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Analysis of peer relationships in Korean Middle School Inquiry and Noninquiry Science Experiment Classes

Dongryeul Kim

Daegu National University of Education, Republic of Korea, dongryeulk@gmail.com, ORCID ID: 0000-0002-0129-9644

ABSTRACT

This study intended to confirm differences in peer relations between inquisitive and noninquisitive experiment class through social network analysis. In this study, inquiry science experiment classes for 30 students and noninquiry science experiment classes for different 30 students in the chapter named "Animals and Energy" of the second year of Korean middle school were conducted by the same teacher and the same class (6th class), The peer relationship between classmates before and after class was compared and analyzed by using a social network analysis method. As a result of the study, it was found that the inquiry experiment class has higher tie density, average number of friends, and connection compared to the noninquiry experiment class. In other words, it could be evaluated that the inquiry experiment class has a positive effectiveness on the relationship of the companion rather than the noninquiry experiment class. In the results of analyzing the status of fellowship relations regarding the degree of being nominated by fellow students and the degree of perfect connection within the group, it was evaluated that the inquiry experiment class was more effectiveness in improving the ratings of members and forming a fully connected community compared to the noninquiry experiment class. In addition, from a point of view that the type of alienation pattern decreases a lot in inquiry experiment class compared to noninquiry experiment class, it could be evaluated that there is a high possibility tha everyone participates in inquiry activities without alienated students in an experiment class.

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Introduction

Science subject applies differentiated teaching and learning methods by taking advantage of its unique subject characteristics. Among them, inquiry is recognized as absolutely important in science learning as a teaching and learning method that can make use of the characteristics of the subject while differentiating from other subjects. Inquiry is at the center of science learning (Demirçalı & Selvi, 2022; Feyzioglu & Demirci, 2021; Jeong et al., 2007), and it provides an opportunity to deeply understand scientific phenomena and principles. Therefore, science learning aims to cultivate essential scientific inquiry skills (Jeong & Chang, 2019; Kacar & Balim, 2021; Kim & Kwon, 2016). However, in the curriculum in Korea, there are learning goals to be achieved every semester, and there are goals that need to be learned within the corresponding period of each unit. In addition, in order to take the midterm and final exams every semester, the progress should be made within that range. Therefore, the textbook includes inquiry activities, but there are cases where the teacher's guidance and answers

are presented. Moreover, in the curriculum of Korea, the emphasis is placed on inquisitive experiment classes in which students design their own inquiry process, but inquiry activities presented in science textbooks are often conducted by cookbook-style noninquisitive experiment classes that follow the experiment process (Shim & Song, 2019). Whether it is an inquiry or noninquiry experiment, there is a common purpose for students to build a scientific knowledge system through direct or indirect activities using scientific instruments and materials (Jeong & Chang, 2019).

The type of inquiry applied in actual science class can be determined by various factors such as the science teacher, class situation, preparation, class time, and progress. In Korean science education curriculum, it is emphasised that when conducting experiments and discussion activities, results are derived through cooperative communication with group members, and inquiry activities are conducted as group-by-group cooperative learning to recognise the importance of mutual cooperation in scientific inquiry. Therefore, in science, it is important to analyse which type of inquiry class can appear as the desired form in peer relationship because it is inquiry class that can change the relationship between learner.

In inquiry activities, peer relationships can influence on the outcome of the activity. The reason for this is that the inquiry may be conducted alone, but since it is actually conducted through group activities, the level of design, diversity, and sophistication of the results also differ depending on the relationships between the members in the group (Shim & Song, 2019). Therefore, since inquiry in science is the key, In situations where group activities should be conducted, whether or not to grasp the level of effectiveness peer relationship also affects continuous science teaching and learning. In previous studies, it was held that peer relationship affects science learning (Kim, 2020). In a study by Kim (2020), it was found that as constructive cooperative learning goes on in which various students participate and work together without bullying, classes centered on learners' participation are more active and science is more likely to be recognized as fun and beneficial. Besides. Jakob (2018) noted that science subject needs to activate peer relations through inquiring experiment activities breaking away from theoretical school learning and improves motivation and achievement through cooperative science activities.

In this context, Identifying which type of inquiry class affects peer relationship in inquiry classes that must be absolutely required in science classes is expected to provide great may have implications for giving direction to science inquiry class in the future. Friendship means the formation of human relationship through an interactive cognitive process for colleagues who are interested in the same situation (Mannarino et al., 1994). In particular, At middle school level, where schooling occupies most of adolescents' time, positive peer relationships play an important role in learning social activities and actions by expressing one's own opinions and sharing experiences with each other (Song & Lee, 2011). Moreover, since the relationship of peer relationship has a lot of influence throughout the life of middle school students, it is deeply related to the satisfaction of life (Aspelin, 2012; Lee & Jeong, 2018). Especially, Tu and Chu (2020) reported that peer relationships are considered as an important interactions at school which moreover affect subject learning.

Peer relationship analysis with these characteristics requires analyzing human relationship, and has used recent social network analysis methods (Tabassum et al., 2018; Valente et al., 2015). A social network is a method that seeks to understand the complex relationship of a link that connects a node and a node. Here, if the node is a person, the human relationship between a person and a person can be understood as the degree of connection and the strength of the connection (Knoke & Yang, 2008). In addition, there are characteristics that can identify a person who plays a mediating role between the two.

