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GENDER DIFFERENCES IN EXPERIENCES OF 6TH-GRADE STUDENTS INQUIRY ACTIVITIES IN THE REPUBLIC OF KOREA

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Abstract. *Each student's individual experience in learning is very important. Lower secondary school students are engaged in activities that focus on inquiry rather than the acquisition of scientific knowledge in science classrooms. Therefore, the experiences and thoughts of lower secondary school students in the stage of scientific inquiry need to be analyzed. To this end, the internal and external experiences of students in the stages of observation, variable control, and conclusion drawing were analyzed through candle-burning experiments. Seventy-seven 6th-grade students were used as participants. The main activities; main actions; main thoughts; and contribution of actions, consciousness, and emotions were analyzed. No differences were observed in the external and internal experiences of male and female students in each stage of the inquiry activities. There were many cases in which other activities related to the inquiry were carried out in addition to the activities that were mainly performed at the corresponding stage. About 1/4 of the participants had internal experiences unrelated to inquiry. The results showed that interaction needs to be increased by including the variable control stage in the inquiry activities. Given that there were no differences in the external and internal experiences of male and female students, equal inquiry activities without gender discrimination can be achieved.*

Keywords: *internal experience, external experience, inquiry stage, gender difference.*

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Introduction

Individuals have various experiences, and depending on the way they construct and interpret the meaning of their experiences, they determine various future behavioral directions. The same goes for learning. In science education, it is the experience of learners directly participating in physical activities and thinking activities related to science and includes learners' emotions and subjective thoughts based on the experiences of classes or inquiry activities in the school curriculum (Choi & Choi, 2012). These experiences can play an important role in the formation of learners' scientific knowledge.

The most representative class in science class is inquiry activity. Inquiry activities are emphasized to encourage active participation and interaction among students in science classes (Nam et al., 2002). They are favored by students (Lim et al., 2021), but they are also a reason why students dislike science classes (Lee et al., 2007; Kim & Yang, 2005). In other words, the critical factor that determines success or failure in science education is inquiry activities (Kang et al., 2007). Small-group inquiry activity is one method for successfully completing inquiry activities. In this activity, students plan the process from designing experiments to drawing conclusions by interacting with other members and experience the problem-solving process by presenting, accepting, criticizing, modifying, and discussing opinions (Lumpe & Staver, 1995; Richmond & Striley, 1996).

Many studies have analyzed the effects (Gillies, 2008; Johnson & Johnson, 2003; Slavin, 2013; Stevens, 2003), role types (Maloney, 2007; Richmond & Striley, 1996), and interactions among students in small-group inquiry activities (Alexopoulou & Driver, 1996; Kim et al., 2017; Lim et al., 2020). However, these studies failed to analyze what kind of activities and actions, thoughts, consciousness, and emotions were experienced by students in each stage of the scientific inquiry activities.

Meanwhile, Problem-solving strategies or interactions in small-group inquiry activities vary depending on gender (Lim et al., 2020; Peltz, 1990), academic achievement, interest, and affective aspects (Alexopoulou & Driver, 1996; Yang et al., 1996; Yang et al. al., 2006). In particular, it is reported that there is a very clear gender difference in attitudes related to science (Park & Shin, 2011). These differences can have a negative impact on successful scientific inquiry activities. Therefore, a study on the causes of gender differences in small group inquiry activities is required.

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Students experience various events, interactions, activities, and thoughts at every moment during small-group inquiry activities. If an analysis is conducted on the interaction or experiences of each stage in the small group inquiry activity, that is, the activities and thoughts, it is possible to find the cause of the gender difference as well as the specific implications for the success of the small group inquiry activity. Therefore, it is necessary to analyze what kind of activities and actions, what kind of thoughts, and what kinds of consciousness and emotions are experienced in each stage of scientific inquiry activities. These experiences are mainly divided into external and internal experiences (Hektner et al., 2007). External experience refers to events experienced externally (Hektner et al., 2007), whereas internal experience refers to events experienced internally (Kim et al., 2005). The experience sampling method (ESM) is used to determine external and internal experiences.

