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The Effect of Factors such as Changes in the Degree of Difficulty of Concepts Presented in the Chemistry I Textbook, Changes in Class Types, etc. on Academic Achievement by Level

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Abstract

We analyzed and compared factors such as changes in the degree of difficulty of concepts presented in Chemistry I textbook, changes in class types (non-face-to-face, face-to-face), etc. on academic achievement by level (upper, middle, and lower). Students from A high school in Gyeongsangnam-do were selected for the subjects of the study. As a result of analyzing the change in the degree of difficulty of concepts, the total score of chemistry I combined by non-face-to-face and face-to-face classes during the second semester was lower than that of the first semester. As a result of analyzing the impact of factors such as changes in conceptual difficulty, changes in class types, etc. on academic achievement by level, students' grades at the 'lower level' by non-face-to-face classes were lower than those by face-to-face classes. In particular, at the lower level of the second semester, there was a large difference in grades between non-face-to-face and face-to-face classes. In the results of these studies, it was found that instructors' active feedback is important to identify difficulties in understanding learning contents for students with low levels of academic achievement and improve them at the same time.

Keywords: *Degree of Difficulty of Concept, Class Type, Academic Achievement by Level, the Lowest Score, Highest Score.*

1. Introduction

The goal of the 2015 revised science curriculum is to develop an attitude to understand the core concepts of science by having interest in natural phenomena and objects and scientifically solving daily problems based

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on exploration [1]. In the teaching-learning process, student-participating classes and activity-oriented inquiry classes are emphasized so that students can become the subject of learning. In other words, it emphasizes the efficiency of academic achievement with the will to self-directed learning by student-participating classes [2, 3].For teaching-learning activities, chemistry textbook is organized according to the learner's level so that students can self-directed learning. In other words, learning contents are organized in consideration of the level of understanding of chemistry, interest and curiosity, usefulness, etc. In particular, the contents of chemistry textbook are organized in consideration of factors such as the organization of chemical concepts based on the level of learners' intellectual development, the degree of understanding of learners according to the step-by-step presentation of the concept of chemistry textbook, and the learner's misconceptions. However, previous studies have shown that it is very difficult for learners to learn the contents of chemistry textbook on their own [4, 5]. Therefore, more research on this is needed.

The contents of Chemistry I textbook, which are elective subjects in high school, consist of the mole of units dealing with quantitative relationships of substances, atoms and molecules that are basic particles that make up substances, and chemical reactions according to changes in substances [1]. As such, the contents of the Chemistry I textbook allow students to cultivate the core competencies of chemistry through scientific exploration and integrated understanding of the ′structure of matter′ and ′change of matter′. In addition, in chemical reactions, the concept of material change between reactants and products and the concept of dynamic equilibrium are simultaneously learned. Students found it difficult to understand this concept of dynamic equilibrium [4, 5]. In particular, students with low levels of academic achievement find it difficult to understand the 'chemical reaction' unit in which various concepts such as 'dynamic equilibrium', 'energy access', etc. are embedded at the same time, even if the textbook's learning content is gradually presented.

Previous studies have shown that students with low achievement levels have low learning motivation and are difficult to understand complex concepts due to passive learning activities [5, 6]. Students with lower academic achievement are found to be difficult to understand the learning content in non-face-to-face classes centered on instructors, and do not actively ask and respond (passive willingness to learn) even if they do not understand the content [7, 8]. Therefore, students with low learning motivation not only have low will to self-directed teaching-learning, but also have low behavioral control or learning immersion in the teaching-learning process [9, 10].

