

IJACT 21-12-27

## Influences for the understanding of General Chemistry according to the completion of chemical subjects in high school

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### Abstract

The purpose of this study is to investigate the influences on the understanding and academic achievement in general chemistry according to chemical grades in high school and College Scholastic Ability Test. We investigated the difference between the completed subjects in high school and the elective subjects in the Test, degree of understanding of the general chemistry according to the subjects completed in high school, and the effects on the academic achievement of general chemistry by dint of the chemical grades in high school and the Test, etc. By the results of the student's perception survey, most of the students choose Chemistry I at the Test. It was found that the understanding of general chemistry was greatly affected by the chemical elective subjects of high school. Chemical grades in high school and the Test were found to have a significant influence on academic achievement of general chemistry.

**Keywords:** Elective Subject in Chemistry, Degree of Understanding, Completed Subject, College Scholastic Ability Test, Chemical Grades in High School

## 1. INTRODUCTION

### 1.1 The background of the study

The 2015 revised science curriculum emphasizes not only the basic literacy that ordinary citizens should have but also scientific literacy. It focuses on acquiring core concepts of science and cultivating scientific attitudes after having a wide range of experiences with interest in natural phenomena and real life issues[1]. In this curriculum, learners actively participate in their own learning, acquire the knowledge they want. It is designed to understand scientific concepts through student participation and student-centered inquiry experiments. In particular, it emphasizes the systematic understanding of chemistry and emphasizes the understanding of the content and concepts in connection with real life from a convergent perspective, even if difficult.

Among science subjects, Chemistry is a discipline with a clear hierarchy, so step-by-step learning is required[2]. In the subject of Science of high school, the content of chemistry is structured to learn two concepts (chemical bond, chemical reaction) that have a depth of concept and a relatively large amount of learning. Chemistry I focuses on material structures and electronic structures and adds chemical changes. Chemistry II is mainly composed of the properties of substances while emphasizing the chemical changes. Because the composition of the contents of chemistry I and chemistry II is different, students who do not complete all

Manuscript received: November 29, 2021 / revised: December 2, 2021 / accepted: December 7, 2021

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chemistry courses will have learning deficits in chemistry and then, various difficulties may be encountered in understandings of the content of the general chemistry[3]. Therefore, there is a desperate need for research on 'the influence of completion of chemical subjects in high school on the understanding of general chemistry content'. For the efficient learning of students, several studies have recently been conducted on the relationship between the completion of high school chemistry and the understanding of general chemistry content[4,5]. In these studies, it was found that students actually felt a large difference in level from high school chemical content while taking general chemistry classes. Therefore, there were relatively more difficulties when taking general chemistry class, and interest in chemistry decreased considerably. In previous results, it was reported that if the contents of science learned in middle and high schools are not properly connected to the contents of general chemistry, intellectual curiosity and learning time is wasted greatly[6]. Therefore, the relationship between high school chemistry and university general chemistry should be fully considered for efficient learning of students. Further research on them is needed.

In terms of the content, the connection between high school chemistry and university general chemistry is emphasized. The content composition of the sub-unit of the high school chemistry textbook was organized to match the educational goals. Looking at the teaching-learning process of the sub-unit, it first induces interest or motivation for the concept and content to be learned. After recognizing the problem between variables, it is configured to conduct an inquiry to solve a problem, derive the results of the inquiry, and then organize the concepts[7].

These series of processes are based on constructivism to understand the contents and concepts of student-led teaching-learning. In addition, all science and chemistry textbooks are organized so that teaching-learning is conducted centering on inquiry and activities. Based on the compilation of textbooks, inquiry activities are progressing at a considerable level in the school classroom field. Be founded on basic concepts and principles in these inquiry processes, students are able to not only strengthen our ability to solve problems such as natural phenomena and real-life problems, but also expand to the deepened contents and concepts presented in general chemistry. Despite these efforts, after science and chemical subjects were designated as elective subjects in the high school curriculum, it is announced that the degree of difficulty in understanding of chemical concepts and contents among college freshmen is increasing[8].

