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Changes in Epistemological Beliefs in Chemistry Following Completion of Advanced Chemistry in Science High School Students

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Abstract

We studied the effects of science high school students on the change of epistemological beliefs in chemistry and the academic achievement of chemistry by completing 'advanced chemistry'. For seven months from July 2023 to January 2024, 80 first-year students at G Science High School in Gyeongnam were surveyed and analyzed for epistemological beliefs about chemistry before and after classes in advanced chemistry. Chemistry academic achievement was classified by 'upper' and 'lower' levels based on the end-of-semester grades of 'advanced chemistry' in the second semester of the first year and analyzed with the SPSS 28 program.

After completing advanced chemistry, the epistemological belief in chemistry increased in the proportion of favorable responses. After completing advanced chemistry, the proportion of favorable responses increased in detailed factors such as 'effort', 'math link', 'outcome', 'reality link', and 'concepts', while the 'visualization' factor decreased. Although completing 'advanced chemistry' positively changed students' epistemological beliefs about chemistry, visual expression showed little contribution to understanding chemical concepts. Based on the above results, we will have to focus on the design of instructors' teaching-learning, such as learner-centered inquiry experiments, creative visual expressions, etc., for successful chemistry teaching-learning.

Keywords: *Epistemological belief, Science high school, Advanced chemistry, Academic achievement*

1. INTRODUCTION

Since the 1970s, research on epistemological beliefs in science has begun to find a correlation with academic achievement as well as understanding individual perceptions of the nature of scientific knowledge and the nature of knowing [1]. Epistemological beliefs defined as 'personal representation of knowledge' attract attention in various fields such as students' learning motivation, learning strategies, learning outcomes, academic achievement, etc [2-4].

While researchers argue that epistemological beliefs do not change because they are a general trait [5], some researchers argue that epistemological beliefs are worth exploring in depth in various disciplines because they vary and can change depending on the characteristics of each discipline [6].

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Recently, in the field of science, specific research has been conducted on the epistemological beliefs of subjects according to the characteristics of chemistry, physics, life sciences, etc [7].

In the field of physics, studies on the relationship between high school students' epistemological beliefs and learning outcomes and the relationship between college students' epistemological beliefs and learning outcomes are reported [8, 9]. In chemistry, reported that the epistemological beliefs of students who completed general chemistry courses were closer to those of beginners than before completion [10]. As a result of studying the epistemological belief characteristics of science high school students in chemistry according to the R&E research activity class, it was reported that the chemistry R&E class was more similar to the professional belief than the other class [11].

In previous studies, researchers have shown that chemistry has unique characteristics that distinguish it from other natural science subjects [12-14]. The characteristics of chemistry describe chemical phenomena through interactions with atoms, molecules, ions, etc., and express them with elemental symbols, formulas, chemical reactions, etc [12, 13]. In addition, chemistry was defined as the study of dealing with the creative and developmental properties of substances, their structures, interactions, etc [14]. At the same time, they argued that this characteristic of chemistry is the reason why learners have difficulty with chemistry. In other words, because chemical phenomena or interactions occur at the molecular level, it is difficult to observe them directly with the eyes, and it is difficult to express them at the symbolic level [12, 13], and it is reported that the emergent properties of chemistry make it difficult for learners to understand chemistry [14-16].

It is very important for instructors to design and teach the teaching-learning process after grasping the difficulties that learners experience in understanding the unique characteristics of chemistry in the chemical teaching-learning process. Therefore, it can be said that it is a very meaningful study to examine epistemological beliefs and check whether students have a deep understanding of chemical concepts in the teaching-learning process.

Science High School is a special purpose high school established at the national level to nurture students with exceptional curiosity about the natural world and scientific talent as competent talents in natural sciences, engineering, technology, etc [17-19]. Therefore, unlike general high schools, science high schools operate specialized curriculum focused on science and mathematics. The 'Advanced Chemistry' course is a specialized course similar to the general chemistry course of the university in terms of content and level [20].