On the other hand, students with high levels of achievement have a high will to self-directed teaching-learning. In addition, it was found that not only effectively controlling the teaching-learning process, but also making continuous efforts to understand difficult content [11-13]. As such, the willingness to self-directed learning varies depending on the level of achievement, so learners' academic achievement is different for each level. Therefore, in non-face-to-face and face-to-face classes that rely heavily on self-directed teaching-learning will, it is urgent to study changes in students' grades in chemistry I subject and their effects on chemistry I grades by level. As such, self-directed learning will varies depending on the level of achievement, and as a result, learners' academic achievement is different. Therefore, in non-face-to-face and face-to-face classes that rely heavily on the will to self-directed teaching-learning, it is urgent to study changes in students' grades in chemistry I subject and their effects on chemistry I grades by level (upper, middle, and lower).

On the other hand, as a result of analyzing academic achievement according to class types, students' academic achievement through face-to-face classes was higher than that of non-face-to-face classes [14]. Although students prefer non-face-to-face classes, low willingness to self-directed learning in non-face-to-face classes makes it difficult to control the class environment, and factors such as low interest, low level of understanding, etc. also make class immersion difficult [15, 16]. It was found that this low willingness to self-directed learning and low class commitment had a negative effect on academic achievement [5, 17]. In non-face-to-face classes, it is difficult for instructors to grasp learners' understanding of learning content in real time, and if there is no learner-teacher interaction such as question and answer, the instructor judges that the learners have understood all of the learning content and the class continues. In particular, it is known that academic achievement was high when learner-teacher interactions such as help requests, feedback, etc. were strengthened [18].

In addition, as a result of previous studies between the will to self-directed learning and academic achievement [19, 20], the higher the control of the classroom environment and the higher the participation in the class, the higher the willingness to engage in class and continue learning [21]. The higher the learner's willingness to engage in class and continue learning, the higher the academic achievement [22]. Therefore, since the level of academic achievement of students varies depending on the willingness of self-directed teaching-learning, it is important to study the relationship between the level of academic achievement and academic achievement.

2. Research Methods

2.1 Object of Study

The contents of the Chemistry I textbook of the 2015 revised curriculum are organized into 'material composition' and 'chemical reaction'. The unit of this textbook becomes deeper and deeper in the concept of content as it goes back. Since the concept of 'chemical reaction' has a deeper content than the concept of 'structure of matter', students find it relatively difficult to understand the chemical reaction unit. It was intended to study the effects of factors such as the difficulty of understanding the contents presented in chemistry I, changes in class types (non-face-to-face and face-to-face classes), etc. on academic achievement.

This study was conducted for 2 years from March 2020 to February 2022 for 2nd graders of **A** High School in Gyeongsangnam-do. In 2020, 123 students took chemistry I as a non-face-to-face class, and in 2021, 100 students took chemistry I as a face-to-face class. High School of **A** is a general high school located in Gyeongsangnam-do. Since they are students who entered by equalization, the entrance grades of students at this school are similar to those of other nearby schools. In the national academic evaluation on a national scale, students show the national average level of academic achievement.

2.2 Class Contents and Evaluation Contents

For second-year students, the effects of factors such as changes in conceptual difficulty presented in the unit of chemistry I, changes in non-face-to-face classes and face-to-face classes, etc. on changes in academic achievement were compared and analyzed. Chemistry I is a general elective subject, and it is a subject with high difficulty in taking, and students' willingness to learn is very high compared to other elective subjects.

The grades of each semester consist of the first and second paper evaluations and the first performance evaluations. The paper-written evaluation (depth content) focused on measuring scientific thinking and problem-solving skills, such as understanding scientific concepts and applying them to real life. The questions of the paper-written evaluation consisted of 16 optional questions and 5 descriptive questions. The allocation ratio of each problem consisted of 55% selective and 45% descriptive. The academic achievement of chemistry

I subject was used by the average grades in the first and second semesters.

The classes of chemistry I subject were conducted for 3 hours per week, and the same teacher conducted non-face-to-face classes in 2020 and face-to-face classes in 2021. The test questions were presented by the teacher in charge of chemistry I, and the deviation of the number of questions and difficulty were adjusted to meet the achievement standards of the curriculum.

