studies could be attributed to this difference in methodology.

As indicated by Kim (2024b), students found chemistry difficult, complex, and confusing. To investigate this, students were asked to identify the reasons behind their negative perceptions of chemistry. The results are shown in Table 8.

Table 8. Reasons behind the negative perceptions toward chemistry

Reasons for negative perceptions		Frequency (%)
Middle school	Chemical symbols (Chemical formulas, element symbols, and other symbols)	11(22.4)
	Chemical equation (including coefficients)	13(26.5)
	Periodic table	5(10.2)
	(Various) Chemical laws	14(28.6)
	Chemistry experiments	3(6.1)
	Others	3(6.1)
	Total	49(100.0)
High school	Chemical symbols (Chemical formulas, molecular formulas, element symbols, and other symbols)	2(10.5)
	Chemical equation (including coefficients)	1(5.3)
	Periodic table	2(10.5)
	Mole	3(15.8)
	Quantitative relationships in the chemical reactions	9(47.4)
	Quantum numbers and orbitals	2(10.5)
	Others	0(0.0)
	Total	19(100.0)

Middle school students' negative feelings toward chemistry were largely attributed to various chemical laws and chemical equations, whereas high school students frequently cited the quantitative relationships in chemical reactions.

Discussions

Krapp (2002) argues that interest is not merely triggered by external stimuli; rather, it is continuously shaped and reconstructed throughout an individual's growth and learning processes in the context of human development. He emphasizes that teachers and educational environments can act as initial facilitators of interest development and should support its establishment as a personal characteristic. In this study, students' interest in science increased when they engaged in enjoyable science experiments during class or when they could explain familiar phenomena through scientific concepts. Since science is a complex subject, fostering intrinsic motivation is crucial. Experiences wherein students explore the causes of familiar phenomena can spark their interest in science. Furthermore, enjoyable and engaging science classes at school and hands-on science experiences outside the classroom can effectively stimulate students' intrinsic motivation, as confirmed by this study. Science, as a whole, is relatively more challenging than other disciplines, as evidenced by how students perceive chemistry as a complex subject. Science deals with abstract concepts such as atoms, electrons, and entropy, which are not directly observable. Although explaining natural phenomena is a crucial aspect of science, students often find it difficult to appreciate its relevance in their everyday lives. Students face challenges in understanding scientific content, partly because it is rarely integrated into their daily lives in a meaningful way. This lack of connection can cause students to perceive science as unrelated to themselves (Aikenhead, 2006). These challenges can be addressed by providing students with opportunities to engage in experiential learning activities related to chemistry. Halim et al. (2016) emphasize that experiential learning not only enhances interest but also encourages meaningful engagement with scientific concepts, fostering intrinsic motivation—an essential element for tackling challenging subjects like chemistry.

It is not easy for students to gain confidence in science. They may feel confident when they achieve relatively high grades, but the opposite is also true, with low performance in science subjects often diminishing students' self-confidence (Kim et al., 2022). In this study, students who reported an increase in confidence after performing well in science highlighted the impact of their academic success. Some students stated that their confidence in science increased after developing an interest in it, whereas others cited participation in science competitions as a key factor in boosting their confidence. Self-efficacy is a powerful determinant of motivation and engagement, as seen in career choices. Successful experiences in science can instill in students a belief that they can succeed in the field (Bandura et al., 2001), as well as strengthen their self-efficacy, leading to aspirations for science-related careers. Similarly, Tytler & Osborne (2012) emphasized the importance of educational programs designed to improve students' attitudes toward science, which can motivate them to consider science-related careers. Immersive experiences, such as laboratory activities, and positive interactions with teachers have also been shown to be foster these positive outcomes.

Engaging and interesting experiences in science classes play a crucial role in enhancing students' affective achievements in science across elementary, middle, and high school levels. Additionally, participating in science-related competitions or explaining scientific concepts to peers can significantly boost students' confidence in science. It is necessary to develop programs that provide students with experiences of success and help them perceive science as useful and socially significant (Tytler & Osborne, 2012). These highlight the importance of science-related experiences, such as participation in science competitions in school or externally, as well as science camps. These experiences serve as dynamic and interactive settings wherein students can explore science and foster a deeper connection to the subject. Furthermore, sharing science learning experiences with peers and taking on the role of a teacher can introduce innovative teaching and learning opportunities. These approaches positively impact students' affective achievements in science, thereby promoting confidence, enthusiasm, and a lasting interest in the subject.