## **1.2 The purpose of the study**

In the high school science curriculum, students are required to select and complete chemical subjects themselves. By the results of previous studies, the influences on academic achievement and interest of general chemistry was large depending on whether you complete the science elective course[4,5,9]. In particular, the result was larger in the non-completed group of chemistry I and chemistry II subjects. It was found that 70% of students who did not take chemistry II had a relatively low level of understanding of chemistry terms and concepts when they learned general chemistry[10]. The other previous result was published that not only academic achievement was relatively low, but also interest in chemistry was low[4].

According to the results of the vertical and horizontal connection studies[11,12,13], it was found that the content linkage between high school chemistry and general chemistry was well constructed in the science curriculum. However, by allowing students to select only a few of the chemical subjects and complete them, there is a learning deficit in the non-completed subjects. As a result, it was found that there was a large difference in the level of understanding of general chemistry content according to completion and non-completion subjects. In particular, according to the non-completion of the chemistry II subject, it is reported that the newly learned units (electrochemistry, spontaneity of reaction, electronic structure and periodic table) in general chemistry are very difficult for students.

As such, problems in the operation of science curriculum are exposed in the high school field, and learning deficits due to non-completion of high school chemical subjects may result in a lack of understanding of general chemistry content. For the expandability of education, the connection between high schools and universities is strengthened by conducting autonomous activities, club activities, volunteer activities, career activities, etc. To improve basic learning skills in college, various programs (university-level program, basic academic ability promotion program, etc.) are in progress.

These efforts in the field have led to the improvement of students' basic education in chemical content. By the result, it was judged that the understanding of general chemistry content of university was high. For 30 chemical education students, the effect of completing the elective high school course on the understanding of general chemical content was studied.

## 2. RESEARCH METHODS

### 2.1 Object of study

According to the completion of science, chemistry I, and chemistry II subjects, the influences for the understanding and academic achievement of general chemistry were studied. The objects of the study were 36 enrolled students who entered the Department of Chemistry Education in Gyeongnam. These students completed Science, Chemistry I, and Chemistry II courses in high school through the 2015 revised curriculum.

The students who participated in the survey were chemistry education students who took general chemistry from 2017 to 2020, and a perception survey was conducted on them. The contents of the study were analyzed with 30 people who faithfully responded to the survey. During this period, the lectures of general chemistry were conducted by the same professor.

**Table 1. Grades of chemistry I of high school and college entrance exam (% , person)**

| Chemistry I                     | Grade       | 1           | 2           | 3           | 4           | 5           | Total         |
|---------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|---------------|
|                                 | High school |             | 10.0<br>(3) | 16.7<br>(5) | 13.3<br>(4) | 10.0<br>(3) | -<br>(0)      |
| College Scholastic Ability Test |             | 6.7<br>(2)  | 3.3<br>(1)  | 13.3<br>(4) | 13.3<br>(4) | 13.3<br>(4) | 50.0<br>(15)  |
| Total                           |             | 16.7<br>(5) | 20.0<br>(6) | 26.7<br>(8) | 23.3<br>(7) | 13.3<br>(4) | 100.0<br>(30) |

Table 1 shows the educational level of chemical education students who are the objects of the study. Students with grades 1-3 and 3-5 were relatively high in high school and college entrance exams, respectively. Because students who go to the department of chemistry education are students who go to school with dreams and hopes for teachers, the average of chemistry I grades in the Test is 1 to 4, which is relatively high. The grades of chemistry I in high school were 10% for the first grade, 16.1% for the second grade, 13.3% for the third grade, 10.0% for the fourth grade, etc. In the College Scholastic Ability Test, the grades of chemistry I were 16.7% for grade 1, 3.3% for grade 2, 13.3% for each grade 3 to 5. Since the grades of science and chemistry II subjects cannot be confirmed on the college entrance exam, they are not presented separately in the table.

Students' academic achievements were based on the grade of high school (occasional admission), the grade of college entrance exam (regular admission), and the grade of general chemistry. Both grades of chemistry in high school and college entrance exam are classified into 9 grades. Grade 1 has a cumulative top score of less than 4%, grade 2 has a cumulative top score of between 5 and 11%, grade 3 has a cumulative top score of between 12 and 23%, grade 4 has a cumulative top score of between 24 and 40%, grade 5 has a cumulative top score of between 41 and 60%, and grade 6 has a cumulative top score between 61 and 77%, etc. These classifications form a standard normal distribution curve.

