

IJACT 23-9-29

The effect of changes in the difficulty level of concepts by semester and changes in class types on academic achievement by level

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Abstract

This study surveyed 2nd graders of B high school and 1st graders of A university in Gyeongnam on factors such as behavior control and interaction in non-face-to-face classes, easy or difficult concepts presented in chemistry I and general chemistry textbooks. Based on the results of the survey, the effect of changes in the difficulty level of concepts presented in chemistry I and general chemistry and changes in class types (face-to-face and non-face-to-face) on students' academic achievement by level was compared and analyzed. In the face-to-face class, the average score between the first and second semesters was similar according to the change in the difficulty of the concepts presented in chemistry I and general chemistry. In the non-face-to-face class, the average score of chemistry I in the second semester was quite low, and the average score of general chemistry was rather high. In non-face-to-face classes, the average score of chemistry I in the second semester of low-level students was significantly lowered due to changes in the difficulty of the concept and changes in class types on academic achievement by level. In the case of 10% of students at the lower level, the academic achievement of chemistry I decreased in both the second semester regardless of the changes in the difficulty level of concepts and the changes in class types.

Keywords: academic achievement by level, difficulty level of content, change in class type, behavior control, will of teaching-learning

1. INTRODUCTION

The 2015 revised science curriculum is a student-participating inquiry-oriented curriculum designed to have scientific thinking through inquiry activities for familiar natural phenomena [1]. The organization of science textbooks according to this curriculum consists of motivation, derivation of the results of inquiry experiments, explanation of key concepts, and application to STS (science-technology-society). First, motivational content introduces a familiar phenomenon that students can often encounter in their daily lives, and the contents are organized so that they can have a conceptual relationship with the content to be learned and curiosity about the content to be learned.

In order to improve scientific thinking skills in the inquiry process, inquiry experiments require

Manuscript received: August 3, 2023 / revised: August 21, 2023 / accepted: August 29, 2023

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heterogeneous groups to be organized and emphasize the division of roles for each. In the inquiry process, each of the inquiry results is derived while controlling the manipulated variables, or an integrated scientific phenomenon is observed without variable control. As a result of the inquiry, the scientific concept of natural phenomena is understood, and it is emphasized that these scientific concepts (principles) are being returned to society along with technological development. In this process of inquiry, core competencies such as scientific inquiry ability, scientific thinking ability, etc., are improved [2, 3].

Students can increase their learning satisfaction in the inquiry-oriented teaching-learning process through the composition of heterogeneous groups with different levels of academic achievement and the successful division of roles. In inquiry-oriented teaching-learning, students can strengthen their self-directed teaching-learning will, such as behavior control, instructor-learner and learner-learner interaction, and as a result, class participation and learning commitment in teaching-learning can be strengthened. Therefore, it is necessary to study the effects of self-directed teaching-learning will on students' academic achievement levels, such as behavior control, various interactions, and so on in the form of face-to-face and non-face-to-face classes [4, 5].

Previous studies have shown that students with low levels of academic achievement participate passively in teaching-learning, and active questions and instructor-learner interactions for content understanding do not occur well [6, 7]. In addition, it was found that the lower-ranked students had low interaction between instructors and learners to understand the learning content [8]. Therefore, learners with low self-directed teaching-learning will have low academic achievement due to poor social skills and low interaction [9]. On the other hand, students with high levels of academic achievement have high instructor-learner interaction and high learning immersion in the teaching-learning process [10-12].

Since face-to-face classes are taught in the same space, instructors can actively induce class participation by grasping learners' understanding of content and controlling the learning environment by instructors, and as a result, quality management of lectures can be strengthened [13-16]. On the other hand, in non-face-to-face classes, instructor-centered lecture-style classes are held in an independent space, so learners participate passively in teaching-learning. In particular, learning immersion is low due to difficulty in behavioral control, and interactions such as question and answer and feedback are difficult, so academic achievement is low [9, 10]. Therefore, there is an urgent need for research on the effect of students' willingness to teach and learn according to the class type on academic achievement by level.

On the other hand, the contents of the chemical subject are composed of detailed areas such as the structure (composition) of the substance, the properties of the substance, and the change of the substance. The composition or properties of a substance are one-dimensional information about a substance, but the content of 'material change' explains the change between the reactant and the product. Therefore, it is necessary to understand multidimensional information that considers not only the structure and properties of reactants and products, but also external variables (temperature, pressure, concentration, etc.) involved in these changes [3].

Currently, chemistry I and general chemistry are organized to learn 'material structure,' 'material properties,' 'material changes,' etc., sequentially. The area of 'material structure' is presented in the front (first-semester class) of the textbook, and the area of 'material change' is presented in the back (second-semester class). In particular, the composition of these learning contents (structure, nature, and change) presented in the chemistry I textbook is gradually deepened and expanded in consideration of the cognitive development stage of students. In other words, it is described in this textbook by deepening and expanding, such as 'from atomic structure to molecular structure' and 'from oxidation-reduction definition by binding oxygen to the definition of oxidation number' [17].