ESM can analyze what kind of activities and emotions that participants feel under what circumstances at a specific time (Hektner et al., 2007). It has been used in various cultures for a long time and is recognized for its reliability and validity (Park & Choi, 2018). ESM can reduce memory bias because it immediately secures information at a specific moment and is suitable for analyzing various psychological changes that students experience. In particular, ESM needs to be applied when the participant is a student because it is difficult to maintain consistency in subjective judgment on cognition or emotion (Savin-Williams, 1987).

ESM is actively applied in psychology or empirical research for professional development. In the field of education, a previous study examined the link between the quality of a cooperative learning environment and the quality of students' experiences in subjects such as English, mathematics, science, and sociology (Shernoff et al., 2016). Another study analyzed the experiences of leaders and alienated students in inquiry activities (Choi et al., 2022). Therefore, it is useful to analyze the experience of general students according to gender.

In lower secondary school, emphasis is placed on improving the inquiry process rather than scientific knowledge (Haefner & Zembal-Saul, 2004), and many inquiry activities centered on observation or simple experiments are performed. The small-group science inquiry activities experienced by lower secondary school students during this period determine very diverse perceptions, such as their future jobs related to science and technology or their dislike for science (Kim & Shin, 2013). Therefore, it is required to have an interest in science and a correct perception of it in the lower secondary school age (Korean Association of Career Education, 2000), which is the stage in which students begin to recognize their career path. Therefore, it is meaningful to analyze the experiences that lower secondary school students experience in small-group science inquiry activities.

In this study, ESM was used to compare external and internal experiences according to gender in small-group science inquiry activities in lower secondary schools. External experiences were divided into the main activities and actions, and internal experiences were divided into thoughts, contributions of actions, consciousness, and emotions, and these were compared and analyzed according to gender groups. To this end, the differences between male and female students were analyzed by comparing the external and internal experiences experienced by both groups at each stage of scientific inquiry activities (observation, variable control, and conclusion drawing). Through this study, it will be possible to provide guidance for inquiry activities by identifying the behavior and thoughts of lower secondary school students in the inquiry stage.

Theoretical Background

Experiences

The daily life experienced by individuals, which consists of trivial things being repeated every day, has been taken for granted. However, from the beginning of emphasizing the specific reality and life of individuals in everyday life, experience has become the subject of academic research (Han & Son, 2009). Individuals, who are the subject of experience, experience various events and activities, and through these external activities, individual subjective evaluations are made at each moment, resulting in various internal experiences. These experiences are settled and accumulated in various forms in human memory. Experience is not simply linear, but it takes on a complex character that is influenced by previous experiences and also affects future experiences. Beyond this temporal sequence, it is reconstructed and reorganized.

Experience can be divided into external and internal experiences (Csikszentmihalyi, 1990). External experience means "an experience that one actually experiences or experiences externally." Internal experience can be defined as "an experience experienced internally in the mind or heart." The former is related to "where, with whom, and what we did," whereas the latter refers to psychological factors related to "what we felt and thought" in such activities.

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In the case of external experiences, previous studies usually classify into the type of activity (Lee & Choi, 2011), the people with whom they are together (Hnatiuk, 1991; Larson et. al, 1986; Lee & Choi, 2011), and the current place (Larson & Richards, 1994; Schneider & Waite, 2005). In the case of inquiry activities, since the current place is the same, the type of activity, and the people with whom they are together were used for classification. At this time, Kim et al. (2005), it was conducted by reflecting the characteristics of science inquiry activities.

On the other hand, although we have various external experiences, what actually determines our consciousness and behavior is the internal experience of how our emotions react when we do these actions (Csikszentmihalyi, 1990). Likewise, although external experiences are important, it can be said that an individual's internal experiences in the process of life are very meaningful to us (Fredrickson, 2009). Accordingly, the internal experience was categorized into what kind of thoughts were made during inquiry activities, whether one thought that one's actions contributed to inquiry activities (Csikszentmihalyi & Schneider, 2000), and what kind of consciousness and emotions were felt during inquiry activities (Shernoff et al., 2016).