As a follow-up study to examine the epistemological beliefs of science high school students in chemistry according to their R&E research class [11], this study investigated the epistemological beliefs of chemistry before and after completing 'advanced chemistry' for first-year science high school students and analyzed the changes in epistemological beliefs. In addition, the purpose is to check the changes in detailed factors of epistemological beliefs according to academic achievement by level after completing 'advanced chemistry' and to check the teaching-learning process of advanced chemistry [20].

Educational researchers used Chemical Expectations Survey (CHEMX) test papers specifically designed for chemistry to confirm the difference between experts' expectations and students' beliefs about chemistry. They presented seven detailed factors such as 'effort', 'concepts', 'math link', 'reality link', 'outcome', 'laboratory', and 'visualization' for their epistemological beliefs in chemistry. It was reported that students' perception changes were measured in various chemistry classes and groups, and as a result, differences in the effectiveness of chemistry learning were identified according to grades [21].

As a result of analyzing several previous studies, there are few cases of studying epistemological beliefs about chemistry among science high school students. Therefore, it is judged that studying the impact of science high school students' epistemological beliefs on chemistry and their chemical academic achievement following the completion of advanced chemistry will greatly contribute to the aspect of gifted education.

Through the research results, it is intended to help instructors design and teach the teaching-learning process so that learners' epistemological beliefs about chemistry can change in the direction expected by experts. Ultimately, we would like to suggest the direction of chemistry education for successful chemistry learning not only for gifted science students who are talented and interested in chemistry, but also for all learners who encounter chemistry.

2. RESEARCH METHODS

2.1. Object of study and advanced chemistry curriculum

This study studied 80 first-year students (male: 67, female: 13) of G Science High School located in Gyeongnam, and studied changes in epistemological beliefs and changes in epistemological beliefs according to academic achievement by level following the completion of Advanced Chemistry for 7 months from July 2023 to January 2024.

G Science High School students take three units of advanced chemistry courses in the second semester of their first year [20]. In the second semester of the first year of 2023 at G Science High School, one teacher taught all classes, and during the second semester, units such as 'chemical equilibrium, ' 'electrochemical, ' and 'reaction rate' of advanced chemistry were taught.

Based on the contents of advanced chemistry textbooks, the instructor reorganized the curriculum into a rapid and in-depth type suitable for science high school students. It was conducted as a lecture-oriented theory class, and pilot experiments or experimental videos were used in the class so that students could participate in teaching-learning with interest. In addition, in advanced chemistry classes, instructors presented exploratory experimental data, and students converted and analyzed data on their own so that they could understand deeper concepts. Students actively interacted with instructors and other students to understand in-depth concepts in the teaching-learning process.

Paper-based evaluation and performance evaluation of advanced chemistry were conducted twice each. The paper-based evaluation was presented by one teacher in consideration of the evaluation area, content, and difficulty according to the curriculum progress operation plan. In order to secure the validity and discrimination of the questions, two chemistry teachers in charge of different grades were jointly reviewed.

The performance evaluation was conducted twice with student-led group activities. The first performance evaluation was a unit related to acid-base equilibrium and chemical cells, and it was evaluated that the exploratory experiment was conducted for 4 hours. The second performance evaluation was a unit related to electrolysis and reaction rate, and was evaluated after performing a subject designated by a teacher for 2 hours. Both the first and second performance evaluation methods were conducted by experimental process and report evaluation. In the 'Advanced Chemistry' class in the second semester of the first year, students conducted an inquiry experiment for a total of 6 hours, which was conducted during the performance evaluation. Table 1 shows the details of the evaluation and operation of advanced chemistry subjects in the second semester of the first year of G science high school.