If the whole class is a large social network, the small community formed in cooperative group science learning is called a sub-network, and even within the sub-network, the relationship between members through inquiry activities can be visualized so that it can be understood at a glance. In particular, social network analysis has been found to have the advantage of being able to identify emotional aspects in science activities and the social characteristics of students in science inquiry activities through a questionnaire to identify peer relationship (Kim, 2020).

Therefore, in this study, after Therefore, in this study, in the second year of middle school science in Korea, in the 'Animals and Energy' unit, an inquiry experiment class and a noninquisitive experiment class were conducted at the same time respectively, the purpose of this study was to check the difference between friendship before and after class using social network analysis. Through the research results, it is expected to suggest important implications for instructional design considering peer relationships in inquisitive experiment class as well as the importance of inquisitive experiment class in the present science teaching & learning methods that value collaborative learning.

The Research Questions were as follows: First of all, what are the indicator and status of peer relationship between inquisitive and noninquisitive science experiment classes, and what are the differences between the classes? Second, what is the type of alienation pattern between inquisitive and noninquisitive science experiment classes, and what is the difference between the classes?

Methods

Participants

In this study, 60 second graders from girls' middle school located in the metropolitan city of Korea were studied. They were taught by a science teacher with 15 years of teaching experience. In the usual science class, during inquiry activities, five students were grouped together to learn through activities at the same experiment table. In addition, the subjects had been in science class together for about 3 months before this study was conducted. However, when the general explanatory class proceeded in science class, learning guidance was given according to the individual type of desk arrangement. For this study, using the same science textbook, 30 students in a class conducted inquiry science experiment and 30 students in a class conducted noninquiry science experiment by the same teacher. Before proceeding with this study, it was confirmed that they were a homogeneous group in the achievement level through the mid-term evaluation. The inquiry science experiment classes and noninquiry science experiment classes were randomly determined among the two second grade classes in charge of a science teacher.

The Process and Subject of the Inquiry Experiment Class and Noninquiry Experiment Class

In science, inquiry is divided into experimentation and conceptual exploration without experiment. Experiments can be divided into inquiry experiments and noninquiry experiments (Kim, 2020).

Inquiry experimentation is when a teacher presents the subject and preparation for an inquiry experiment, and students in each group design experiments to derive experiment results. In the process, when additional necessary preparation were requested, the teacher provided only those in the laboratory. In order not to see the experiment process of the textbook, the subject of the experiment, preparation, and instructions from the teacher were delivered without a textbook, and the group experiment was freely conducted according to the experiment design. However, it is not a subject of complete free inquiry, but an experiment subject that can be completed within a period of time. The subject of an experiment in a science textbook that can be completed in 45 minutes is presented as an experiment that can be completed within time. Teachers acted as advisors and guides so that each group produced results within 45 minutes. However, if more time was required depending on the subject of the experiment, while the science teacher in charge was in the laboratory, the after-school activity time was used, and the additional time did not exceed more than 30 minutes.

Noninquiry science experiment class is a method that students conduct in a deductive format in the form of an experiment process in a textbook. Korean textbooks provide conceptual guidance on the results of inquiry activities and the course of activities in textbooks. In other words, a number of inquiry activities are in the form of knowing the conclusions through the textbook contents. Therefore,

if it proceeds in the form of a science textbook, it proceeds in a deductive form. Above all, as the students who conducted the noninquiry class follow the preparation and procedures presented in the textbook, it was in a form that could be meaningful in that they experimented directly. The inquiry should be finished within 45 minutes, but if more time was needed, an additional 30 minutes was provided through after-school activities under the residence of the science teacher in charge.

The subject of inquiry experiments and noninquiry experiments was the subject of 'Animals and Energy' unit's inquiry activity in the second year of middle school. This unit aims for students to learn the types and functions of nutrients and explore the structure and function of the organ system according to the processes of digestion, circulation, respiration, and excretion through the process necessary to perform life activities with energy obtained by decomposing nutrients. Kim (2014) argued that animals and energy units should be approached systematically by each time, not separately by time, and that the relationship between topics should be understood through inquiry activities as it is important to derive various ideas. Therefore, it was considered that 'Animals and Energy' unit requires a learning process in which students interact with each other through inquiry activities.

A total of 6 topics were extracted from the experimental activities of science textbooks (Table 1). Since this subject does not require professional experimentation, it is a form that can be completed in time, whether in the form of inquiry experiments and noninquiry experiments, provided the necessary preparation are provided. In particular, it is a five-member group activity, so it is an experiment topic that has no difficulty in completing in time. The difference between inquiry and noninquiry experiments only depends on whether students design the experiments themselves or follow the textbook experiment process.