Previous studies on experience classified quality of life into internal and external experiences (Kim & Kim, 2019; Lee, 2017) and analyzed students' class environment (Park, 2018; Cho & Kim, 2018). In science education, studies have analyzed the influence of science awareness and experience on career choice in science and technology (Lee, 2011) and conducted qualitative research on self-efficacy according to science teachers' experiences (Park, 2001). In addition, some studies have surveyed the impact of informal science experiences outside the classroom (Bell et al., 2009; Galen, 1993; Parker & Gerber, 2002) and science experiences through mentorship with experts in the field of science (Feldman, 2007; Koch & Appleton, 2007; Markowicz, 2004) on students' cognitive and affective aspects. However, these studies did not analyze students' actual experiences during scientific inquiry activities.

The Experience Sampling Methods

A person's behavior is what appears in the interaction with the situation (Oishi et al., 2004). ESM was developed by Csikszentmihalyi and Larson as an effective way to properly identify changes in human behavior depending on the situation. Several previous studies (Brandstatter, 1983; Flory et al., 2000; Oishi et al., 2004) revealed the complexity of the interaction between situations and humans, all of which used ESM. Since ESM requires immediate responses at random points in real life, it has the advantage of being able to analyze complex interactions of situations, behaviors, and emotions.

It is a psychometric method in which participants' actions are stopped at specific points and their experiences are recorded in real time. The ESM is classified into three types according to the response signal notification method: interval-contingent sampling, signal-contingent sampling, and event-contingent sampling (Reis, & Gable, 2000). Interval-contingent sampling is a method of responding at predetermined intervals. Signal-contingent sampling is a method of responding according to a randomly notified signal without fixing the timing. Although it can reduce the psychological distortion of the respondent, it has a problem of increasing the burden on the respondent. Event-contingent sampling is a method of responding when a predetermined event occurs. Event-contingent sampling is effective when analyzing events with a very low frequency of occurrence (Cho & Nam, 2005). Likewise, because participants' experiences are sampled multiple times, a reasonable understanding of the phenomena experienced by individuals can be obtained, and changes in participants' experiences can be observed over time (Stone et al., 1999). It is also a research method with very high ecological validity that immediately grasps what an individual feels and thinks on their own in a state where the intervention of the observer is minimized without resorting to reminiscence (Csikszentmihalyi & Larson, 1987). Therefore, in previous studies on ESM, the internal and external experiences experienced by general students (Choi et al., 2003; Csikszentmihalyi & Graef, 1980; Kim et al., 2005; Shernoff et al., 2016), gifted children (Choi & Choi, 2012), and adults (Han & Son, 2009) regarding small sample of a specific layer were measured in specific situations, and the resulting quality of life or emotions were analyzed. In other words, ESM records and analyzes the experience or emotion of the period presented by the researcher in a questionnaire distributed in advance to the subject (Hektner et al., 2007).

ESM compensates for the disadvantages of existing research methods, such as memory errors caused by recall, and allows the observer to directly record the behavior and emotions of subjects, preventing the involvement of the observer's subjectivity. In addition, as a method to effectively identify changes in human behavior according to various situations, ESM can analyze the complex interaction between situations, individual behavior, and emotions (Shin, 2010).

Experiential knowledge helps solve problems in new and uncertain situations by providing information about

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possible limitations in solving the problem, what to focus on, or what not to do (Kolodner, 1997). In this way, students' experiences can provide implications for teaching-learning strategies. In particular, by analyzing students' experiences in science inquiry activities, which are the most representative form of class in science subjects, it is possible to provide implications for the success of science inquiry activities and science learning. Therefore, it is very useful to measure the behaviors and emotions that students typically experience during scientific inquiry activities by ESM.

Research Methodology

Design

This study was conducted using a quantitative research design to answer the research question. The quantitative research design involves collecting quantitative statistical data on several variables studied to answer the research questions (Cohen & Manion, 1994; Creswell, 2003). This study is a quantitative research design that collects data using questionnaires.