In the non-face-to-face class, the performance evaluation was conducted in an ′organization of learning contents after learning individually′ and a ′learning portfolio method that describes what you learned and felt′. The evaluation elements of the portfolio were scored based on evaluation factors such as the correct understanding of the learning content contained in each subunit, the use of scientific concepts, what they learned and felt based on the learned content.

For 17 weeks on a semester basis, classes with Chemistry I textbook were conducted, and classes were conducted according to the organized contents. Unit I-II of the textbook was taught for the first semester and Unit III-IV was taught for the second semester. The number of classes was conducted after organizing the same face-to-face and non-face-to-face classes. The test questions for the first and second paper-written tests in the first semester were presented in Unit I-II of the Chemistry I textbook, and the questions for the first and second paper-written tests in the second semester were presented in Unit III-IV.

In order to study students' academic achievement by level, the upper, middle, and lower grades were classified as the average value of all chemistry I grades during the first to second semesters. According to the order of grades, the upper, middle, and lower grades divided the total number of students by one-third. After summing the chemistry I grades of students at each level, they were analyzed using the average score for each level.

Non-face-to-face classes in the first semester of 2020 were conducted by using class contents such as pre-produced videos. In the second semester, face-to-face and non-face-to-face classes were held every other week. In 2021, face-to-face classes were held. Therefore, the impact of factors such as changes in difficulty due to the content organization of chemistry I, changes in class types (non-face-to-face classes and face-to-face classes), etc. on students' academic achievement was analyzed.

The IBM SPSS Statistics program was used for statistical processing. The grades of students who completed chemistry I in 2020 and 2021 were collected by dividing them into the first and second semesters, and then the average score was analyzed for each semester. In addition, after analyzing students' academic achievement according to changes in class types, the average score of chemistry I for non-face-to-face and face-to-face classes was obtained. After that, the statistical meaning was analyzed through the t-test.

2.3 Research Questions

This study studied the impact of factors such as the degree of difficulty in learning content presented in the unit of chemistry I, changes in class types, etc. on students' academic achievement. In particular, as learning in the first and second semesters progressed sequentially, the effect of changes in the difficulty of learning content, changes in class types, etc. on the level of academic achievement was studied. The research questions accordingly are as follows.

1. What is the impact of factors such as changes in the degree of difficulty of the concepts presented in the Chemistry I textbook, changes in class types, etc. on academic achievement by semester?
2. For each semester, what are the effects of factors such as changes in the degree of difficulty of the concepts presented in the Chemistry I textbook, changes in class types, etc. on the highest and lowest scores?
3. What is the impact of factors such as changes in the degree of difficulty, changes in class type, etc. of the concepts presented in the Chemistry I textbook on the level of academic achievement (upper, middle, and lower) by semester?

3. Results and Discussion

3.1 The Effect of Factors Such as Change in Concept Difficulty, Change in Class Type, etc. on Academic Achievement for Each Semester

The contents of the Chemistry I textbook are organized into 'structure of matter' and 'chemical reaction'. After learning the 'structure of atoms' unit during the first semester, they learn the 'chemical reaction' unit in the second semester. The 'structure of atoms' section describes the electronic structure of atoms based on quantum numbers. The ′chemical reaction′ unit explains complex ′chemical change′ concepts in which various variables such as reactants, products, reaction energy, etc. are involved at the same time. Therefore, because the 'chemical reaction' unit has a depth of concept, students find this unit relatively difficult.

First, to find out the changes in students' academic achievement according to the difficulty of the concept by semester, the average score of chemistry I calculated by non-face-to-face classes in 2020 and face-to-face classes in 2021 was analyzed for high school second graders. After summing the average grades of chemistry I calculated by non-face-to-face and face-to-face classes, the combined grades were analyzed by semester, and the results were presented in figure 1(A). In addition, the average grades calculated by non-face-to-face classes and face-to-face classes were analyzed by the first and second semesters, and the results are shown in figures 1(B) and 1(C), respectively.