Table 1

Topics and Objectives of the Experiments

	Subjects	Objective
1	Detecting nutrients	An experiment that detects nutrients organic can confirm the nutrients contained in an unknown solution.
2	What nutrients does saliva digest?	Students investigate can check the digestive action of saliva and explain the action of saliva.
3	How do breathing exercises happen?	Using a chest cavity model, students can understand the principles of breathing motion and make students' own chest cavity model.
4	What is the shape of blood cells in the blood?	Blood cells can be distinguished by observing it through a microscope.
5	How is urine produced?	When urine is produced in our body, students can express the path through which various substances travel.
6	expressing the relationship between digestion, circulation, breathing, and excretion through role play	The relationship between digestion, circulation, breathing, and excretion can be expressed through role play.

Data Analysis

The peer nomination method proposed by Moreno (1953) was used to investigate the relationship between the inquiry experiment class and the noninquiry experiment class. The peer

nomination method is a questionnaire that designates the names of friends related to oneself.

The actual questionnaire content was intended to analyze the friendship through inquiry to the subjects of the study with "Who would it be helpful when doing scientific inquiry?" The survey was conducted for 10 minutes each in separate science class hours before the first inquiry activity and after the last inquiry activity and the science teacher supervised it so that pupils did not consult among one another. Since the survey activity is composed of 5 people per group, up to 4 people excluding themselves can write their names. As the members of the same group were requested to be selected, the community formed 6 classes each for inquiry and noninquiry experiments. All 60 student s participated in the survey and inquiry activities without absence. In the analysis process, numbers were given instead of the names of actual students, but they were assigned randomly, not in the order of numbers used in schools, to ensure anonymity.

Social network analysis to identify friendships uses the NetMiner for Friendship program developed by Syram to analyse class relationship indicators (total number of students, number of stud ents selected alone, number of isolated students, tie density, average number of friends, connectivity), peer relationship status (the most selected student, alone, isolated), popularity maps, and friendship maps. The number of students selected alone refers to the number of students who have not been nominated by other students, and the number of isolated students refers to the number of students who have no relationship with other students. Tie density is expressed as a value between 0 and 1 to the extent that peer relationship in the class are formed. The average number of friends refers to the average number of friends made by students, and the degree of connection is shown as a value between 0 and 1 to the extent that all students in the class are connected without isolation, and the closer to 1 means that all are connected.

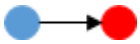
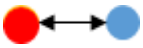
Peer relationship maps take a typical social network format, and it has an interactive pattern that connects class members to each other according to the peer nomination method among class members. Peer relationship map is connected by arrows from the nominating student to the nominated student, and the dot (small circle) in the peer relationship map means the student, and the more nominated, the more concentrated the arrow and the larger the size of the dot.

In order to understand the alienation patterns of peer relationship, six alienation patterns as shown in Table 2 were defined, and the frequency analysis was performed to find the corresponding alienation pattern type for each sub-network. The risk level can be evaluated to be lower as it goes from 1 to 6. Reclusive type is a form of being completely alienated. It is evaluated as a serious level in the relationship in a case of not making and receiving any choices. Unrequited love or one-sided love is a case of making unilateral choices without receiving a nomiation, and can be evaluated as a very incomplete state in peer relationships. Avoidance type is a state unilaterally chosen by only one pupil and a state of not making a choice. One-way type is a case when one is chosen by another, but one chooses the others without forming a mutual relationship. Single-dependent type is a state in which choices are exchanged and rely only on students, but interaction occurs. The self-conceited type is popular and is unilaterally selected by two or more peers, but does not make a choice, so if this situation persists, serious problems may arise in the relationship.

Table 2

Types of Alienation Patterns

Risk ranking	Types	Patterns	Characteristics
1	Reclusive type		A form of being completely alienated in a case of not making and not receiving any nominations.
2	One-sided love type		A very incomplete state of one-sided relationship not chosen by anyone while making unilateral choices

3	Avoidance type		A state unilaterally selected by only one student
4	One-way type		If there is no bilateral connection at all, only one-sided relationship are formed and unstable.
5	Single-dependent type		A state of very high dependence on a student if the others choose only one student.
6	Self-conceit type		A state in a risk as only two or more students unilaterally are selected but do not choose anyone.

In this study, an inquiry and noninquiry experiment class were not conducted together in one class and randomly selected as an inquiry and noninquiry experiment class instead of using both an inquiry and noninquiry experiment in one class. There is a limitation of the study that it was not possible to control the indicator and status of peer relationship, and the patterns of alienation.

Findings and Discussion

Table 3 shows the results of analyzing the index of peer relationship of the class to be studied before and after the inquiry and noninquiry experiment classes.

Table 3

Indicators of Peer Relationships in Experiment Class

Experiment class (n = 30)		Total number of students	Number of students selected alone	Number of isolated students	Tie density	Average number of friends	Connection diagram
Inquiry Experiment Class	Pre	30	10	1	0.046	1.333	0.018
	Post	30	0	0	0.09	2.6	0.138
Noninquiry Experiment Class	Pre	30	12	1	0.04	1.167	0.023
	Post	30	4	0	0.059	1.7	0.087