The graphs for students who participated in this study suggest that those who attended the chemistry experiential camp are likely to achieve higher outcomes in the affective domain of science compared to their peers. The graphs in our study revealed that students' interest and confidence in science had an upward trend during their school years, with significant spikes after specific experiences. These findings support the importance of experiential programs such as chemistry camps. Unfortunately, the COVID-19 pandemic, however, disrupted such opportunities, reducing students' access to science fairs and hands-on experiments—factors critical for affective achievement in science (Ahmed & Mudrey, 2019). Many participants in the chemistry camp expressed interest in STEM careers, and their interest and confidence in science were closely tied to their career aspirations. These findings align with the research of Cui et al. (2022), who emphasized the role of experiential opportunities in developing epistemic curiosity and STEM career interests. Similarly, Reinhold et al. (2018) underscore that well-designed school interventions can encourage career aspirations in science, addressing concerns about the declining STEM workforce. Thus, considering the declining number of STEM professionals in Korea, providing experiences that enhance students' affective achievement in science can encourage them consider STEM-related careers. Beier et al. (2019) found that authentic project-based learning significantly improves students'attitudes and career aspirations in STEM. Additionally, Tytler (2014) highlights that programs integrating experiential learning and real-world connections can motivate students to engage deeply with science and envision themselves in related professions. To improve students' affective achievement in science and address STEM workforce concerns, it is essential to develop extracurricular programs such as chemistry camps and science competitions, as well as enhance positive science-related experiences within schools. This could foster a greater interest in STEM careers and contribute to building a robust STEM talent pipeline in Korea.

Conclusions and Implications

In this study, we conducted in-depth analysis of affective achievement in science among students who participated in a chemistry experience camp. This was done by asking participants to graph their interest in science, confidence in science, career interest/career selection over time. Surveys were also conducted to analyze their attitudes toward chemistry and the causes behind their negative perceptions about the subject. Our key findings are discussed below.

First, many students who participated in the chemistry experience camp reported a consistent increase in their interest in science since the third grade, which was closely linked to their increasing confidence in the subject. These students often actively engaged in extracurricular science activities and typically exhibited higher levels of affective achievement in science compared to their peers. This affective achievement in science naturally translates into cognitive achievements and fosters interest in STEM-related career paths. Many students noted that engaging with science experiments in school sparked their initial interest in the subject, which was further developed after exposure to engaging science content outside the classroom. Although challenges such as poor academic performance in science might occasionally diminish their interest, the overall upward trend is noteworthy. Thus, fostering students' interest and confidence in science through positive experiences both inside and outside the classroom is crucial in developing their intrinsic motivation toward science, which contributes to improved academic achievements and supports the development of talent in STEM fields. These findings underscore the importance of providing diverse and engaging science experiences to nurture students' long-term interest and success in the field.

Second, the increasing trends in interest was often accompanied by increasing confidence in science, which was further boosted by participation in science competitions, improved grades, and achievements in science. Since science is perceived as more challenging and complex compared to other subjects, fostering confidence requires providing students with varied and positive experiences that allow them to build interest and achieve success in science. We suggest revitalizing large-scale science events, such as the annual April Science Month activities and nationwide events such as the Science Festival, which were scaled back during the COVID-19 pandemic. Reintroducing these opportunities for experiencing science-related successes and fostering interest is vital for the future of science education and developing the STEM workforce.

Third, students often demonstrated a keen interest in pursuing careers in STEM fields. Students' interest and confidence in science were closely linked to their career aspirations, especially after their career interest shifted to a STEM field. Conversely, students who shifted their interest to non-STEM fields often experienced a decline in their interest and confidence in science. Thus, to foster a positive attitude toward science, it is essential to provide students with positive experiences that highlight the relevance and excitement of science. Career education programs can also help students see the connection between their career aspirations and the field of science. Research indicates that some students are unaware that their desired careers fall under STEM categories (Jeong et al., 2022), which can lead to diminished interest and motivation in science due to a perceived disconnect between their interests and science (Kim et al., 2022). Proper career education is crucial, especially in the context of the Fourth Industrial Revolution, where STEM plays a pivotal role in addressing global challenges such as developing treatments for pandemics or advancing artificial intelligence. Targeted guidance can help students better understand the relevance of STEM in their career paths, ensuring they do not neglect science education due to this perceived disconnect. This approach can enhance students' interest in STEM fields and prepare them to contribute to groundbreaking innovations in the future.

Fourth, students perceived chemistry as a satisfying and challenging, yet complex discipline. The abstract concepts introduced in middle school, such as chemical laws, chemical symbols, and reaction equations, caused many students to view chemistry as intricate and difficult. Meanwhile, high school students attributed their negative perceptions to the quantitative relationships in chemical reactions, often associated with mathematical calculations. To foster a more positive attitude toward chemistry, students should be provided with positive experiences, such as engaging chemistry experiments. When students encounter abstract concepts in chemistry, incorporating hands-on, experience-based activities can enhance their understanding. This can make learning more interactive and help students bridge the gap between theoretical and practical knowledge. For fields such as physical chemistry, where mathematical calculations are integral for understanding concepts, it is important to ensure that the emphasis on calculations does not cause students to lose interest in chemistry. In particular, teachers should minimize overreliance on calculation-heavy tasks, particularly those linked to high-stakes examination questions (e.g., "killer questions") that often distinguish between top-performing students. Excessively complex calculations can negatively impact students' attitudes toward chemistry. Efforts should focus on assessments that evaluate scientific reasoning and chemistry competency, rather than solely emphasizing mathematical skills. By doing so, educators can promote a balanced approach that supports students' critical thinking abilities and their overall engagement with chemistry.

Acknowledgements

This work was supported by the Korea Foundation for the Advancement of Science & Creativity with funding from the Ministry of Education in 2024.

Conflicts of Interest

The authors declare no conflicts of interest.

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