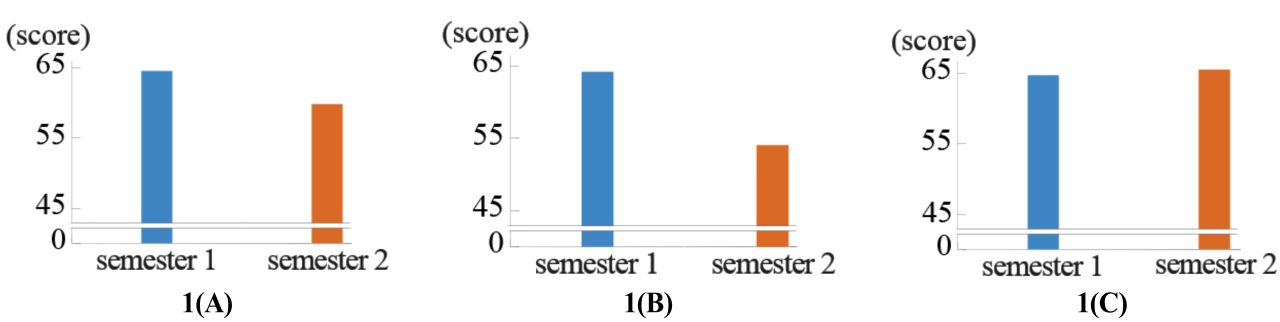


Figure 1. The combined grades by non-face-to-face and face-to-face classes were analyzed by semester and presented in 1(A). The grades by non-face-to-face and face-to-face classes were analyzed by semester and presented in 1(B) and 1(C), respectively.

In the figure 1(A) divided by semester for the total chemistry I grades added by non-face-to-face and face-to-face classes, the average score (64.5) in the first semester was higher than the average score (59.8) in the second semester. In the figure 1(B) shown by semester for chemistry I grades derived by non-face-to-face classes, the average score (64.2) in the first semester was also higher than the average score (54.1) in the second semester. On the other hand, in the figure 1(C) shown for each semester for chemistry Ⅰ grade derived by face-to-face class, the average scores for the first and second semesters were similar.

As shown in figure 1(B), the grades of the second semester of chemistry I derived from non-face-to-face classes were significantly low. These results on academic achievement were found to be more affected by learners' self-directed learning willingness than the difficulty of learning content. In non-face-to-face classes, learners' low self-directed willingness to learn and low instructional commitment were found to have a negative effect on academic achievement. As a result of previous studies, in non-face-to-face classes, difficulties in understanding the content were found due to factors such as poor lecture quality, lack of instructor-learner interaction, etc [23, 24]. In particular, it was found that it was not only difficult for learners to control the class environment on their own, but also low class immersion [14].

Second, in order to understand students' willingness to self-directed learning according to the type of class, the average performance of chemistry I subject for one year by non-face-to-face and face-to-face classes was analyzed, and the results were presented in 2(A). In addition, the average results of non-face-to-face and face-to-face classes for each of the first and second semesters were presented in 2(B) and 2(C), respectively.