Before the inquiry experiment class, the number of students who did not receive a nomination from other friends and chose alone was 10, and the number of students who did not have any relationship with other students was 1, and the tie density was 0.046 to the extent that peer relationships were formed in the class. The average number of friends was 1.333, and the degree to which all students in the class were connected without isolation was 0.018. However, after conducting the inquiry experiment on 6 subjects, students selected alone and students isolated did not appear, and the tie density was also improved to 0.09. The average number of friends also doubled to 2.6 and the connection was also improved more than sevenfold to 0.138. After the inquiry experiment, the tie density, average number of friends, and connections were all improved compared to before. In particular, given that zeroes appeared in the number of students selected alone and isolated, the inquiry experiment class is believed to have increased the relationship between students by activating interactions within the group. This means that as the Inquiry Experiment Class goes through the process of designing experiments in cooperation with the members of the group, the time to exchange

opinions for cooperation among members increases, the number of isolated students decreased due to the increase in tie density, and the number of students who were selected alone was judged to disappear. As such, in inquiry experiments, it can be assessed that learners played a role as active creators of thought ideas and the teacher as a guide to the listener. In particular, inquiry experiments can facilitate problem solving and critical thinking learning through group activities and are believed to have played an active role as a participant in order to receive a good evaluation as a qualitative assessment.

Before the noninquiry experiment class, the number of students selected alone was 12, the number of isolated students was 1, the tie density was 0.04, the average number of friends was 1.167, and the connection rate was 0.023. After the noninquiry experiment, the number of students selected alone decreased to 4, and the number of isolated students did not appear. Tie density was also slightly improved to 0.059, and the average number of friends was 1.7, and the connection was 0.087, which was slightly improved compared to before class. In the noninquiry experiment, the density of the relationship increased somewhat, but there were still students who chose alone. The reason for this was that there was no change in social familiarity among the members as the amount of conversation was reduced and the opportunity to share each other's ideas was limited by the set course of the textbook experiment. In the noninquiry experiment, it is difficult to form an active community because the learner is highly likely to become passive, so an increase in tie density is evaluated as unpredictable.

As a result of comparative analysis according to the two experiment classes, in the dictionary, the number of students selected by the noninquiry experiment group alone was more than two, and other factors were analyzed at almost similar levels. However, after both experiment classes, no single student was selected in the inquiry experiment class, and the tie density, average friend count, and connectivity were nearly twice as high as in the noninquiry experiment class, making the inquiry experiment more effectiveness than the noninquiry. In particular, considering that the average number of friends is 0.9 higher, having more relationship with an average of one friend could be evaluated as a big change, given that there are five in a group. Salinitri et al. (2018) argued that science class is not a teacher-led form, but a learner-led form, and in order to achieve this, inquiry-oriented classes must be conducted. Through this, it was considered that the relationship between students could be improved in the process of deciding whether to accept each other's opinions while expressing their opinions freely. Whether it is an inquiry experiment class or a noninquiry experiment class, the overall low level of connection can be interpreted as being low because the level of connection within a group was confirmed rather than selecting a fellow friend in the whole class. However, as there was no isolated student after death in both the inquiry experiment class and the noninquiry experiment class, it could be interpreted that inquiry activities in science subjects promote cooperative activities in the group. In this context, Romero-Ariza et al. (2019) saw that inquiry plays a role in reducing stress in forming peer relationship by naturally inducing relationship between new colleagues.

Table 4 shows the pre and post companion relations between the inquiry and noninquiry experiment classes.

Table 4

Shows the Pre and Post Companion Relations between the Inquiry and Noninquiry Experiment Classes

Experiment class		Most nominated students (number of nominations)	Students not nominated by other students	Group (a group in which all members are completely connected to each other, with 3 or more members)
Inquiry experiment class	Pre	E-S14(4), E-S27(3), E-S18(3), E-S13(3), E-S8(3), E-S7(3), E-S4(3)	E-S3, E-S6, E-S9, E-S10, E-S11, E-S15, E-S20, E-S21, E-S24, E-S30	
	Post	E-S27(4), E-S2(4), E-S29(3),E-S25(3),E-S22(3),E-S21(3),E-S18(3),E-S17(3),E-S15(3),E-S14(3),E-S13(3),E-S12(3),E-S10(3),E-S8(3),E-S7(3),E-S6(3),E-S1(3)		1(E-S1, E-S2, E-S3) 2(E-S6, E-S7, E-S8) 3(E-S12, E-S14, E-S15)
Noninquiry Experiment Class	Pre	NE-S25(3),NE-S20(3),NE-S19(3),NE-S12(3),NE-S9(3),NE-S1(3)	NE-S2, NE-S5, NE-S7, NE-S8, NE-S11, NE-S15, NE-S17, NE-S18, NE-S22, NE-S24, NE-S26, NE-S29	
	Post	NE-S10(4),NE-S27(3),NE-S25(3),NE-S19(3),NE-S7(3),NE-S3(3)	NE-S2,NE-S8,NE-S17,NE-S26	

Before the inquiry experiment class, seven students were nominated by three or more members, and no group appeared in a group where all members were completely connected to each other. However, after the inquiry experiment class, 17 students were designated by more than 3 members, and 3 complete groups with 3 completely connected appeared. In particular, 1 student was beforehand selected by 4 in a group composed of five, but after that 2 students were selected. Overall, if there were 17 out of 30 students who were designated by more than three students after an inquiry experiment, more than 50% of the students were nominated, and it could be interpreted as active interaction in the group. In addition, 3 students completely connected groups consisting of 5 showed 3 out of 6 groups, indicating that 50% of the total formed a complete community.