The independent variable in this study was gender, and the dependent variables were external and internal experiences during inquiry activities. Quantitative data of this study were collected by modifying and supplementing the questionnaire developed by Kim et al. (2005) on external experience and the questionnaire developed by Csikszentmihalyi and Schneider (2000) and Shernoff et al. (2016) on internal experience.

The study was conducted from October to December 2018. The participants were students from three schools located in metropolitan cities and municipalities in the Republic of Korea and were sixth-grade lower secondary school students who were not gifted or special students.

Under the scope of this study, the participants were invited through the homeroom teacher at the lower secondary school. All of the participants and their parents agreed to participate voluntarily in the research. While collecting the data, the participants did not write their names and last names while responding to the items.

Participants

The participants of this study were 6th-grade students. Students from two schools located in a metropolitan city with a population of 2.5 million and one school located in a city with a population of 300,000 in the Republic of Korea were sampled. A total of 77 students (40 male and 37 female students) were sampled. Students who agreed on the purpose and method of the study were targeted, and the science achievement level of these students was moderate. By the central limit theorem, this study was conducted on the basis that quantitative verification is possible because if the sample for quantitative verification is large enough ($n>30$), independent, and sampled at random, it exhibits a normal distribution regardless of the distribution (Kwak & Kim, 2017).

Inquiry Programs

The program used in this study is a candle-burning experiment. In this inquiry activity, a candle is set in clay in a water tank, and a glass cup is placed over the candle. Students observe the rising water level in the glass as the candle goes out. Through observation, an inquiry problem is given, and an experiment is designed and conducted to solve the given inquiry problem. The reason for selecting this topic is that it is not covered in lower secondary schools in the Republic of Korea, so it is possible to conduct research activities without prior knowledge. The total time of the program was 100 min (40 min for the observation stage, 25 min for the variable control stage, 25 min for the conducting experiment stage, and 10 min for the conclusion drawing stage).

The stages of inquiry activity consist of observation, variable control, and conclusion drawing. In the observation stage, students directly observed the candle burning and described various observations. After the observation activity, the classroom teacher presented the research topic "the amount of water rising in the collector according to the number of candles." In the variable control stage, the experimental design was designed to verify the research topic presented through interaction among the group members. At this stage, the group members were asked to discuss with each other how to control the variables and carry out the experiment in detail. According to the experimental plan, each small group conducted the experiment, collected the data, converted the data, and drew conclusions based on the experimental results.

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Questionnaire

ESM was used to analyze external and internal experiences in scientific inquiry activities. The questionnaire surveys students' external and internal experiences in three stages: observation, variable control, and conclusion drawing.

The questionnaire consisted of the main activities and main actions as the external experience and the main thought and contribution of actions during the inquiry activities as the internal experience. For internal experience, questions about consciousness and emotions felt during inquiry activities were included. Table 1 presents the detailed composition of the questionnaire items.

Table 1
Composition of the Questionnaire

Experience	Item numbers	Contents	Item type
External experiences	1	Main activities	Closed-ended
	2	Main actions	Open-ended
Internal experiences	3	Main thoughts	Open-ended
	4	Contribution of actions	Open-ended
	5	Consciousness*	Likert scale
	6	Emotions*	Likert scale

*survey after the scientific activity

The items of the main activities and actions of external experience were based on the study by Kim et al. (2005) with some modifications. The main activities in the external experience were structured in closed-ended questions so that students could present and choose from listening to the teacher's words or directives, conducting the experiment with their peers, talking about the experiment, and personal behavior (Kim et al., 2005). The main actions were configured in open-ended questions so that the participant could record what kind of action and with whom it was conducted during the inquiry activity.

The main thoughts and contributions of the main actions of internal experience were constructed based on the form used by Csikszentmihalyi and Schneider (2000). Consciousness and emotion during inquiry activities were used by modifying the questionnaire by Shernoff et al. (2016). The main thought in the internal experience was made possible to present all of the thoughts that were in each stage of the inquiry activity and to present activities related and unrelated to the class. The contribution of actions made it possible to suggest whether the actions of the participant were helpful to the inquiry activity (Shernoff et al., 2016). In addition, in the internal experience, the consciousness and emotion felt during the inquiry activity were presented on a five-point scale.