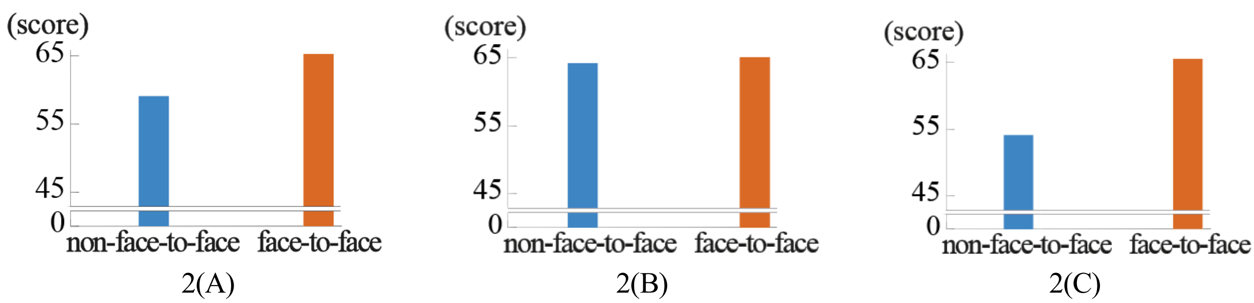
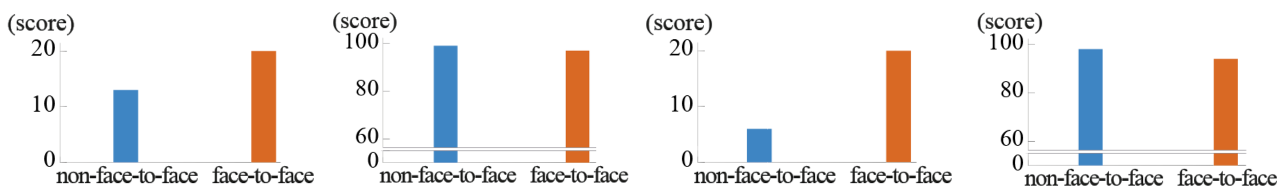


Figure 2. The average score of chemistry I by non-face-to-face and face-to-face classes is presented in 2(A). For each semester, the average results of non-face-to-face classes and face-to-face classes were presented in 2(B) and 2(C), respectively.

In figure 2(A), the average score (59.1) of students by non-face-to-face class was significantly lower than the average score (65.3) by face-to-face class. The t-test was conducted to find the statistical meaning of the average score difference, and the average score difference according to the difference in class type was significant ($p<0.05$). In figure 2(B), it was found that the difference in average grades of chemistry I by non-face-to-face and face-to-face classes during the first semester was similar. In figure 2(C), the average scores by non-face-to-face classes and face-to-face classes during the second semester were 54.07 and 65.79, respectively. The average score of face-to-face classes was 11.72 points higher than that of non-face-to-face classes. In other words, academic achievement was significantly low in non-face-to-face classes in the second semester. Therefore, in classes with conceptual difficulty, it suggests that learners' self-directed learning will to focus and immerse themselves in classes is quite necessary in non-face-to-face classes.

3.2 For Each Semester, the Effect of Factors Such as Changes in the Difficulty Level of Concepts Presented in the Unit of Chemistry I, Changes in Class Types, etc. on the Highest and Lowest Scores

In teaching-learning, factors such as the difficult degree of concept, class types, etc. affect students' academic achievement level. The unit of the Chemistry I textbook consists of concepts with deeper (advanced) learning contents in the second semester than in the first semester, so the difficulty of the concept varies from semester to semester. Therefore, according to the difference in the difficulty of the concept by semester, the effect of class type on the lowest score and the highest score was analyzed. During the first semester, figures 3(A) and 3(B) showed the distribution of the lowest and highest scores by non-face-to-face classes and face-to-face classes, respectively. During the second semester, the lowest and highest scores by non-face-to-face classes and face-to-face classes are shown in figures 3(C) and 3(D), respectively.



3(A) 3(B) 3(C) 3(D)

Figure 3. During the first semester, the lowest and highest scores by non-face-to-face and face-to-face classes were presented in 3(A) and 3(B), respectively. During the second semester, the lowest and highest scores by non-face-to-face and face-to-face classes were presented in 3(C) and 3(D), respectively.