Before the inquiry experiment class, there were 6 students were nominated by 3 or more members, and no group with 3 or more members fully connected did not appear. After the noninquiry experiment class, there were 6 students who were nominated by more than 3 members, showing the same number before and after. However, it was analyzed that one student was identified by four members after that. But no fully connected group of more than three members appeared.

It is surmised that the reason that the students who were designated by three or more members before inquiry experiments and noninquiry experiments are similar is that they have been given the same class by the same science teacher so far. However, given that the number of students who was nominated by three or more students of inquiry experiment classes is nearly three times more than that of noninquiry experiment classes, interaction is activated in the process of designing the experiment process directly and positively affects the friendship between groups.

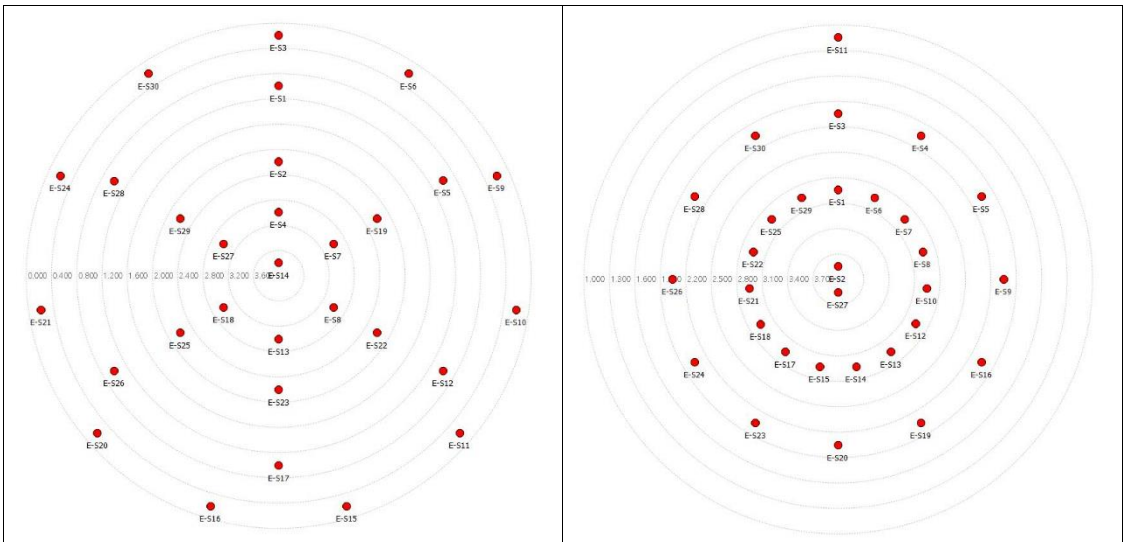
In particular, given that three fully connected groups which did not appear in noninquiry experiment classes appeared in the inquiry experiment class, the interaction in one group was active, and the fully connected group was activated in the group by building acquaintances in science

learning activities, Jeong et al. (2007) stated that students can communicate with their peers while engaging in open inquiry activities, and that the process of agreeing and negotiating behavior decisions occurs naturally. Carter and Nutbrown (2016) interpreted that the learner's friendship is not achieved in a simple one-sided solving of subject tasks, but because there are special factors that form an intimate network of relationship. Therefore, the special factor is considered as self-experiment design, which is characteristic of inquiry experiment classes. Cozoulino (2013) saw that the incidence of bullying was high after experiencing a social transition period in middle school. Cho and Choi (2015) also said that middle school students spend most of their daily lives in relationship with school classmates, and that friendship has an important impact on their healthy emotional development, personality formation and social habits. It can be expected that it can affect the social activities among schoolmates.

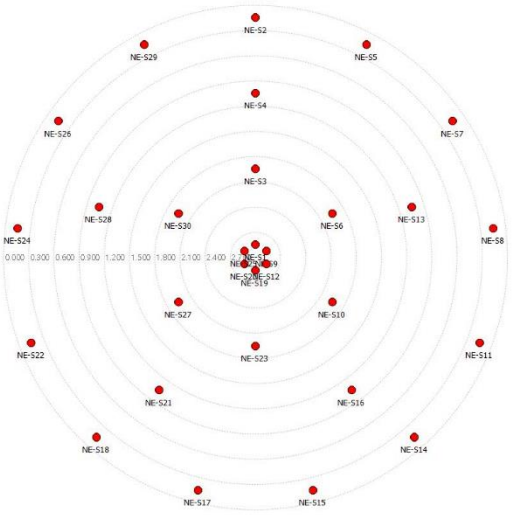
As a result of analyzing the popularity map (Figure 1), it can be seen that the inquiry experiment class is in a circular picture the post class compared to the pre class and it is spread out at the pre class and gathered in the middle at the post class. It can be interpreted that the number of highly popular students has increased. It can also be interpreted as a result of an increase in the number of students designated by more than three students than those who are not named. In the pre class, as noninquiry experiment classes, some students are gathered in the centre of the circle and many students are distributed on the outer side of the circle. In the post class, there is a tendency to gather inward around the centre of the circle, but some students can still be seen distributed at the outer angle. Therefore, it could be judged that the degree of popularity of the inquiry experiment class, which is the level designated by other students after class, was improved for several students than that of the noninquiry experiment class.