Six experts were consulted to verify the validity of the test items. Among them, four had doctoral degrees in science education, and two were science teachers with master's degrees and more than 10 years of experience. The content validity of the item was 90.4%. The Cronbach's alpha and reliability of the questionnaire for consciousness and emotion were .939 and .872, respectively.

Analysis Framework

To analyze the open-ended items in the questionnaire, students' external and internal experiences were categorized into experimental activities (A), emotions (B), interactions (C), and others (D) sections based on the questionnaire's contents (Table 2). The experimental activities section (A) selected observation, measurement, variable control, result prediction, data transformation, and conclusion drawing in the basic inquiry and integrated inquiry among the inquiry process elements of the Test of Science Process Skills. Experiment preparation (A1) and conducting experiment (A2) were added because the activities of preparing and conducting experiments through interaction among students within a small group are important activities.

The emotion section (B) was classified into positive and negative emotions. Positive emotions are fun, enjoyable, exciting, interesting, surprising, and want to do more experiments, whereas negative emotions are futile, annoying, difficult, boring, and uninteresting.

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The interaction section (C) was classified into questions, responses, presentation of opinions, receiving opinions, behavioral participation, atmosphere, and responses to opinions (Lee et al, 2002). Experiences that were not included in the above classification and actions, thoughts, and non-responses that were not specifically related to inquiry activities were classified in the others section (D). The validity of the analysis framework was obtained by consulting five science education researchers, and a validity of 88% was obtained.

Table 2
Framework for Analysis

Experimental activities (A)	Experiment preparation(A1), conducting experiment (A2), observation(A3), measurement(A4), variable control(A5), result prediction(A6), data transformation(A7), data interpretation(A8), conclusion drawing(A9)
Emotions (B)	Positive emotion(B1), negative emotion(B2)
Interactions (C)	Question(C1), response(C2), presentation of opinions(C3), receiving opinions(C4), behavioral participation(C5), atmosphere(C6), responses to opinions(C7)
Others (D)	Non-response, actions, and thoughts not related to inquiry activities (e.g., personal action, small talk, thinking about games, thinking about break time, etc.)

Data Collection and Analysis

People's experiences emerge through their interactions with situations (Oishi et al., 2004). In other words, students' experiences emerge in the interaction with the situation of inquiry activities. In order to collect various internal and external experiences experienced by students, the small group was randomly composed of five members. According to Lim et al. (2019), the most diverse forms of interaction appear in a small group consisting of five members, it was assumed that various internal and external experiences could be collected. According to the science block time, the science inquiry activities took three classes, each lasting 40 minutes. At this time, event-contingent sampling, which is the most efficient way to sample students' experiences in the special situation of scientific inquiry, was used (Cho & Nam, 2005). In the Republic of Korea, most participants in lower secondary schools, including science, are taught by homeroom teachers. Lower secondary school education in the Republic of Korea is centered on the class, and the homeroom teacher is responsible for managing each class. Homeroom teachers in lower secondary schools, guide students in subject learning, help them adjust to society, provide evaluation and feedback, and provide guidance and counseling on life attitudes. This inquiry activity program was also conducted by the homeroom teacher. Before the inquiry activity program was conducted, the homeroom teacher held a seminar and practiced on the program treatment process in advance.

When each step of the inquiry activity was completed, an alarm was sounded, and each step-by-step questionnaire was answered for 10 min. Among the questionnaires collected from the students, closed-ended items were analyzed based on frequency analysis, and open-ended items (item 2 to item 5) were analyzed based on the analysis framework (Table 2). Four doctors of science education used the analyzed data to determine agreement, and 92% agreement was obtained among them.

The collected data were quantitatively analyzed using SPSS 25.0. The open-ended items were analyzed in a classification frame, followed by descriptive statistics, and the χ^2 test was used to compare male and female students in each stage of the inquiry activity. In the case of the five-point Likert scale items, differences were compared and analyzed through descriptive statistics and independent sample *t*-test. In the case of negative items, analysis was performed through reverse scoring.