In figure 3(A), the lowest score during the first semester was 13 points in non-face-to-face classes and 20 points in face-to-face classes. According to the change in class types, the difference in the lowest score was 7 points. Meanwhile, in figure 3(C), the lowest score during the second semester was 6 points in non-face-to-face classes and 20 points in face-to-face classes. The difference in scores between them was 14 points. Comparing the difference in the lowest score by semester, there was a difference of 7 points in the first semester, while there was a difference of 14 points in the second semester. In particular, in the second semester, the difference in scores among students in the lower grades was quite large. In figures 3(B) and 3(D), the highest scores were similar to each other in non-face-to-face classes and face-to-face classes.

In the non-face-to-face classes in figures 3(A) and 3(B), the lowest score of chemistry I was significantly low. In addition, since the ′chemical response′ unit, which is the learning content of the second semester, is relatively difficult, the lowest score of chemistry I in the second semester of students with low academic achievement was lower than in the first semester. In non-face-to-face classes and difficult-to-understand content, it was found that learners' self-directed learning will greatly affects students' academic achievement. In particular, in non-face-to-face classes, it is similar to the previous results that it is difficult for instructors to grasp learners' willingness to learn, and also difficult to induce behavior control or immersion in classes [14, 23].

3.3 For Each Semester, the Effect of Factors Such as Changes in the Difficulty Level of Concepts Presented in the Unit of Chemistry I, Changes in Class Types, etc. on the Level of Academic Achievement

In order to study the impact of factors such as differences in the degree of difficulty in learning content, changes in class types, etc. on students' academic achievement by level, it was divided into three groups: 'lower', 'middle', and 'upper'. The distribution of academic performance by non-face-to-face class and face-to-face class was analyzed by level, and the results are shown in figure 4(A). During the first and second semesters, academic performance distributions by non-face-to-face and face-to-face classes were analyzed by level, and the results are shown in figures 4(B) and 4(C), respectively.

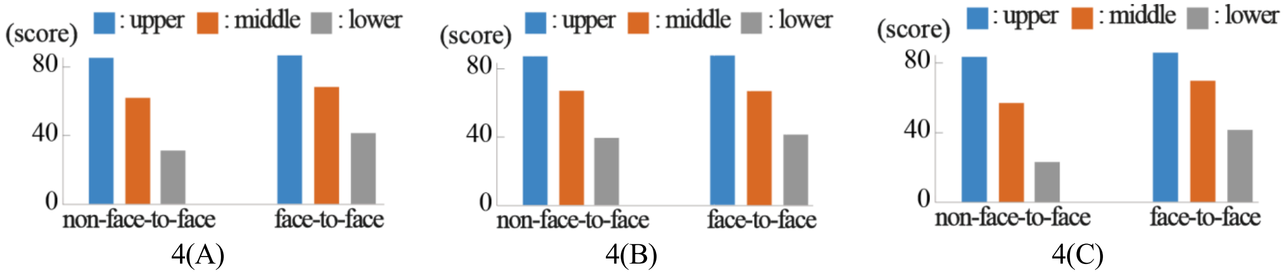


Figure 4. By level, the average results of chemistry I by non-face-to-face and face-to-face classes was presented in (4-A). During the first and second semesters, distributions by level of average grades by non-face-to-face and face-to-face classes are presented in (4-B) and (4-C), respectively.

In the case of 'lower' and 'middle' students in figure 4(A), the average scores by face-to-face classes were 10.2 and 6.5 points higher than the average scores by non-face-to-face classes, respectively. There was also a statistically significant difference in the t-test results. In Figure 4(B) presented as the academic achievement of chemistry I in the first semester by level, the level of academic achievement according to the class types was almost the same. On the other hand, in Figure 4(C), which presents the academic achievement of chemistry I in the second semester by level, the difference was large at the lower level. There was an average difference of 18.8 points at the lower level. Since the chemistry I content learned during the second semester is more difficult, the lower the level of academic achievement, the greater the average score difference between face-to-face and non-face-to-face classes. In particular, students with low levels of academic achievement showed low academic achievement because it was difficult to understand the concept.