Table 1. Evaluation method and contents of advanced chemistry courses in the second semester of the first year of G science high school

assortment	Paper-based evaluation		Performance evaluation	
	1st	2nd	1st	2nd
contents	acid-base equilibrium, chemical cells	electrolysis, reaction rate	acid-base equilibrium, chemical cells	electrolysis, reaction rate
reflection rate	25%	25%	25%	25%
method	descriptive		experimental process and report	
timing	in October	in December	in October	in December

2.2. Survey and analysis of epistemological beliefs in chemistry subjects

First-year science high school students were asked about their epistemological beliefs in chemistry before and after completing advanced chemistry. The pre-questionnaire was conducted in July 2023, and the post-questionnaire was conducted in January 2024. The test paper for the epistemological belief in chemistry was used by modifying CHEMX to suit the purpose of this study [21]. CHEMX consists of a total of 47 questions. A detailed explanation of the detailed factors of CHEMX is shown in Table 2.

In a questionnaire of epistemological beliefs in chemistry, students read the questions and answered what they thought on a 5-level Likert scale (strongly agree: 5; agree: 4; neutral: 3; disagree: 2; strongly disagree: 1). The survey took about 15 minutes, and the survey results of 80 students who faithfully participated in the survey were analyzed. The reliability of all survey questions was 0.891 and 0.859 before and after completing advanced chemistry, respectively. The survey analysis of epistemological beliefs in chemistry was classified into favorable (strongly agree: 5 and agree: 4 responses), unfavorable (disagree: 2 and strongly disagree: 1 response), neutral (neutral: 3 responses), etc., and the responses to each were expressed as percentages.

Table 2. Description of the detailed elements of the seven CHEMX clusters and the composition of the questionnaire (Ref. 21.)

Cluster	Description	CHEMX Items
Effort	beliefs about the kinds of activities and work necessary to make sense out of chemistry	2, 6*, 8, **19***, 22, 31*, 34*, 38*, 41
Concepts	beliefs about the content of chemistry knowledge	4*, 28*, **36**, 37*, **43**
Math Link	beliefs about the role of mathematics in learning chemistry	5*, 9*, 11, 21*, 29*
Reality Link	beliefs about the connections between chemistry and the real world	14*, 26, 30*, 35, 42
Outcome	beliefs about the value of learning chemistry	7, 15, **16***, 17*, 25*, 40, **45***, 47
Laboratory	beliefs about the purpose and value of performing chemistry experiments in the laboratory	**1***, 12*, 13, 23*, 32*, **39**, 44*, 46*
Visualization	beliefs about the role of picturing atoms and molecules in learning chemistry	3, 10, **18***, 20, 24, 27, 33

note: CHEMX item numbers shown in bold are the questions excluded to increase reliability in the analysis.; * negatively worded statements

2.3. Advanced chemistry academic achievement level of science high school students

The chemistry academic achievement of science high school students used the end-of-semester grades of the 'Advanced Chemistry' course in the second semester of the first year of 2023. In order to investigate the correlation between epistemological beliefs in chemistry and chemical academic achievement, advanced chemistry academic achievement was classified into 'upper' and 'lower' levels based on end-of-semester scores. Differences in epistemological beliefs about chemistry according to completion of advanced chemistry courses, differences in epistemological beliefs about chemistry by 'upper' and 'lower' levels in chemistry academic achievement were studied.

2.4. Statistical processing

Frequency analysis and descriptive statistics were performed to compare and analyze the favorable and unfavorable rates of epistemological beliefs in chemistry in order to find out the changes in epistemological beliefs according to whether science high school students have completed advanced chemistry. Before and after completion of advanced chemistry, t-test was performed to confirm whether there was statistical significance in differences by detailed factors in epistemological beliefs about chemistry. In addition, the degree of favorable responses of the 'upper' and 'lower' groups of science high school students' academic achievement in detailed factors of epistemological beliefs was compared and analyzed through t-test. IBM SPSS Statistics 28 program was used for all analysis.