The 'material change' area is described as a chemical reaction, which involves various factors such as chemical changes between reactants and products, dynamic equilibrium, energy entry and exit, and various external factors (concentration, temperature, pressure, catalyst, etc. Although these contents are gradually presented in chemistry I textbooks, students with low academic achievement levels find it difficult to understand the concept of "chemical change," in which various concepts such as "dynamic equilibrium," "energy access," and others are simultaneously embedded. As such, in chemical changes involving various

variables, it was found that the difference in students' content understanding varies depending on the level of achievement [2, 17].

Previous studies have shown that students with low levels of achievement are passive teaching-learning activities, making it difficult to understand complex concepts [8, 9]. In particular, it was found that it was difficult to understand the learning content in non-face-to-face classes centered on instructors, they did not actively answer questions even if they did not understand the content, and behavioral control or learning immersion in teaching-learning was also low [18, 19]. On the other hand, it was found that students with high levels of achievement effectively control the teaching-learning process and make continuous efforts to understand difficult content [11, 20]. As such, because students' willingness to teach and learn varies depending on the level of achievement, learners' academic achievement is different for each level.

Although the contents of chemistry textbooks are organized based on the learner's level of intellectual development, it was found that it was very difficult for students with low academic achievement to learn the contents of chemistry I on their own [2, 17]. Therefore, in non-face-to-face and face-to-face classes, there is an urgent need for research on the degree of understanding of the learning content presented in chemistry I according to the level of academic achievement.

Until now, most studies have studied the effect of non-face-to-face class types on students' academic achievement and learning satisfaction for a single school level [21]. On the other hand, this study studied the effect of changes in the difficulty of learning concepts presented in chemistry I and general chemistry and changes in class types on academic achievement by level. These research results are expected to greatly contribute to future curriculum reorganization or real-time online classes.

2. RESEARCH METHODS

2.1. Object of study

In 2022, students enrolled in the Department of Chemistry Education at A University's College of Education in Gyeongsangnam-do were surveyed on the level of understanding of concepts (easy concept, difficult concept) presented in chemistry I and general chemistry, students' willingness (behavior control, interaction) to teach-learning in non-face-to-face classes. The contents of the study were analyzed for students who faithfully responded to the survey. Fifty students participated in surveys such as understanding chemistry concepts, behavioral control, and interaction in non-face-to-face classes, and 25 students were divided into upper and lower groups according to the level of academic achievement.

Based on the survey, the academic achievement of chemistry I subjects was analyzed for 223 -second graders of B high school in Gyeongnam between 2020 and 2021 to study the effect of changes in conceptual difficulty (from simple to complex) and class type (face-to-face and non-face-to-face classes) on academic achievement. In addition, the academic achievement of general chemistry was analyzed by 79 first-year students in the Department of Chemistry Education at University A in Gyeongsangnam-do from 2019 to 2020. One hundred high school students and 47 college students in 2019 have completed chemistry classes in face-to-face classes in 2021, and 123 high school students and 32 college students have completed chemistry classes in non-face-to-face classes in 2020.

2.2. Class contents and evaluation contents

High school chemistry I was taught three hours a week as a general optional subject, and units I and II (basic step in chemistry, world of atoms) of chemistry I textbooks were taught during the first semester and units III and IV (chemical bonds and world of molecules, dynamic chemical reaction) during the second semester. In 2020, non-face-to-face classes were conducted, and in 2021, face-to-face classes were conducted. The ratio of test evaluation in non-face-to-face classes in 2020 was reflected as 80% of paper evaluation and 20% of performance evaluation, and 70% of paper evaluation and 30% of performance evaluation in face-to-face classes in 2021.

For each semester's test, two paper evaluations and one performance evaluation were conducted. The paper-based evaluation (depth content) focused on measuring scientific thinking and problem-solving skills, such as understanding scientific concepts, applying them to real life, etc. The composition of questions in the paper-written evaluation consisted of optional (55%) and descriptive (45%), respectively.

After learning each unit of chemistry I, the performance evaluation was conducted in a "learning organization after learning individually" and a "learning portfolio method that describes what you learned and felt." The evaluation elements of the portfolio were to describe in detail the contents of each subunit, such as "correct understanding of learning content," "use of scientific concepts," and "what you learned and felt based on what you learned." The test questions were created by a teacher in charge of chemistry I.

General chemistry was taught for 3 hours a week, and units 1 to 11 were taught for the first semester, and units 12 to 24 were taught for the second semester. Face-to-face classes were conducted in 2019, and online non-face-to-face classes in 2020. A paper-written evaluation was conducted for each semester, and it consisted of midterm and final exams. The paper-based evaluation is a descriptive question (100%), and the evaluation focused on evaluating scientific thinking, problem-solving, etc. based on the understanding of scientific concepts learned in general chemistry.

Credit was given by the relative evaluation scale in the face-to-face class in 2019 and by the absolute evaluation scale in the non-face-to-face class in 2020. In the grade shown as credits, A grade was compared by converting 4 to 4.5 points, B grade was 3 to 3.99 points, C grade was 2 to 2.99 points, D grade was 1 to 1.99 points, and F grade was compared by converting to 0 points. The test questions were presented by a professor in charge of general chemistry.