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Research Results

External Experience

Main Activities

The external experience in the inquiry activity stage was largely classified into main activities and main actions. Table 3 shows the main activities that students performed in the stages of observation, variable control, and conclusion drawing among scientific inquiry activities. This allows for multiple responses.

Table 3
External Experience regarding the Main Activity at Each Stage of Inquiry

	Observation: *n*(%)			Variable control: *n*(%)			Conclusion drawing: *n*(%)		
	Male	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
Listening to the teacher's directives	12 (21.4)	14 (22.2)	26 (21.8)	12 (21.1)	12 (22.2)	24 (21.6)	11 (18.0)	10 (17.2)	21 (17.6)
Experiment with peers	29 (51.8)	30 (47.6)	59 (49.6)	21 (36.8)	14 (25.9)	35 (31.5)	29 (47.5)	25 (43.1)	54 (45.4)
Conversation with peers about experiments	12 (21.4)	17 (27.0)	29 (24.4)	18 (31.6)	20 (37.0)	38 (34.2)	16 (26.2)	17 (29.3)	33 (27.7)
Personal action	3 (5.4)	0 (0.0)	3 (2.5)	4 (7.0)	2 (3.7)	6 (5.4)	3 (4.9)	3 (5.2)	6 (5.0)
Others	0 (0.0)	2 (3.2)	2 (1.7)	2 (3.5)	6 (11.1)	8 (7.2)	2 (3.3)	3 (5.2)	5 (4.2)
Total	56 (100.0)	63 (100.0)	119 (100.0)	57 (100.0)	54 (100.0)	111 (100.0)	61 (100.0)	58 (100.0)	119 (100.0)

Experiments with peers (49.6%) was the main activity performed by students in the observation stage, followed by conversation with peers about experiments (24.4%) and listening to the teacher's directives (21.8%). Conversation with peers about experiments (34.2%), experiments with peers (21.4%), and listening to the teacher's directives (21.6%) were the main activities in the variable control stage. Meanwhile, experiments with peers (45.4%), conversation with peers about experiments (27.7%), and listening to the teacher's directives (21.6%) were the main activities in the conclusion drawing stage.

The following gender differences were observed in each stage of the inquiry activity. For male students, experiments with peers was the main activity in the observation stage, followed by listening to the teacher's directives and conversation with peers about experiments (both having the same frequency). For female students, experiments with peers was the main activity, followed by conversation with peers about experiments and listening to the teacher's directives. As such, experiments with peers showed the highest frequency regardless of gender in the observation stage. In the variable control stage, experiments with peers was the main activity for male students, followed by conversation with peers about experiments and listening to the teacher's directives. For female students, conversation with peers about experiments was the main activity, followed by experiments with peers and listening to the teacher's directives. In the conclusion drawing stage, experiments with peers was the main activity for male and female students, followed by conversation with peers about experiments and listening to the teacher's directives.

The results showed that experiments with peers was the main action performed in most inquiry activity stages. However, conversation with peers about experiments had a higher frequency for both genders in the variable control stage compared with other stages. During the inquiry activities, students mostly conducted experiments with peers, conversed with peers about experiments, and listened to the teacher's directives. However, the frequency of conversation with peers about experiments was relatively higher in the variable control stage compared with other stages. This is expected to be more active among students in the variable control stage, in relation to a previous study (Choi et al., 2022) that reported that verbal interactions occur more actively in the variable control stage than in other stages.

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Main Actions

The main actions performed by lower secondary school students in each stage of the science inquiry activities are as follows (Table 4). In the experimental activity section (A) during the observation stage, the students' main activities were conducting experiments or observing. In the emotion section (B), only positive emotions appeared. In the interaction section (C), behavioral participation (C5), presentation of opinions (C3), and behavior related to the atmosphere (C6) were in that order.

In the experimental activity section (A) during the variable control stage, students usually prepared experiments or control variables as their main actions. In the emotion section (B), only negative emotion (B2) appeared unlike that in the observation stage. In the interaction section (C), the presentation of opinions (C3) and receiving opinions (C4) had the highest frequency. In the variable control stage, the frequency of behavior related to interaction was higher than that in other stages. In particular, there were many practical verbal interactions in which opinions were exchanged on inquiry activities.