2.5. Research questions

Science high school students are students of extraordinary talent and interest in science. For science high school students, this study studied whether or not the epistemological belief in chemistry changed due to the completion of 'advanced chemistry', and also studied the changes in detailed factors of the epistemological belief in chemistry according to academic achievement by level. According to the purpose of this study, research questions were set as follows.

1) What is the change in epistemological beliefs about chemistry with completion of advanced chemistry?

2) What are the changes in the detailed factors of epistemological beliefs about chemistry with the completion of advanced chemistry?

3) What is the relationship between the epistemological beliefs of chemistry according to academic achievement by level?

3. RESEARCH RESULTS

3.1. Changes in epistemological beliefs about chemistry subject of first-year science high school students according to completing advanced chemistry

In order to study whether there is a change in epistemological beliefs about chemistry, students' surveys were analyzed before and after completing 'advanced chemistry', and the results are shown in Figure 1 and Table 3, respectively. According to the Likert scale of five levels, the survey questions were classified into three groups: favorable (strongly agree, agree), unfavorable (disagree, strongly disagree), neutral (neutral), and so on.

Figure 1 shows the change in epistemological beliefs about chemistry before and after completion of 'advanced chemistry', and the percentage of favorable responses of (B) after completion was high. In a previous study of chemistry undergraduate students at the University of the United States, Liberal Arts College students had the highest percentage of favorable responses before taking a chemistry course, while Public Community College students had the lowest. In the case of taking a chemistry course, Liberal Arts College students showed the highest percentage of favorable responses, while Small Public University students showed the lowest. On the other hand, in the comparison between before and after taking the chemistry course, the difference in favorable response rates was found to be reduced.

Looking at the teaching-learning contents of the 'Advanced Chemistry' course in the second semester of the first year of G Science High School, Lewis' concept of acid-base was expanded in the acid-base unit, and in the chemical cell unit, standard cell potential difference and Gibbs free energy were introduced beyond the concept of oxidation and reduction to teaching-learning the principle of chemical cells and electrolysis. In-depth teaching-learning was conducted using a mathematical approach and Science·Technology·Society (STS) teaching model to understand and apply chemical concepts, such as calculating pH through derivation and utilization of the Henderson-Hasselbach equation, derivation and utilization of the reaction rate equation of the 0th to 2nd reactions, etc. In addition, it was found that in the teaching-learning process, instructors also need to understand and apply deeper concepts through inquiry experiments, expand concepts through mathematical approaches, etc. For this reason, it is judged that students' epistemological beliefs about chemistry have changed positively.

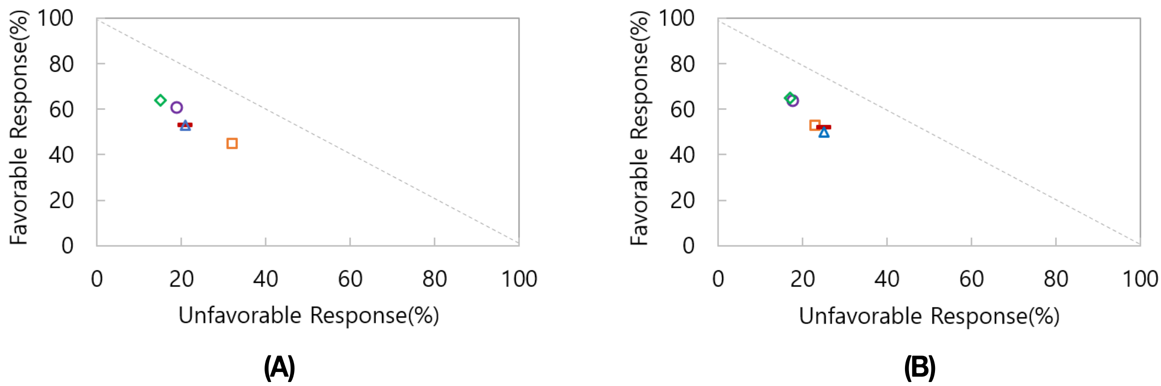

Figure 1. Degree of change in epistemological belief in chemistry before (A) and after (B) completion of advanced chemistry courses (○: G Science High School). Changes in epistemological beliefs about chemistry before (A) and after (B) general chemistry courses (□: Public Community College, △: Small Public University, ▬: Medium Public University, ◇: Liberal Arts College) are cited from Ref. 21.