2.3. Questionnaire Survey

Based on the previous inspection tools, [2-4, 10, 17, 21, 22], the questionnaire used consisted of a total of four questions asking for easy or difficult concepts in chemistry I and general chemistry textbooks. Among the learned contents, the corresponding concept that the student himself/herself understood was described, and then the reason for easy or difficult was described.

In non-face-to-face classes, there are a total of 12 questions about interaction (4 questions on teacher-learner interaction, three questions on learner-learner interaction, and five questions on learner-content interaction) and a total of 4 questions about behavioral control. They consisted of a 5-point Likert scale. These surveys were modified to suit the characteristics of students in the Department of Chemistry Education and then used. The first preliminary survey was conducted on 30 students enrolled in the Department of Chemistry Education at University A. Based on the preliminary survey, the students' understanding of the survey, the opinions of professors and experts in the area were synthesized and finally revised.

2.4. Analysis Method

To confirm the effect of changes in the difficulty level of concepts presented in chemistry I and general chemistry textbooks and changes in class types (face-to-face, non-face-to-face) on academic achievement, the average score of chemistry I and general chemistry by semester, the average score of (upper and lower) by achievement level, and the average score of the lower 10% of students were compared and analyzed.

In order to confirm the difference by level of academic achievement, it was divided into 'upper level' and 'lower level' by 1/2 of the total number of students. The comparison by academic achievement level analyzed the difference in academic achievement by level according to the change in conceptual difficulty and the change in class type. In particular, in order to study the teaching-learning will of lower-level students, the average score of chemistry I of the lower 10% of high school students was compared and analyzed.

2.5. Research questions

This study studied the effect of changes in the difficulty of concepts presented in chemistry I and general

chemistry textbooks and changes in class types (face-to-face and non-face-to-face classes) on academic achievement. In addition, the following research questions were set up to find out the impact on the academic achievement of each level (upper and lower), especially the lower 10% of students.

1. What is the impact of changes in the difficulty of concepts and changes in class types on academic achievement for each semester based on the results of students' surveys?
2. What is the impact of changes in the difficulty of the concept and changes in class types on academic achievement by level (upper, lower)?
3. What is the impact of changes in conceptual difficulty and class type on the academic achievement of the bottom 10% of students?

3. RESEARCH RESULTS

3.1. Survey of students' perceptions of teaching-learning will (behavior control, interaction) by class type (face-to-face, non-face-to-face)

Several previous studies have reported that learners' willingness to self-directed teaching-learning, such as behavior control, interaction, etc., in non-face-to-face classes, affects students' academic achievement [4, 5]. In non-face-to-face classes, a survey was conducted on factors such as behavioral control, interaction, etc., to study the effect of students' willingness to teach and learn on academic achievement by level (especially at a lower level).

A survey on behavioral control was conducted on students who experienced non-face-to-face classes, and the results are shown in Figure 1. In Figure 1(A), the intensity of behavioral control was higher in higher-level students than in lower-level students. In the detailed factors of behavior control in Figure 1(B), 'task obsession' was the highest, and 'concentration of behavior' was the lowest. In all detailed factors, the average score at the upper level was higher than the score at the lower level. The difference between the upper and lower levels was the largest in 'task obsession', and the difference was the smallest in 'concentration of behavior'. It was found to be similar to previous studies that the lower the level of achievement, the more difficult it is to control behavior in non-face-to-face classes [13, 15, 16].

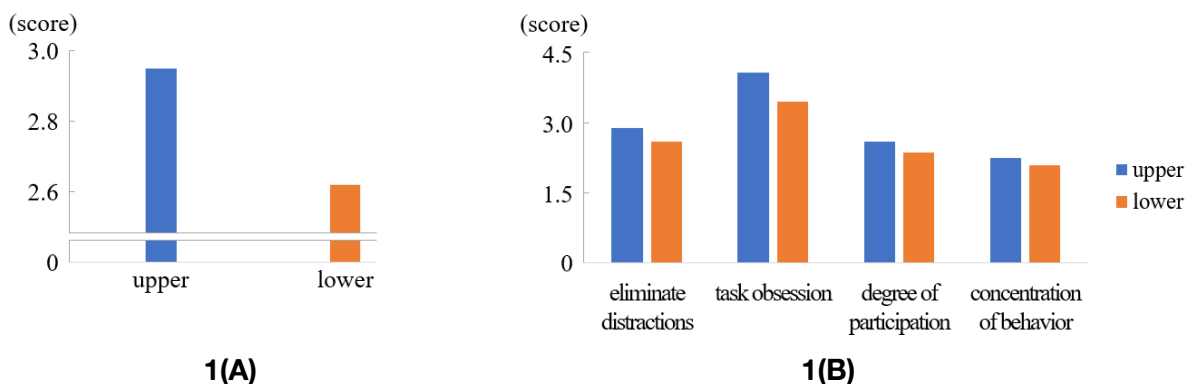


Figure 1. By achievement level, the results of the perception survey on behavioral control [1(A)] for non-face-to-face classes and their detailed factors [1(B)].