In the case of chemical grade in high school, it is the average grade up to the first semester of the third grade. It is the average grade completed in two semesters for Science and Chemistry I, and Chemistry II is the grade completed in one semester. The College Scholastic Ability Test requires you to select two out of eight subjects in the field of scientific inquiry (Physics I, Physics II, Chemistry I, Chemistry II, Life Science I, Life Science I, Earth Science I, and Earth Science II). Among the students in the study, the grade of chemistry I was used for the college entrance exam. For the academic achievement of general chemistry, the average values of the first and second semesters were used. A grade is 4.5~4.0, B grade is 3.99~3.0, and C grade is 2.99~2.0, and D grade is 1.99~1.0.

## **2.2 Questionnaire survey**

A questionnaire was conducted to study the influence for the understanding of general chemistry contents according to whether students complete a chemical subject in high school. Based on the previous test tools, the questionnaire used was modified to suit the characteristics of chemistry education students [4,5]. The first preliminary survey was conducted on 15 fourth-grade students in the Department of Chemistry Education at A University. Referring to the results of the preliminary survey, students' understanding of the questionnaire, opinions of professors and experts in the Department of Chemistry Education, etc., were finally revised and supplemented.

The questionnaire consisted of eight questions, such as the degree of understanding of general chemistry content according to the completion of chemical subjects in high school, changes in interest after taking general chemistry, whether student experienced difficulties in taking general chemistry classes, etc. The two questions about 'the degree of understanding of general chemistry content' and 'the difference in content between high school chemistry and general chemistry' are a 5-point Likert scale. These questions were organized by selecting scores from 1 (not at all) to 5 (very much so) points corresponding to one's own thoughts. The remaining questions consisted of a descriptive questionnaire asking about students' responses.

Among the 36 students surveyed, 6 questionnaires judged to have responded insincerely or insincerely were excluded, and 30 questionnaires were finally used. The time required for the post-examination was about 50 minutes.

## **2.3 Research questions**

The following research questions were set up for chemical education students to find out the influence for their understanding and academic achievement of general chemistry according to their grades in chemical subjects in high school and college entrance exams.

First, Are the chemistry subjects completed in high school and the elective subjects in the College Scholastic Ability Test consistent with each other?

Second, what is the degree of understanding of general chemistry according to the course of high school completion?

Third, What is the distribution of chemical grades in general chemistry according to chemical grades in high school and chemical I grades in the College Scholastic Ability Test?

### 3. RESEARCH RESULTS

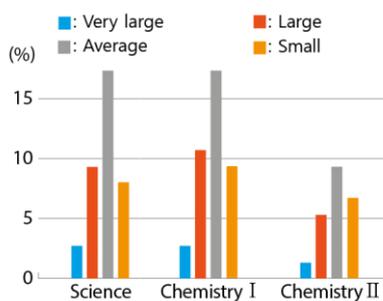
For 30 students enrolled in the Department of Chemistry Education, we investigated whether they matched the subjects selected in the high school (Science, Chemistry I, Chemistry II) and the College Scholastic Ability Test. As a result of the survey, there was a difference between the subjects that completed high school and the elective subjects in the College Scholastic Ability Test. This is because only two subjects can be selected in the field of scientific inquiry of the Test.

All students of the study selected Chemistry I, and 93.3% of Science and 56.7% of Chemistry II. Since all the students took 'Chemistry I' in high school, it was found that the students who understood the basic concept of chemistry went to the Department of Chemistry Education. On the other hand, 56.7% of students chose Chemistry II, but there was a difference between the actual class status and the degree of class. The proportion of students who completed chemistry II was low at 13.3%, and the proportion of students who partially learned was quite high at 43.3%.

However, only 50.0% of students chose Chemistry I in the field of scientific inquiry for the College Scholastic Ability Test. At the time of deciding on the elective subject, it was selected by factors such as interest in the subject, basic subjects in the field to go to, and disadvantage in the college entrance examination. But it is judged that the most confident subject in the college entrance examination was selected due to the burden of learning amount, grades, and disadvantages in the examination. Our results are similar to those found in previous studies[11].