Figure 1

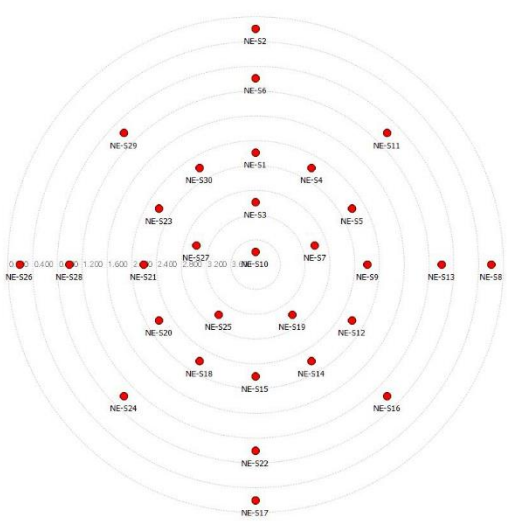
Popularity Map Before and After Inquiry and Noninquiry Experiment Classes



Popularity Map Before Inquiry Experiment Class	Popularity Map After Inquiry Experiment Class



Popularity Map Before Noninquiry Experiment Class



Popularity Map After Noninquiry Experiment Class

Table 5 shows the results of analyzing the types of alienation patterns in the relationship between peers before and after the inquiry and noninquiry experiment classes. The maps of the pre and post friend relations of the inquiry and noninquiry experiment classes are shown in Figure 2-5. Since group activities were organized into 6 groups for each class, six group maps for each experiment class in the friendship map could be observed.

Table 5

Analysis Result of Alienation Pattern Type

Unit: Number of times (person)

Ranking	Type	Inquiry experiment classes.		Noninquiry classes.	Experiment
		Pre	Post	Pre	Post
1	Reclusive type	1	0	1	0
2	One-sided love type	10	0	12	4
3	Avoidance type	1	0	0	0
4	One-way type	6	3	9	8
5	Single-dependent type	0	0	2	0
6	self-conceit type	1	0	0	0
	Total	19	3	24	12

Before the inquiry experiment class, there were 1 lonely type, 10 unrequited love type, 1 avoidance type, 6 one-way type, and 1 self-conceit type. In other words, it was a very incomplete pattern because many students had a one-sided relationship with no one who chose the student as a one-sided love type. After that, there were many one-way types, which were unstable because only a

one-way relationship was formed that was not connected by both sides. Thus, a total of 19 alienation patterns of the alienation pattern types appeared in the pre class. After the inquiry experiment class, there were only 3 one-way types. Given that the rest of the alienation pattern types did not appear, it was confirmed that the percentage of complete peer relationship increased. In other words, four groups in a total of six groups could be seen forming very complete friendships. However, since the two groups are also one-way type, rather than a high-risk reclusive type or unrequited love type, there is a high possibility of a two-way connection if inquiry experiment classes are continuously conducted. This is because in open scientific exploration, long-term exploration together can create intimacy and become psychologically close (Kim & Kwon, 2016). Kim (2018) also reported in the study that if one-way type becomes a circular or fully connected type through continuous relationship formation, as the opinions suggested by the person are returned through other members, there is high possibility that multi-directional communication is possible and everyone is more likely to participate without alienated students.

Before the noninquiry experiment class, there were analyzed as 1 reclusive type, 12 one-sided love types, 9 one-way types, and 2 single-dependent types. Given that there are many high-risk unrequited love types, peer relationship was analyzed in a very incomplete form before the noninquiry experiment activities. A total of 24 alienation patterns appeared in the pre class. After the noninquiry experiment class, the total alienation pattern was 12, which was significantly reduced by half compared to the previous one, but it was difficult to say that even one group had a perfect peer relationship, as there were still 4 unrequited love types and 8 one-way types. This non-exploratory experimentation class tends to follow the textbook experiment process as it is, so it is judged as a result of the inability to revitalize peer relationship through communication such as discussion.

Although it started with a difference in the total number of preliminary alienation patterns bet ween the noninquiry and inquiry experiment classes, the exploratory experiment classes saw a higher decrease in the ratio compared to the post class. Therefore, it was judged that the science subject emph asized cooperative activities, and as the positive peer relationship through this was important, the inq uiry experiment class should be activated. Open inquiry has the effectiveness of enhancing the interact ion among members with opportunities for students to take the lead in solving problems (Lee & Lee, 2 009). Inquiry, in which students design their own experiment process, constantly communicates with f riends and gives each other help to solve the inquiry problem, and sometimes conflicts arise, but they also learn how to solve those (Kim & Kwon, 2016). Wang et al. (2022) argued that open inquiry class h elps students make plans, deduct results, discuss with peers and reach agreements with scientific idea s and even promotes their interaction.