In Table 3, the average of favorable responses (strongly agree, agree) of epistemological beliefs about chemistry before and after completion of advanced chemistry was 61% and 64%, respectively, and the favorable response rate increased by +3% after completion of advanced chemistry.

A study by chemistry students at the U.S. University found that after completing 'General Chemistry' at Public Community College, the change in the favorable response rate of epistemological beliefs about chemistry increased the most to +8%, while after completing 'General Chemistry' at Small Public University, the change in favorable response rate decreased the most to –3% [21]. In addition, after completing 'General Chemistry' at Liberal Arts College, the change in the favorable response rate to the epistemological beliefs of chemistry subjects increased only by +1%. The epistemological beliefs of G science high school students in chemistry were almost similar to those of chemistry undergraduate students at Liberal Arts College in the United States, and the tendency of changes in favorable response rates to epistemological beliefs was similar to those at Public Community College and Liberal Arts College.

Therefore, it is judged that G science high school students have a more in-depth understanding of the concept and application of chemistry after completing 'advanced chemistry'. In other words, it is because the content composition of advanced chemistry subjects is structured to understand a wide range of concepts from the basic concept of chemical change to the application of concepts. These results are similar to previous studies in undergraduate students in the United States that showed the more students who completed in-depth and professional chemistry courses, the more positively the favorable response rate of epistemological beliefs about chemistry changed [21].

Table 3. Changes in epistemological beliefs about chemistry before and after completion of advanced chemistry courses (Favorable, Unfavorable, Neutral Student Responses, Respectively, in Percent)

School type	Pre			Post			rate of change (%)
	F	U	N	F	U	N	
G Science High School	61	19	20	64	18	19	+3

*Public Community College	45	32	23	53	23	24	+8
*Medium Public University	53	21	26	52	25	23	-1
*Small Public University	53	21	26	50	25	25	-3
*Liberal Arts College	64	15	21	65	17	18	+1

*The data cited from previous research by Ref. 21.

3.2. Changes in detailed factors of epistemological beliefs according to the completion of advanced chemistry

In order to confirm the change in the detailed factors of the epistemological belief in chemistry following the completion of advanced chemistry, the response ratio before and after completion was analyzed for each detailed factor, and the results are shown in Figure 2 and Table 4, respectively. In Figure 2, the favorable response rate was high in the detailed factors of epistemological beliefs in chemistry such as 'laboratory', 'reality link', 'visualization', etc., and the favorable response rate was low in the 'concepts' factor. In other words, after completing advanced chemistry, the favorable response rate increased in detailed factors such as 'effort', 'concepts', 'math link', 'reality link', and 'outcome', and the favorable response rate decreased after completion in factors such as 'laboratory' and 'visualization'.

In the class of advanced chemistry, instructors conducted teaching-learning to understand advanced chemistry concepts using media such as pilot experiments and experimental images. It is judged that students have understood advanced concepts through teaching-learning about chemical changes such as 'acid-base', 'oxidation and reduction', and 'reaction rate'. As a result of understanding chemical concepts in depth mathematically, such as mathematical interpretation, application, etc., it was found that students recognized the need for a mathematical approach to understanding formulas or concepts. In addition, after completing advanced chemistry, students were found to positively recognize the concept of chemistry in its application to STS, the importance of experiments to understand concepts, and so on.