The results of a survey of the difference in content between high school chemistry and general chemistry are shown in Figure 1. Students who answered 'Average' were the highest at 44.0%, followed by 25.3 percent who answered 'Large', and 6.7 percent who answered 'Very large'. Students who completed Science and Chemistry I had a relatively higher percentage of 'Small' than those who completed Chemistry II. On the other hand, 24.0% of students answered 'Very small'. Therefore, it was investigated that there was no significant difference between high school chemical content and university general chemistry content. This is because it is similar to what appears in Chemistry II of high school, except that some new units are organized at the end of the book in the composition of the contents of general chemistry.

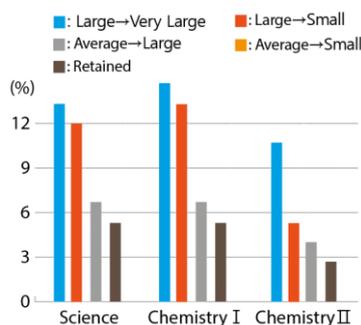
In studies on the link between high school chemistry and university general chemistry [14,15], it was found that there is a lack of linkage between the chemical content of high school and university general chemistry. It was found that students felt a great gap between high school chemistry classes focused on problem-solving and general chemistry that focused on concept-oriented learning.



**Figure 1. The difference between high school chemistry and general chemistry (% , Duplicate allowed)**

According to the completion of chemical subjects of high school, the change in interest in general chemistry content was investigated and the results are shown in Figure 2. After learning General Chemistry, 56.0% of students showed an increase in their interest in chemistry, such as (38.7%) from 'Large' to 'Very Large', 'Average' to 'Large' (17.3%), etc. The relative ratio (64.7%) of students who completed Chemistry II was higher than Science (53.6%) and Chemistry I (53.3%), indicating that interest in chemistry increased. Meanwhile, the ratio of 'no change' and 'decrease in interest' was relatively low.

This is because the contents and concepts of high school Science and Chemistry I only learn the simplest and most essential contents, so the applicability of the concept and examples in real life are limitedly presented. On the other hand, Chemistry II is a more advanced content, and conceptual applicability is expanded or examples of real life are presented in relatively various ways. Therefore, it is judged that interest has increased due to overlapping with general chemistry content or similar scalability of the concept. As a result of Han et al. [16], the learning aptitude for general chemistry was found to be related to the type and degree of learning of chemical subjects completed in high school, the type of chemical subjects selected in the college entrance exam, etc.



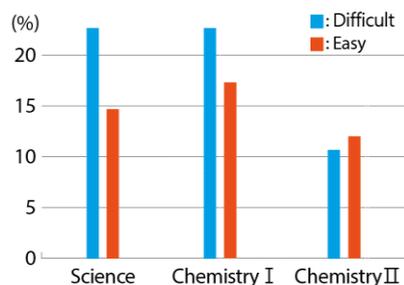
**Figure 2. The influence of completion of high school chemistry on the change in interest in general chemistry contents (% , Duplicate allowed)**

The understanding of the contents of general chemistry according to the completion of the chemical subject was investigated, and the results are presented in Figure 3. 22.7% of students who completed Science and Chemistry I, respectively, and 10.7% of students who completed Chemistry II were 'difficult' in general chemistry understanding. This reason is judged to have experienced difficulties because many students learned only part of Chemistry II. On the other hand, the content of Chemistry II is highly related to that of General Chemistry, so it was found that students who learned the entire Chemistry II were easy to understand General Chemistry. Therefore, it was found that the degree of understanding of general chemistry was greatly influenced by the chemical subject of high school.

On the other hand, although the difference of chemical content between high school chemistry and general chemistry is not significant, and the interest in general chemistry content has generally increased depending on the science elective course, some students responded that they have difficulty in understanding general chemistry content.

According to previous studies[17], there was a significant difference in understanding the electrochemistry concept depending on whether or not Chemistry II was completed, and even if General Chemistry was taken, it was difficult to accurately understand the related concept. In the group of students who did not complete Chemistry II, it was said that the improvement in conceptual understanding was significant after taking general chemistry classes. By the previous some results [14, 18], it was found that the group who completed both high school chemistry I and II subjects had a positive influence on general chemistry learning, while the group who

did not complete chemistry II had great difficulty learning General Chemistry.