Figure 2

Inquiry Experiment Class Pre Peer Relationship Map and Alienation Pattern Type

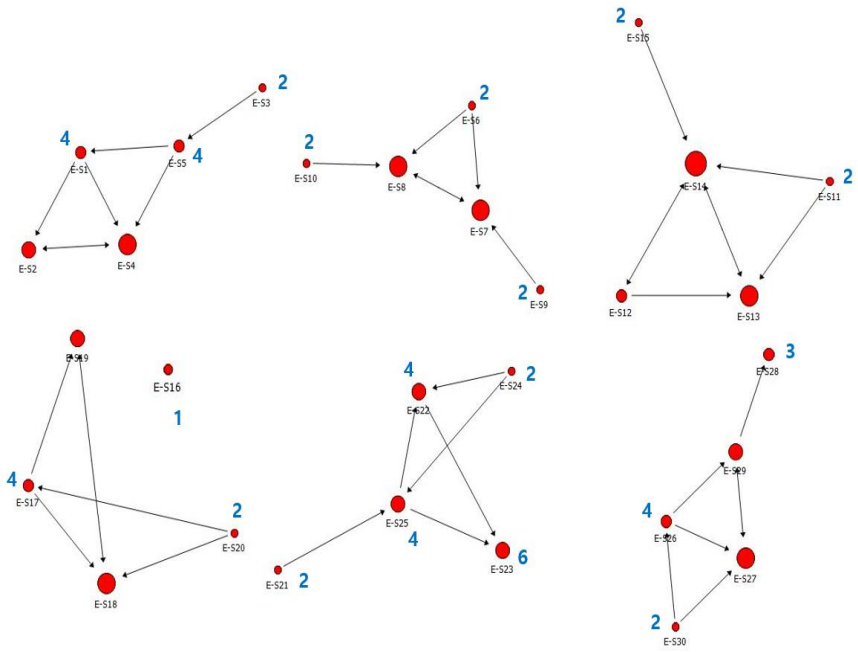


Figure 3

Inquiry Experiment Class Post Peer Relationship Map and Alienation Pattern Type

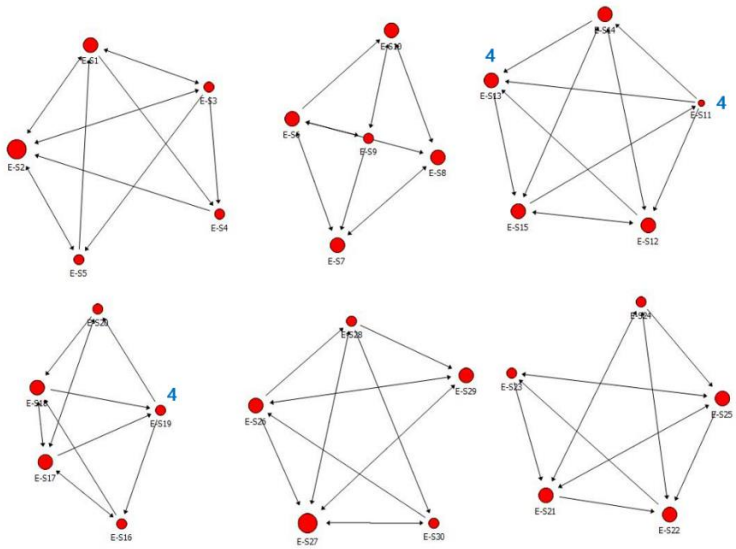


Figure 4

Noninquiry Experiment Class Pre Peer Relationship Map and Alienation Pattern Type

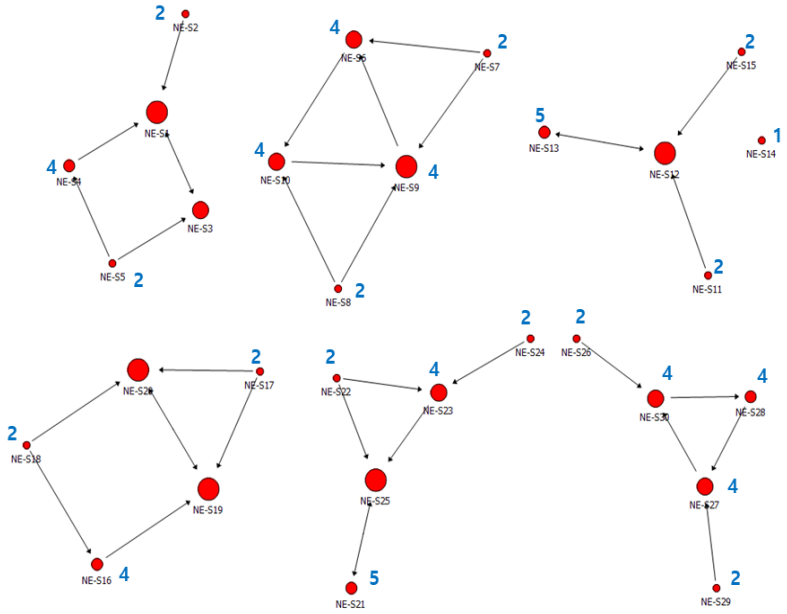
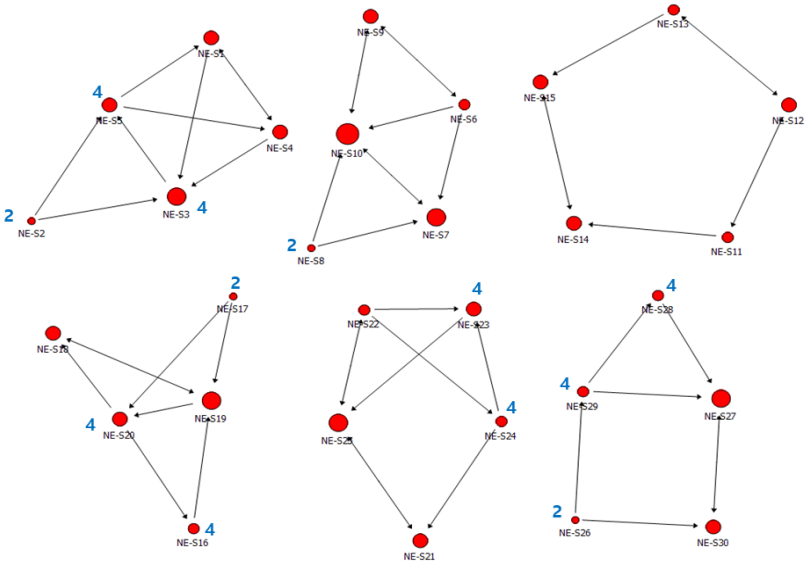