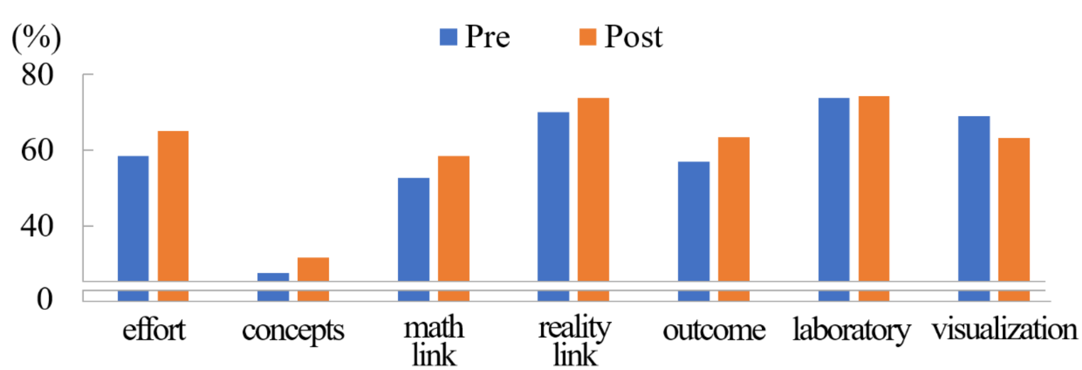

Figure 2. Changes in favorable response rates by detailed factors of epistemological beliefs in chemistry before and after completion of advanced chemistry

Before and after completion of advanced chemistry, 'effort' (+7%) was the most positive for the rate of change in favorable response of the detailed factors of the epistemological belief in chemistry presented in Table 4. Detailed factors such as 'math link' (+6%), 'outcome' (+6%), 'reality link' (+4%), and 'concepts' (+4%) were shown in order. In the second semester of the first year, units of 'advanced chemistry' such as 'chemical equilibrium, ' 'electrochemical, ' and 'reaction rate' deal with deeper concepts related to chemical change. It is judged that science high school students are aware of the imperative of factors such as the need for self-directed teaching-learning, understanding concepts through mathematical approaches, and applicability of chemical concepts to science, technology, and society to understand in-depth concepts.

On the other hand, before and after completion of advanced chemistry, the change in the favorable response rate in the 'laboratory' detailed factor was similar, and the favorable response rate of the 'visualization' factor decreased to –6%. In other words, after completing advanced chemistry, science high school students showed that visualization materials such as illustrations, pictures, etc. did not significantly affect in-depth conceptual understanding in teaching-learning activities, while responding favorably to the need for conceptual understanding through inquiry experiments.

Table 4. Response rate and change rate by detailed factors of epistemological belief in chemistry following completion of advanced chemistry (The favorable, unfavorable, and neutral response rates (%) were expressed as F, U, and N, respectively)

Cluster	G Science High School							*Liberal Arts College						
	Pre			Post			rate of change(%)	Pre			Post			rate of change(%)
	F	U	N	F	U	N		F	U	N	F	U	N	
effort	58	22	20	65	18	17	+7	72	8	20	75	12	13	+3
concepts	28	44	29	32	45	23	+6	45	18	37	57	22	21	+12
math link	53	25	22	59	25	17	+6	60	17	23	65	13	22	+5
reality link	70	10	20	74	10	17	+4	62	18	20	46	27	27	-16
outcome	57	22	21	63	17	20	+6	66	14	20	62	19	19	-4
laboratory	74	10	16	74	13	13	0	84	6	10	81	17	2	-3
visualization	69	12	19	63	11	26	-6	50	27	23	58	25	17	+8
average	61	19	20	64	18	19	+3	65	14	21	66	17	17	+1

*The data cited from previous research by Ref. 22.