A perception survey was conducted on interactions in non-face-to-face classes, and the results are shown in Figure 2. In Figure 2(A), the degree of interaction of upper-level students was higher than that of lower-level students. In all detailed forms of interaction in Figure 2(B), the degree of interaction of upper-level students was also higher than that of lower-level students. The learner-learner interaction was the highest, and the instructor-learner interaction was the lowest. As for the interaction, it was found that there were many questions

and answers and feedback to understand the learning content. As a result of previous studies, it was found that if it is difficult to understand the learning content, not only there is less interaction but also low academic achievement [5, 22, 23].

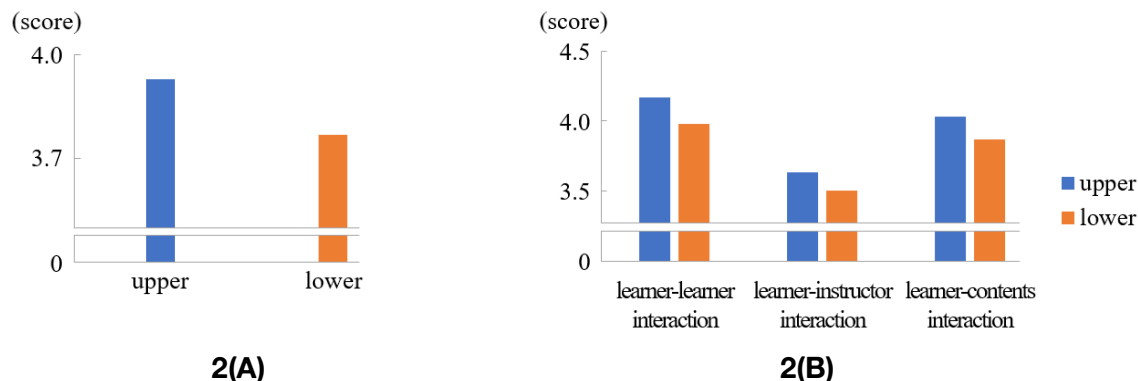
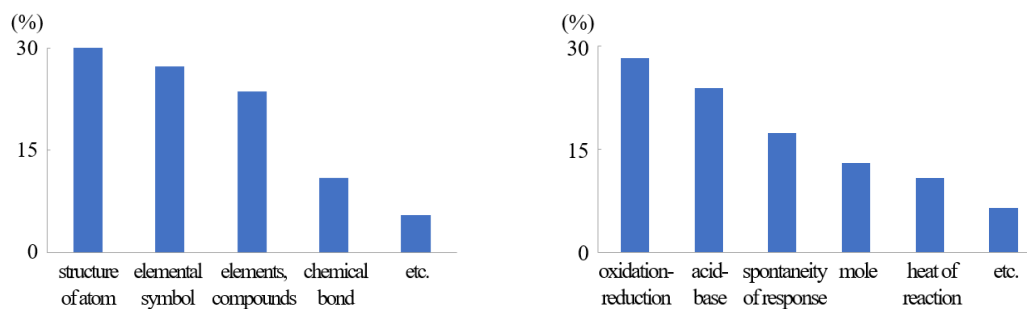


Figure 2. In non-face-to-face classes, a perception survey on interaction [2(A)] and its detailed form [2(B)] by level of academic achievement.

3.2. A survey of students' perceptions of the degree of understanding of concepts presented in chemistry I and general chemistry textbooks

After conducting a survey on the understanding of the concepts presented in chemistry I and general chemistry textbooks, the results are shown in Figure 3 and Figure 4, respectively. As shown in Figure 3(A), concepts such as 'atomic structure', 'periodic properties of elements', 'elements and compounds', etc., presented in chemistry I were found to be easy to understand. Concepts such as the structure of atoms, periodicity of elements, etc., have already been learned in middle school science, so they have been found to be relatively familiar to students. It was also found to be easy for students to understand because it was simple and regular content. They are organized at the front of the chemistry I textbook, so they are mainly taught-learned in the first semester.

In Figure 3(B), concepts of chemical reactions such as 'oxidation-reduction', 'acid-base', 'voluntary reaction', etc., appeared to be difficult to understand. The definition of these responses is deepened and expanded step by step according to the level of cognitive development of students. In addition, chemical reactions involve various external variables (temperature, pressure, concentration, etc.), so chemical changes depend on these variables. Therefore, these concepts were found to be difficult for students to understand because their definitions deepened and expanded step by step, and various variables were involved. These concepts are organized at the back of the chemistry I textbook, so they are mainly taught-learned in the second semester.



3(A)

3(B)

Figure 3. Easy concepts [3(A)] and difficult concepts [3(B)] in the perception survey of the understanding of concepts presented in chemistry I.

As shown in Figure 4(A), concepts such as 'electronic structure of atoms', 'structure of matter', etc., presented in general chemistry, were found to be relatively easy to understand. These concepts have already been learned in chemistry I, chemistry II textbooks, etc., and only advanced and expanded concepts in general chemistry are explained. Since they have already been taught-learned in high school, it has been found that students understand these concepts relatively easily.