Figure 5

Noninquiry Experiment Class Post Peer Relationship Map and Alienation Pattern Type



Conclusion and Suggestions

The purpose of this study was to compare and analyze changes in peer relationship, with 30 of the total 60 students in the second year of middle school in Korea, 30 students taking inquiry experiment classes and 30 noninquiry experiment classes. The class was conducted by one science teacher.

There were 10 students who were selected alone before the inquiry experiment class, but 0 after that, and one isolated student appeared in the pre inquiry experiment class, but did not appear after the inquiry experiment class. Tie density, average number of friends, and connection were also

improved after that. The number of students selected alone was 12 before the noninquiry experiments class, but after that decreased to 4. The number of students who were isolated was 1 before the noninquiry experiments class, but also decreased from 1 to 0 after that. Tie density, average number of friends, and connection were also improved. Therefore, it was seen that the index of peer relationship was improved through inquiry activity, so inquiry activity could be seen as improving the relationship regardless of type. However, in view of the higher tie density, average number of friends, and connection of the inquiry experiment class than that of the noninquiry experiment class, it could be evaluated that the inquiry experiment was more effectiveness in improving the density of peer relationship index than the noninquiry experiment class.

As a result of analyzing the status of peer relationship, the number of students who were designated by three or more colleagues at the post inquiry experiment class compared to the pre inquiry experiment class increased, and three groups were completely connected with three or more people. In the noninquiry experiment class, there was no change in the number of students who were nominated for three or more, but the number of students who were not designated decreased. However, it was analyzed that the complete group could not be formed in the noninquiry experiment class. In addition, in the analysis of the popularity map, it was found that the popularity of many students after class compared to before the inquiry experiment class was gathered from the outside to the center in the original figure, but before the noninquiry experiment class, only some of the students started with a group of students in the middle. After class, some students were still not picked up by other students and popularity map also can be seen staying in the outskirts. In other words, in inquiry experiment classes, it was possible to see a popularity map from the spread form to the gathered form and in noninquiry experiment classes, it was possible to see a popularity map of the spread form. Therefore, even in the analysis of the relationship status of peer relationship, it could be evaluated that the inquiry experiment class is more effectiveness in improving the awareness of members and forming a fully connected community compared to the noninquiry experiment class.

As a result of analyzing alienation pattern types, a total of 19 patterns appeared before the inquiry experiment class, but significantly decreased to 3 after the inquiry experiment class. Even in the noninquiry experiment class, the number of alienation pattern types was cut in half from 24 beforehand to 12 afterwards. In comparison between two classes, when it is seen that the inquiry experiment class has a higher percentage of alienation pattern types compared to the noninquiry experiment class, it can be seen as more effectiveness in improving peer relationship. In particular, it was analyzed as a large feature that high-risk unrequited love types did not appear after the inquiry experiment class.

Alienated students are not active in learning science and are likely to hate science. Therefore, it is necessary to prepare a solution by grasping the relationship in advance. In particular, as science subjects which focus on inquiry often have to achieve results through group activities rather than individual activities, an inquiry-based experiment class type should be activated.

In this study, quantitative changes in peer relationship were analyzed through social network analysis. This quantitative analysis can confirm the effectiveness in the consequential aspect of inquiry instruction, but qualitative analysis must be accompanied to find out the cause. Therefore, in future research, it is necessary to find out what aspects of the inquiry experiment class are more effectiveness in improving peer relationship compared to the noninquiry experiment class through interviews with students participating in the study. In addition, observation evaluation should also be made on what factors affect peer relationship through direct observation by researchers during inquiry activities. Meanwhile, in order to generalize the results of this study, it is necessary to verify the difference in the relationship between peers in elementary science and in high school science inquiry experiment classes and noninquiry classes.

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