3.3. Changes in detailed factors of epistemological beliefs about chemistry by level of academic achievement in chemistry according to completion of advanced chemistry subjects

Changes in detailed factors of epistemological beliefs about chemistry were compared and analyzed by academic achievement levels of 'upper' and 'lower', and the results are shown in Figure 3. In the change of detailed factors of epistemological beliefs by academic achievement level, the favorable response rate of the 'upper' group increased in the order of 'effort' (+9.7%), 'math link' (+9.0%), and 'reality link' (+8.0%). On the other hand, in the 'lower' group, the favorable response rate increased in the order of 'outcome' (+8.3%) and 'effort' (+3.8%).

As a result of this, it was found that students at the 'upper' level are largely aware of the need for the 'effort' factor to understand the deepened chemical concept of chemical change. In addition, a mathematical approach is an essential factor in understanding and expanding the concept of chemistry, and the applicability of the concept to STS is a positive factor in understanding the concept. It was found that students in the 'lower' group recognized that chemistry was necessary at the level of their career, but due to the narrow range of understanding, the understanding of the concept through inquiry experiments was insufficient.

On the other hand, in the detailed factors of 'visualization' after completing advanced chemistry, the favorable response rate of students in the 'upper' (-7.5%) and 'lower' (-4.2%) groups decreased. This is because science high school students, unlike general high school students, have a high level of understanding of the science field, so regardless of their academic achievement level, 'visualization' factors such as illustrations, pictures, etc. did not significantly affect their deeper understanding of concepts.

In particular, in the 'laboratory' factor, the favorable response rate of the 'upper' group increased by +5.4%, but the favorable response rate of the 'lower' group decreased by –4.6%. In the process of teaching-learning centered on inquiry experiment, it is absolutely necessary to activate the division of roles of group members, instructor-learner (learner-learner) interaction, etc. It was found that when factors such as role division, interaction, etc. are strengthened, the academic achievement of students participating in the class increases. [23]. In the performance evaluation of 'Advanced Chemistry' in the second semester of the first year of G Science High School, the class of inquiry experiments for each group was conducted for 6 hours. The instructor guided students to freely design and perform the experiment without detailed explanation in the inquiry experiment. In this type of inquiry experiment, if the division of roles between group members is not properly achieved, the inquiry experiment is conducted centering on students at the 'upper' level with high understanding of the inquiry experiment. In other words, it was found that the favorable response rate of the 'lower' group decreased because students at the 'lower' level got on a free ride.

In particular, it can be seen that for 'lower' level students, the division of roles and interactions among group members in inquiry experiments act as important factors in understanding chemical concepts from the experimental results. In other words, students at the 'lower' level who lack understanding have a low level of understanding in inquiry experiments, become more passive in inquiry experiments, and their satisfaction with the class decreases. As a result, inquiry experiments are led by students at the 'upper' level, and the results of the experiments lead to conceptual understanding, while students at the 'lower' level showed that the inquiry experiments lacked a connection to conceptual understanding. In other words, since the 'lower' group of students' will to self-directed teaching-learning rather weakens through experimental classes, it is judged that this result was caused by a decrease in class participation and learning commitment in teaching-learning.

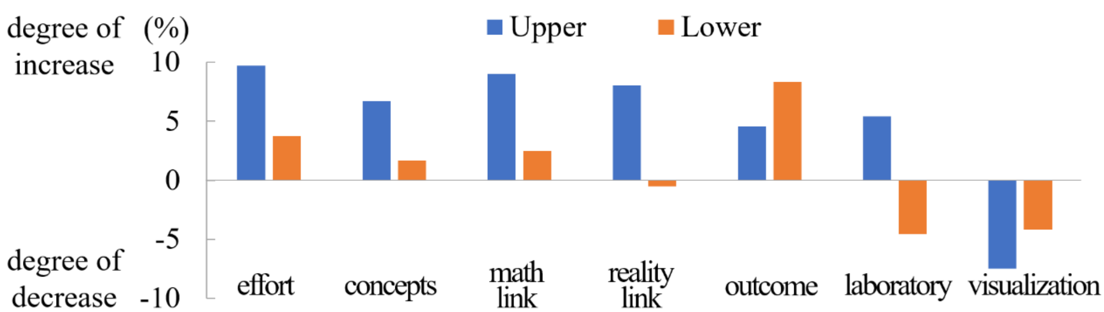

Figure 3. The degree of change (%) in the epistemological beliefs of chemistry according to the degree of chemical academic achievement by level before and after completion of advanced chemistry