As shown in Figure 4(B), it was found that it is difficult for students to understand concepts such as 'electrochemical', 'thermal chemistry', 'coordination chemistry', etc. presented in general chemistry. These concepts allow us to understand the structural changes, property changes, energy changes, etc., of reactants and products due to chemical reactions. It also quantifies the amount of changes according to external variables. Therefore, it was found that students had difficulty understanding these concepts. Since these concepts are organized behind general chemistry, they will be taught-learned in the second semester. In a previous study [3, 17]. Concepts in which the definition is deepened and expanded step by step, such as oxidation-reduction, acid-base, etc., have been found to be difficult to understand the definition of the concept to be learned in the next step unless the concept defined in the previous step is accurately understood.

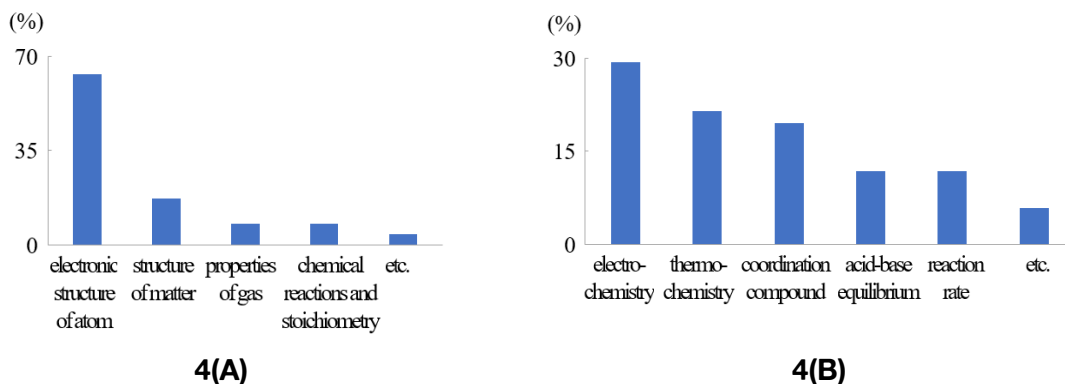


Figure 4. Easy-to-understand concepts [4(A)] and difficult concepts [4(B)] in the survey on concept understanding presented in general chemistry.

As a result of the students' survey, the degree of behavioral control and interaction of high-level students in non-face-to-face classes was higher than that of low-level students. In addition, it was found that the learning contents of the second semester were more difficult than those presented in chemistry I and general chemistry textbooks in the first semester. Based on the results of the survey, the effects of changes in concept difficulty presented by semester, changes in class types, and etc., on changes in academic achievement of chemistry I and general chemistry by level were compared and analyzed.

3.3. Effects of factors such as changes in conceptual difficulty by semester, changes in class types, etc. on academic achievement

According to the type of class, the average grades of chemistry I and general chemistry by semester were compared and analyzed, and the results are shown in Figure 5 and Figure 6, respectively. As shown in Figures 5(A) and 5(B), the average scores of chemistry I and general chemistry were similar for each semester according to the change in conceptual difficulty in face-to-face classes. Since face-to-face classes directly interact between instructors and learners at the same time and place, it is possible to manage the quality of

lectures (understand learners' understanding of content) and immediately communicate with students (questions and answers between instructors and learners, feedback, etc.). [14]. In addition, learners can be controlled by the instructor's lecture in a limited time and space, so it is judged to be the result of actively participating in the class regardless of the semester [24].

Although the concepts presented in chemistry I and general chemistry textbooks are sequentially deepened and expanded (from easy to difficult concepts), these concepts were found to be understood relatively well through instructor quality management, instructor-learner interaction, learner behavior control, etc. As a result, in face-to-face classes, the effect of the difference in concept difficulty by semester on academic achievement was insignificant.

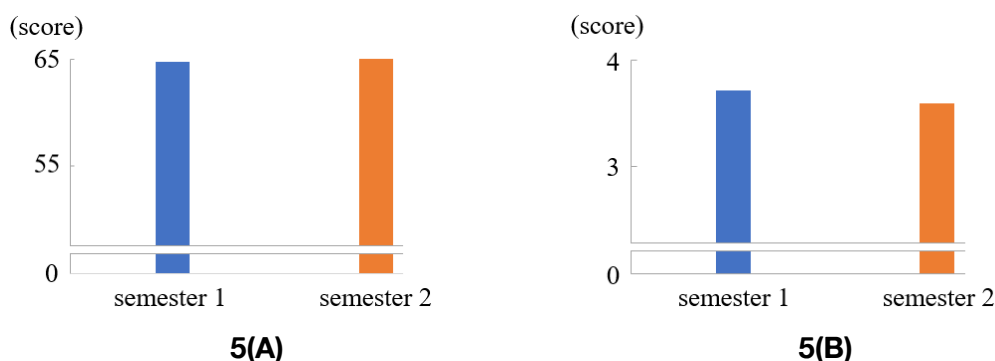


Figure 5. In face-to-face classes, the average score of chemistry I [5(A)] and general chemistry [5(B)] subjects by semester.

In the non-face-to-face class of Figure 6(A), the average score of chemistry I in the second semester was lower than the average score in the first semester. According to the change in learning content, the average score for the second semester was significantly lower (10.1 points) than that of the first semester. In a survey for this study, concepts such as 'oxidation-reduction', 'acid-base', etc., were found to be difficult, and these contents were taught in the second semester. In particular, these concepts are presented in stages (deepened and expanded content) according to the level of intellectual development of students.