Previous studies have shown that students with ′middle′ and ′lower′ achievement levels have relatively low self-directed learning motivation, so changes in the external class environment have a significant impact on academic achievement [25].

Therefore, it is important for instructors to grasp students' concept understanding in real time. In particular, it is more important to grasp the degree of conceptual understanding of students with low academic achievement. In addition, in teaching-learning, it was found that it was important for instructors to identify difficult concepts of students' content understanding and explain the difficult parts to students in detail to improve them.

4. Conclusion

We analyzed the impact of factors such as changes in the concept difficulty of chemistry I learned during the first and second semesters, changes in class types (face-to-face classes, non-face-to-face classes), etc. on students' academic achievement by level. This study was conducted on second-year students of general **A** high school in Gyeongsnagnam-do. During the first semester, the learning content of the Chemistry I textbook is the area of 'structure of matter', and in the second semester, the area of 'chemical reaction' is learned. Since the difficulty of the concept presented in the textbook varies depending on the semester, the effect on academic achievement was studied. In addition, since teaching-learning of Chemistry I textbook was conducted in non-face-to-face classes in 2020 and face-to-face classes in 2021, the effect of changes in class types on academic achievement was studied.

First, during the second semester, the learning contents of Chemistry I textbook are not only deepened, but also composed of more complex concepts. Therefore, after comparing the grades of chemistry I by semester, the effect of the difficulty of learning content on academic achievement was analyzed. In the semester-by-semester comparison of the total grades of chemistry I by non-face-to-face classes in 2020 and face-to-face classes in 2021, the grades in the second semester were lower than those in the first semester.

In addition, the impact of academic achievement of chemistry I subject by non-face-to-face and face-to-face classes on each semester was analyzed. The score of chemistry I by non-face-to-face class was significantly lower than that by face-to-face class. During the second semester the grades of non-face-to-face classes were significantly lower than those of face-to-face classes, while during the first semester, the difference in grades of chemistry I according to class types was similar.

This reason is not only due to difficulty in understanding the content due to factors such as poor quality of lectures and lack of interaction in non-face-to-face classes, but also to the learner's low willingness to self-directed learning. In non-face-to-face classes, students' academic achievement was found to be low because learners' instructional immersion and self-directed learning will were low.

Second, the effects of factors such as differences in the difficulty of concepts presented in Chemistry I textbook, differences in class types (non-face-to-face classes, face-to-face classes), etc. on the lowest and highest scores of chemistry I subject were compared by semester (1st and 2nd semesters).

In the first semester, the difference in the lowest score between non-face-to-face and face-to-face classes was 7 points, and the difference in the lowest score in the second semester was 14 points. In the second semester of lower-ranked students, the difference in scores by non-face-to-face and face-to-face classes was larger. In the first and second semesters, the differences in the highest score between non-face-to-face classes and face-to-face classes were similar to each other.

Since the content of chemistry I learned during the second semester was more difficult, the lowest score in the second semester of students with low academic achievement was significantly lower than in the first semester. As such, due to the difference in conceptual difficulty presented in chemistry I, the difference in students' grades in chemistry I subject by semester was large.

Third, changes in the concept difficulty of Chemistry I textbook and changes in class types affect the academic achievement of chemistry I subject, and the results were analyzed by level. In the comparison of grades by non-face-to-face and face-to-face classes, 'lower' and 'middle' students showed higher grades by face-to-face classes than by non-face-to-face classes, respectively. In the case of "upper" students, the average score according to the type of class was similar.

When comparing academic achievement by level according to semester changes, academic achievement by level differed significantly at the lower level during the second semester, while academic achievement by level during the first semester was almost the same. This is because the contents of the second semester are relatively difficult, so students with low academic achievement showed lower grades in chemistry I in the second semester.

Therefore, it is very important for instructors to grasp the degree of content understanding for students with low levels of academic achievement. In addition, active explanation and feedback from instructors are absolutely necessary for parts that are difficult to understand about the learning content.

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