4. DISCUSSION

The effect of science high school students' completion of 'advanced chemistry' on their epistemological beliefs in chemistry and academic achievement in chemistry subjects was studied. First, data were collected through surveys before and after completing advanced chemistry. Next, the epistemological belief in chemistry and the change in its own detailed factors were compared and analyzed according to the completion of advanced chemistry. Finally, the changes in detailed factors of epistemological beliefs based on chemical academic achievement by level were compared and analyzed according to the completion of advanced chemistry.

First, in the comparison of G science high school freshmen before and after completing advanced chemistry, the percentage of favorable responses was 61% and 64%, respectively, and the percentage of unfavorable responses was 19% and 18%, respectively. In other words, after completing advanced chemistry, students were found to have a higher percentage of favorable responses of epistemological beliefs about chemistry. This reason indicates that advanced chemistry deals with the in-depth concept and application of chemical change, so students can understand chemistry more in-depth after completing advanced chemistry.

Second, after completing 'advanced chemistry', the favorable response rate increased in the detailed factors of epistemological beliefs about chemistry such as 'effort', 'math link', 'outcome', 'reality link', 'concepts', etc. On the other hand, in comparison before and after completion, the 'laboratory' factor was similar, and the 'visualization' factor decreased. It was found that science high school students recognize the need for self-directed and active teaching-learning activities to understand the advanced chemical concept in advanced chemistry classes. In particular, it was recognized that mathematical interpretation for understanding concepts, application of chemical concepts to STS, etc. were necessary. On the other hand, since the favorable perception was low in 'visualization', it indicates that visual expressions such as illustrations, pictures, etc. for understanding the concept of advanced chemistry do not significantly affect science high school students.

Third, after completing 'advanced chemistry', the favorable response rate increased in the 'upper' group in the order of 'effort', 'math link', 'reality link', etc. Students in the 'upper' group recognized that detailed factors such as 'effort', mathematical understanding, and applicability of chemical concepts to STS were needed to understand advanced chemical concepts. On the other hand, after completing advanced chemistry, the 'outcome' detailed factor in the 'lower' group showed the most favorable response rate. It was found that the 'lower' group recognized the necessity of chemistry in terms of their career path through the teaching-learning process of 'advanced chemistry'.

In particular, in the 'laboratory' detailed factors, the 'upper' group showed an increase in the favorable response rate, but the 'lower' group decreased. The reason for this is that through inquiry experiments, students at the 'upper' level were linked to in-depth conceptual understanding and application, while students at the 'lower' level had a narrow range of understanding, so the inquiry experiment showed insufficient connection to conceptual understanding.

5. CONCLUSION

Most science high school students, with a strong curiosity and exploration of nature, immerse themselves in the field they are interested in and constantly and persistently strive to solve problems they perceive themselves. In this study of science high school students, it was found that the completion of advanced chemistry positively changed the epistemological belief in chemistry, and the teaching-learning of advanced chemistry in science high schools was showing great results in its own way. Based on these results, we found that in the chemistry teaching-learning process, the instructor's accurate understanding of the characteristics of chemistry subjects and individual learners is an essential factor in positive changes in students' epistemological beliefs about chemistry. In particular, a detailed teaching-learning plan is needed to provide education for consumer-centered inquiry experiments, and it was found that teaching-learning treatment centered on learning materials such as creative visual materials, illustrations, videos, etc. is important.

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