In the conclusion drawing stage, most actions were related to the experimental activity section (A), followed by actions related to the interaction section (C) and actions related to the emotion section (B).

Table 4
Main Actions of External Experiences at Each Stage of Inquiry

Sections		Observation: *n(%)*			Variable control: *n(%)*			Conclusion drawing: *n(%)*		
		Male	**Female**	χ^2	**Male**	**Female**	χ^2	**Male**	**Female**	χ^2
Experimental activities (A)	A1	1(1.1)	1(0.9)	3.345	19(21.6)	15(14.4)	1.113	7(9.3)	4(4.6)	3.650
	A2	31(35.6)	30(28.3)		3(3.4)	5(4.8)		29(38.7)	28(32.2)	
	A3	14(16.1)	15(14.2)		0(0.0)	0(0.0)		8(10.7)	9(10.3)	
	A4	2(2.3)	1(0.9)		0(0.0)	0(0.0)		7(9.3)	6(6.9)	
	A5	0(0.0)	0(0.0)		13(14.8)	11(10.6)		1(1.3)	1(1.1)	
	A6	0(0.0)	3(2.8)		5(5.7)	6(5.8)		1(1.3)	0(0.0)	
	A7	0(0.0)	0(0.0)		0(0.0)	0(0.0)		0(0.0)	1(1.1)	
	A8	0(0.0)	0(0.0)		0(0.0)	0(0.0)		1(1.3)	1(1.1)	
	A9	0(0.0)	0(0.0)		0(0.0)	0(0.0)		3(4.0)	1(1.1)	
	sub-total	48(55.2)	50(47.2)		40(45.5)	37(35.6)		57(76.0)	51(58.6)	
Emotions (B)	B1	2(2.3)	3(2.8)	.000	0(0.0)	0(0.0)	.000	1(1.3)	2(2.3)	.444
	B2	0(0.0)	0(0.0)		0(0.0)	3(2.9)		0(0.0)	1(1.1)	
	sub-total	2(2.3)	3(2.8)		0(0.0)	3(2.9)		1(1.3)	3(3.4)	
Interactions (C)	C1	0(0.0)	2(1.9)	7.486	0(0.0)	2(1.9)	4.655	0(0.0)	0(0.0)	1.415
	C2	0(0.0)	0(0.0)		0(0.0)	0(0.0)		0(0.0)	0(0.0)	
	C3	4(4.6)	13(12.3)		16(18.2)	22(21.2)		2(2.7)	7(8.0)	
	C4	2(2.3)	7((6.6)		17(19.3)	21(20.2)		2(2.7)	5(5.7)	
	C5	20(23.0)	18(17.0)		4(4.5)	7(6.7)		6(8.0)	13(14.9)	
	C6	7(8.0)	7(6.6)		2(2.3)	7(6.7)		3(4.0)	5(5.7)	
	C7	3(3.4)	5(4.7)		4(4.5)	2(1.9)		3(4.0)	3(3.4)	
	sub-total	36(41.4)	52(49.1)		43(48.9)	61(58.7)		16(21.3)	33(37.9)	
Others (D)		1(1.1)	1(0.9)	_	5(5.7)	3(2.9)	_	1(1.3)	0(0.0)	_
Total		87 (100.0)	106 (100.0)	–	88 (100.0)	104 (100.0)	–	75 (100.0)	87 (100.0)	–

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In the observation stage, actions related to experimental activities had the highest frequency for male students, followed by actions related to interactions and actions related to emotions. On the other hand, actions related to interaction had the highest frequency for female students, followed by actions related to experimental activities and actions related to emotion. In the observation stage, actions related to experimental activities and interactions had the highest frequency regardless of gender. Specifically, male and female students conducted experiments and observations in relation to experimental activities. In the interaction section, actions related to behavioral participation had a high frequency regardless of gender. There was no difference in the main actions of external experiences at the observation stage of inquiry by gender (p>.05): In the experimental activities section (χ^2 = 3.345, df = 8, p = .911), interactions section (χ^2 = 7.486, df = 6, p = .278), and emotions section (χ^2 = .000, df = 1, p =1.000).