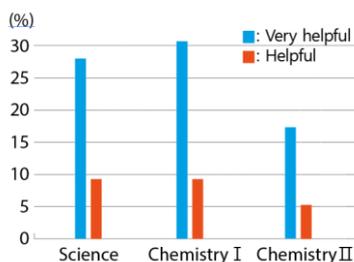


**Figure 3. The degree of understanding of general chemistry content according to chemical subjects (difficulty, %)**

The degree of help in understanding the general chemistry content according to the completion of the chemical subject was investigated, and the results are shown in Figure 4. All students responded that the chemistry they learned in high school was helpful in understanding general chemistry content.

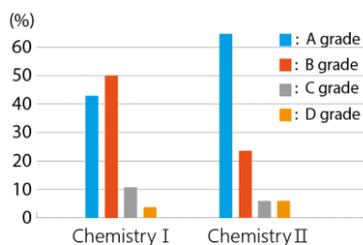
76.0% of students said it was 'very helpful', followed by 30.7% of students who answered that Chemistry I helped, 28.0% of Science, and 17.3% of Chemistry II. As a result of this survey, the degree of help of the group who completed Chemical II was the lowest in understanding the contents of general chemistry. The reason for this is that the number of students who completed the entire content of chemistry II is small, so it is judged that the statistical value was low. Meanwhile, no students gave negative answers.

On the other hand, according to a study by Hong et al. [19], students who did not learn chemistry II had difficulties in the basic course of their first-year major, but recognized that they could overcome the impact with their own efforts. It was reported that students who completed both chemistry I and chemistry II showed significantly higher achievement in the basic major process than those who completed chemistry I only.



**Figure 4. Understanding of general chemistry according to the completion of the chemical subjects (degree of help, %)**

Figure 5 shows the results of investigating the influence of chemical grade in general chemistry due to the completion of chemistry I and chemistry II. Students who completed chemistry I had the highest B grade at 50.0%, followed by A grade at 42.9%, C grade at 10.7%, and so on. More than 92.9% of students who completed chemistry I received A and B grades in general chemistry grades. In the case of completed chemistry II, the proportion of students who received grade A in general chemistry grades was the highest at 64.7%, and grade B was the second highest at 23.5%. Therefore, it can be seen that the completion of chemistry I and chemistry II has a great influence on the grade of general chemistry.

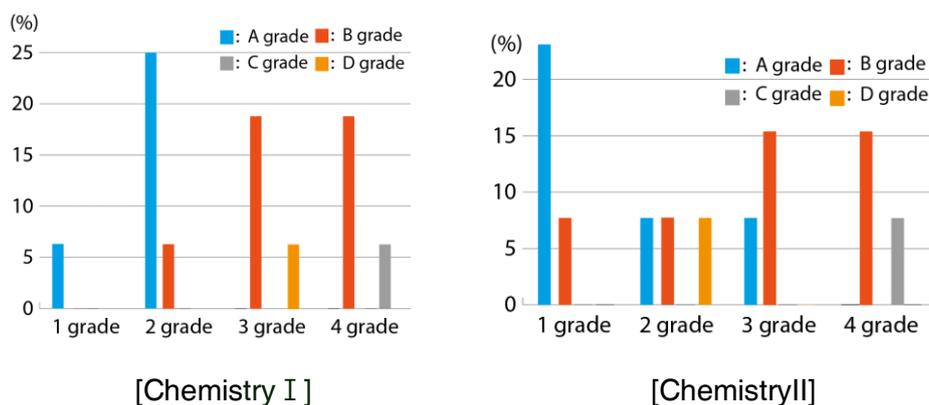


**Figure 5. Grades in general chemistry according to the completion of Chemistry I and Chemistry II (%)**

In the recruitment of college entrance exams (regular and occasional), 66.7% of students completed all three subjects (Science, Chemistry I, Chemistry II), 26.7% of Science and Chemistry I, and 6.7% of Chemistry I and Chemistry II, respectively.

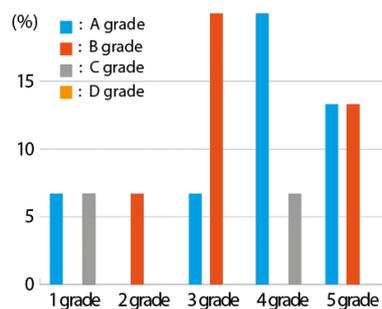
In the case of occasional recruitment, it is determined by the grades of chemistry I and chemistry II. The influence of chemistry I and chemistry II grades on general chemistry grades was investigated, and the results are presented in Figure 6. Students with high chemistry I and chemistry II grades (1, 2-grade) also showed high grades (A and B grades) of general chemistry. In General Chemistry, grade A was the highest in grade 2 and grade 1 of chemistry I and chemistry II, respectively, and grade B was the highest in grades 3 and 4 of chemistry I and chemistry II, respectively. Therefore, it was found that the grade of general chemistry was greatly influenced by the grade of chemistry I and chemistry II. In addition, it was found that the performance of chemistry II was more affected than chemistry I.