In previous studies, it was found that non-face-to-face classes had a significant impact on learning satisfaction depending on the role of instructors and the learner's willingness to learn [25]. In particular, it was found that high school students had a significantly different content understanding depending on the learner's willingness to teach and learn [8, 10]. Therefore, in non-face-to-face classes, classes with changes in concept difficulty suggest that factors such as the instructor's willingness to manage lecture quality, interactions such as question-answer and feedback between instructors and learners, and the learner's willingness to focus and immerse in the class are quite important.

In Figure 6(B), the average score of general chemistry was slightly higher in the second semester. In addition, as the non-face-to-face teaching-learning period continued, the non-face-to-face teaching-learning ecosystem was restored by college students' adaptation to the non-face-to-face teaching-learning environment and instructors' quick response to the non-face-to-face class environment. As a result, it is judged that the average performance of general chemistry in the first and second semesters is similar. These findings have been similarly presented in previous studies [23, 26].

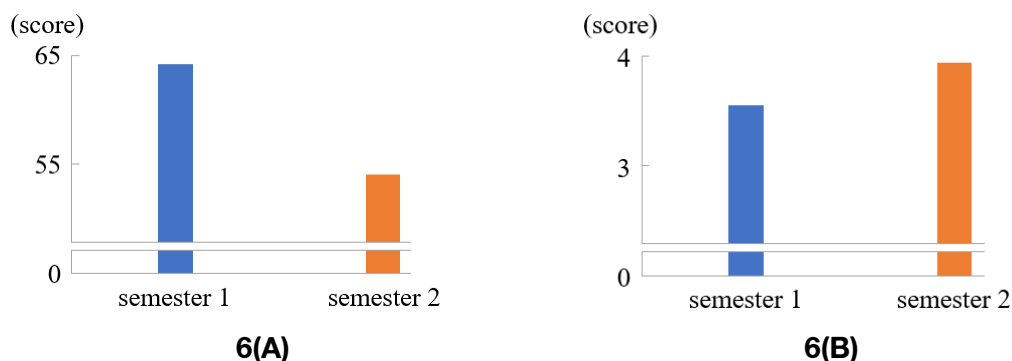


Figure 6. In non-face-to-face classes, the average score of chemistry I [6(A)] and general chemistry [6(B)] subjects by semester.

3.4. The effect of changes in conceptual difficulty and class type on the level of academic achievement (upper and lower) by semester

The effects of changes in the concept difficulty of chemistry I and general chemistry and changes in class types (face-to-face and non-face-to-face classes) on students' academic achievement by level were analyzed, and the results are shown in Figure 7 and Figure 8, respectively. The level of academic achievement was divided into two groups: 'upper' and 'lower' based on academic achievement. As shown in Figures 7(A) and 7(B), the average score of each level (upper and lower level) of chemistry I and general chemistry was similar for each semester in a face-to-face class. Although there is a difference in the concept difficulty of chemistry I and general chemistry textbooks for each semester, the effect on academic achievement by level was insignificant. This is judged to understand relatively well even if the learning content is difficult due to the control of the class environment by the instructor, such as the learner's behavior control, active class participation, etc., in face-to-face classes.

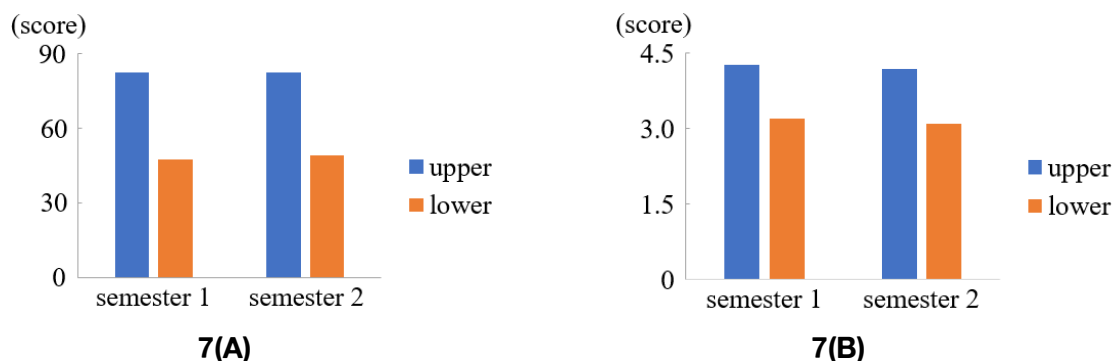


Figure 7. In face-to-face classes, the average score by achievement level of chemistry I [7(A)] and general chemistry [7(B)] subjects by semester.

As shown in Figure 8(A), the average score for each level of chemistry I in the second semester of the non-face-to-face class was lower at the lower level. Between the first and second semesters, the difference in average scores at the lower level was relatively larger than the difference in scores at the upper level. In other words, the difference in average scores by level between the first and second semesters decreased significantly as the level of academic achievement was lower (upper: 5.3 points, lower: 15.1 points). It is judged that students in the lower grades have a lower understanding of the contents of chemistry I in the second semester. Therefore, it implies that the will to self-directed teaching-learning is more urgent in order for low-level students to

understand the in-depth and expanded content in non-face-to-face classes. These results are well consistent with the fact that the lower the achievement level in the survey for this study, the more difficult the learning content of chemistry I in the second semester is and is not easy to understand.