According to Choi et al. [20], it was suggested that the selection rates of chemistry II were different depending on the characteristics of the study, and that the tendency to complete chemistry II could be an important evaluation factor in college entrance exams.



**Figure 6. Influences of high school chemistry I and chemistry II grades on grades of general chemistry (%)**

In the case of regular admission, it is determined by the grade of chemistry I of the College Scholastic Ability Test. The influence of the general chemistry grade according to the chemistry I grade of the Test was investigated, and the results are presented in Figure 7. In general chemistry grades, students who received A grade were the highest at 20.0% in 4th grade of chemistry I, the second highest in 5th grade, etc. And B grades were the highest at 20.0% in the 3rd grade of Chemical I, followed by 5th grade, 2nd grade, etc. As shown in Table 1, the reason why the general chemistry grades were high with A and B grades is that students in the Department of Chemistry Education have a high ratio of 3 to 4 grades.



**Figure 7. Distribution of general chemistry grades according to the chemistry I grade of the College Scholastic Ability Test (%)**

#### 4. CONCLUSIONS

For students who completed science, chemistry I, and chemistry II subjects in high school, the influences on understanding and academic achievement in general chemistry lectures were studied. The research problem is the influence on the understanding and academic achievement of general chemistry according to the chemical grades of the high school and the college entrance exam. A survey was conducted on 30 students enrolled in the department of chemistry education. In high school, the grade distribution of chemistry I was 1 to 4, and in the College Scholastic Ability Test, chemistry I was 1 to 5 grades.

As a result of the students' perception survey, there was a difference between the chemical subjects completed in high school and the chemical subjects selected in the College Scholastic Ability Test. Since all the students in the study completed chemistry I, it is judged that they understood the basic concept of chemistry, but only 50.0% of students in the College Scholastic Ability Test chose chemistry I due to the burden of learning, grades, and disadvantages in the Test. Meanwhile, only 56.7% of all students completed chemistry II, and the proportion of students who partially learned this subject was quite high at 43.3%.

As a result of examining the difference in content between high school chemistry and general chemistry, 44.0% of students answered 'Average', 25.3% of 'Large', and the difference in the content was not significant. According to previous linkage studies [14, 15], there was a lack of content linkage between high school chemistry and university general chemistry.

As a result of investigating changes in understanding and interest in general chemistry according to the subject completed in high school, it was found that students who completed chemistry II had relatively high content understanding, and 56.0% of students showed increased interest. Since Chemistry II is an advanced content and conceptual applicability is widely described, it is judged that the content understanding and interest have increased due to overlapping with general chemistry content or increasing the scalability of the concept. In previous studies [14,17-19], groups who completed chemistry I and chemistry II subjects were positive for general chemistry learning, while those who did not complete chemistry II had great difficulty in understanding of general chemistry. Therefore, it was found that the degree of understanding of general chemistry was affected according to the chemical subjects of high school.

As a result of examining the impact of completion of high school chemistry on the chemical grade of general chemistry, 92.9% or more students who completed chemistry I received A and B grades in their grades, and 64.7% or more students who completed chemistry II received A grades. Therefore, it can be seen that the completion of chemistry I and chemistry II has a great influence on the academic achievement of general chemistry.

As a result of examining the influence for the grade of general chemistry according to the chemical grade

of high school, students with high chemical grade in high school also showed higher grade in general chemistry, and the grade of chemistry II was more affected than chemistry I. By the results of investigating the influences for the grade of general chemistry according to the grade of chemistry I of the College Scholastic Ability Test, A and B grades in general chemistry were high in chemistry I grades 3-5 on the Test. This is believed to be because the proportion of students with chemistry I grades 3-5 is high.

The results of this study are expected to contribute greatly not only to the reorganization of the high school curriculum but also to the drafting of the university admission policy in the future.

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