In previous studies [11, 12], it was reported that lower-level students had difficulty understanding the learning content because their willingness to self-directed teaching-learning, such as behavior control, interaction for content understanding, learning participation, etc., was not strengthened. Therefore, factors such as quality management of the instructor, instructor-learner interaction (question and answer, feedback), and learners' willingness to teach and learn were particularly important in the teaching-learning of low-level students.

On the other hand, in the non-face-to-face class of Figure 8 (B), the average score by achievement level of general chemistry was generally similar, or the average score of the lower level increased slightly in the second semester. Unlike high school students, the selected college students are believed to have improved their grades in the second semester due to their self-directed willingness to teach and learn (behavior control, interaction, etc.). In addition, universities have a relatively well-established environment for non-face-to-face classes, such as the Internet environment, digital media, and etc., so it is judged that students have used it well for teaching-learning. Previous studies have shown that the longer the experience of non-face-to-face teaching-learning, the better the willingness of self-directed teaching-learning to control themselves in learning and actively engage in classes [13].

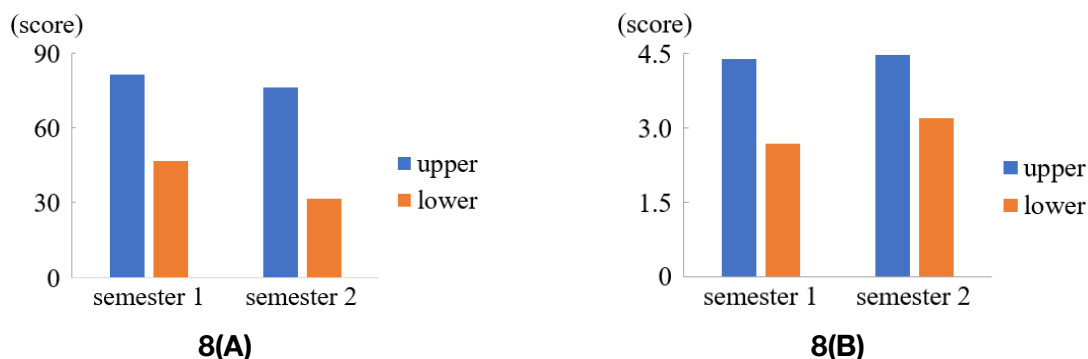


Figure 8. Average score by achievement level of chemistry I [8(A)] and general chemistry [8(B)] subjects by semester in non-face-to-face class.

3.5. The effect of changes in the difficulty level of concepts by semester and changes in class types on the academic achievement of the lower 10% of high school students

In the previous Figure 8(A), the average score of chemistry I of lower-level students in the second semester was significantly lowered. In other words, the difference in the average score in the lower grades of the first and second semesters was 16.5 points. In non-face-to-face classes, factors such as students' behavioral control, interaction for understanding learning content, and etc. were found to have a significant impact on the academic achievement of low-level high school students. Therefore, among all lower-level students, the effect of changes in concept difficulty by semester and changes in class form on the academic achievement of the lower 10% of students was analyzed.

The effect of changes in the concept difficulty of chemistry I textbooks and changes in class types on the academic achievement of the bottom 10% of students was analyzed, and the results are shown in Figure 9. In Figure 9(A) of face-to-face classes and Figure 9(B) of non-face-to-face classes, the average score of the second

semester was relatively lower than that of the first semester. In particular, even in the face-to-face class of Figure 9(A), the average score of the bottom 10% of students was low in the second semester. These results show a different tendency from the results in which the average scores of all lower-level students in the first and second semesters were similar in the face-to-face class of Figure 7(A). Even if it is a face-to-face class, it is judged that the academic achievement of lower-level students is low because it is difficult for them to understand the learning content with high conceptual difficulty.

On the other hand, in the non-face-to-face class of Figure 9 (B), the average score for the second semester was also low. Since non-face-to-face classes are centered on instructors, academic achievement has been reduced due to factors such as difficulty for instructors to grasp learners' content understanding and difficulty in active interaction between instructors and learners. Previous studies have shown that students in the lower ranks of non-face-to-face teaching-learning have low will to self-directed teaching-learning such as behavior control, interaction to understand learning content, active participation, etc. [4, 5, 6, 7].

Therefore, it was found that the degree of understanding of learning content with high difficulty in non-face-to-face classes had a relatively greater impact on the academic achievement of students in the lower grades. In addition, since students with low academic achievement have low will to self-directed teaching-learning, such as behavior control, instructor-learner interaction, and etc., it is important to prepare a teaching-learning plan (execution plan) to increase students' willingness to teaching-learning.

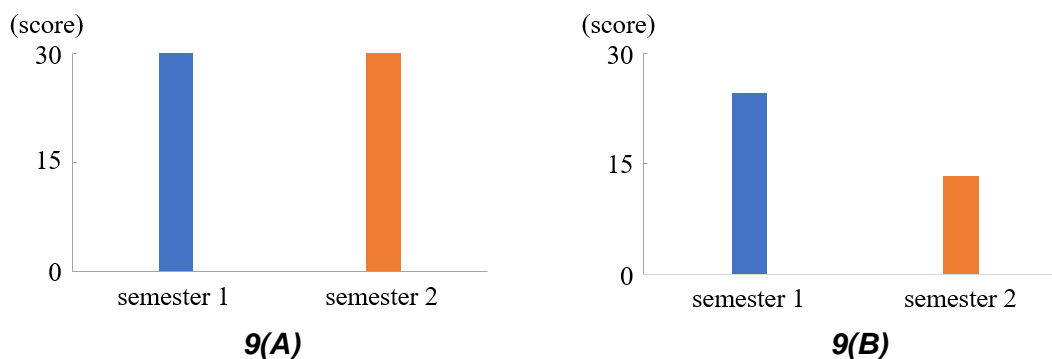


Figure 9. In face-to-face [9(A)] and non-face-to-face [9(B)] classes, the average score of chemistry I in the first and second semesters of the bottom 10% of students

4. CONCLUSIONS

We longitudinally studied the effect of changes in the level of difficulty of concepts and changes in class types on the academic achievement of 10% of students at the lower level. As basic data for this study, a survey was conducted on factors such as easy or difficult concepts presented in chemistry I and general chemistry textbooks, and students' willingness to teach-learning (behavior control, various interactions) in non-face-to-face classes. This study was conducted on 223-second graders at B high school and 79 first graders at A University in Gyeongnam.

In the survey results, students' understanding of the concepts presented in chemistry I and general chemistry was different for each semester. In addition, students' willingness to teach and learn, such as behavior control, various interactions, and others, was different according to changes in class types (face-to-face and non-face-to-face). As a result, academic achievement by level was also different. Based on the results of these surveys, the effect of changes in the difficulty of concepts presented in chemistry I and general chemistry by semester and changes in class types on academic achievement by level (lower level 10%) was studied longitudinally.

In the face-to-face class, the average score between the first and second semesters was similar according to the change in the difficulty of the concepts presented in chemistry I and general chemistry. Since face-to-face

classes have face-to-face interactions with instructors in limited time and space, factors such as understanding learners' content, instant communication (question and answer, feedback, etc.), and controlling learners' behavior can be strengthened. Even if there is a difference in the difficulty of concepts between the first and second semesters, the effect on academic achievement was not significant.

In the non-face-to-face class, as the conceptual difficulty changed by semester, the score of chemistry I in the second semester was lower than that of the first semester. Concepts such as 'oxidation-reduction', 'acid-base', etc. (in-depth and expanded content by step) were found to be difficult for students, even if they were to be taught in the second semester according to their level of intellectual development. In these difficult concept classes, several factors such as the instructor's willingness and role in managing lecture quality, interactions such as question-answer and feedback between instructors and learners, and the learner's willingness to teach-learning have a significant impact on students' academic achievement. Meanwhile, the average score of the second semester of general chemistry was slightly higher than that of the first semester. As the non-face-to-face class period continues, it is judged that the average score of general chemistry in the first and second semesters is similar as a result of college students adapting to the environment of non-face-to-face classes.

The effect of changes in the difficulty of the concept presented in chemistry I and general chemistry and changes in class types on academic achievement by level was analyzed. In face-to-face classes, changes in academic achievement at each level were similar between the first and second semesters. Although there is a difference in the difficulty of concepts in chemistry I and general chemistry between the first and second semesters, the effect on academic achievement at each level was insignificant. Since it is possible to control the teaching-learning environment by the instructor in the face-to-face class, it is judged that learners' willingness to teach-learning has increased.

In non-face-to-face classes, the average score of chemistry I in the second semester of lower-level students was significantly lower than in the first semester. In addition, the difference in average scores by level between the first and second semesters decreased significantly as the level of academic achievement was lower. Therefore, in non-face-to-face classes, lower-level students imply that the will (behavior control, interaction) to self-directed teaching-learning is more urgent. It is judged that factors such as the instructor's quality management of lectures, interaction between instructors and learners, and learners' willingness to teach and learn are important in the teaching-learning of lower-level students.

In general chemistry, the average score of lower-level students in the second semester was slightly higher than that of the first semester. This is because, unlike the teaching-learning environment in high schools, universities have a well-established non-face-to-face teaching-learning environment such as digital media, Internet environment, etc. In addition, it is judged that the selected college students have a high will to self-directed teaching-learning.

For each semester, the effect of changes in the difficulty of the concept presented in chemistry I and changes in class types on the academic achievement of the bottom 10% of students was analyzed. In face-to-face and non-face-to-face classes, the average score of the bottom 10% of students in the second semester was relatively lower than in the first semester. These results show a different tendency from the results in which the average score of all students in the lower grades in the second semester was slightly higher than in the first semester in face-to-face class. Regardless of the type of class, students with low achievement levels were found to have low willingness to teach-learning such as behavior control, instructor-learner interaction, etc. Therefore, it suggests the importance of preparing a teaching-learning plan that can increase the will to self-directed teaching-learning for students with low achievement levels in class.

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