In the variable control stage, actions related to interaction had the highest frequency regardless of gender, followed by the actions related to the experimental activities section (A). Specifically, actions related to presenting opinions and receiving opinions had a high frequency regardless of gender. The actions related to the experimental activities section, experiment preparation and variable control activities were mainly performed. In this way, there was no difference in the main actions of external experiences at the variable control stage of inquiry by gender (p>.05): In the experimental activities section (χ^2 = 1.113, df = 8, p = .997), interactions section (χ^2 = 4.655, df = 6, p = .589), and emotions section (χ^2 = .000, df = 1, p =1.000).

In the conclusion drawing stage, actions related to the experimental activities section (A) had the highest frequency regardless of gender, followed by actions related to interaction and emotion section (B). Moreover, actions related to the experimental activities section (A) had a higher frequency in the conclusion drawing stage compared with other stages, confirming that actions related to interactions had a low frequency. On the other hand, it was confirmed that students did not perform activities related to conclusion drawing, such as conducting experiments or conducting observations, in the conclusion drawing stage. In this way, there was no difference in the main actions of external experiences at the conclusion drawing stage of inquiry by gender (p>.05): In the experimental activities section (χ^2 = 3.650, df = 8, p = .887), interactions section (χ^2 = 1.415, df = 6, p = .965), and emotions section (χ^2 = .444, df = 1, p =.505).

In the observation and conclusion drawing stages, actions related to the experimental activities section (A) had the highest frequency. However, in the variable control stage, actions related to interactions had the highest frequency. In the variable control stage, verbal interaction was found to facilitate the exchange of opinions. This result proves that the variable control stage does not need to be focused on increasing student interaction. However, negative emotions were most often felt in the variable control stage. This showed that the student was relatively intimidated or felt difficulties through verbal interaction. Thus, students should be provided with emotional support.

Internal Experience

Main Thought

To analyze the internal experience of lower secondary school students, their main thoughts were presented at each stage of inquiry. The students' responses were classified into experimental activities, emotions, interactions, and other sections (Table 5). In the observation stage, thoughts related to interaction had the highest frequency appearing 78 times (43.8%), followed by others (48 times, 27.0%), experimental activities (38 times, 21.3%), and emotions related to experimental activities (14 times, 7.9%). In terms of gender, male and female students thought about interaction the most, followed by thoughts related to others, experimental activities, and emotion sections. Specifically, in the interaction section of the observation stage, thoughts related to question (C1) had the highest frequency. Meanwhile, in the experimental activities section, thoughts about result prediction (A6) had the highest frequency. However, there was no statistically significant difference by gender at the observation stage (p > .05): experimental activities (χ^2 = 3.638, df = 8, p = .888), interactions (χ^2 = 4.570, df = 6, p = .600), and emotions (χ^2 = .207, df = 1, p =.649).

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Table 5
Main Thoughts of Internal Experience at Each Stage of Inquiry

Sections		Observation: *n(%)*			Variable control: *n(%)*			Conclusion drawing: *n(%)*		
		Male	Female	χ^2	Male	Female	χ^2	Male	Female	χ^2
Experimental activities (A)	A1	2(2.2)	0(0.0)	3.638	6(6.6)	7(6.7)	3.853	0(0.0)	3(3.5)	10.413
	A2	4(4.5)	4(4.5)		1(1.1)	4(3.8)		7(9.6)	5(5.9)	
	A3	4(4.5)	6(6.7)		0(0.0)	0(0.0)		2(2.7)	2(2.4)	
	A4	1(1.1)	2(2.2)		0(0.0)	0(0.0)		0(0.0)	0(0.0)	
	A5	0(0.0)	0(0.0)		6(6.6)	13(12.5)		0(0.0)	2(2.4)	
	A6	6(6.7)	8(9.0)		16(17.6)	13(12.5)		5(6.8)	17(20.0)	
	A7	0(0.0)	0(0.0)		0(0.0)	0(0.0)		1(1.4)	0(0.0)	
	A8	0(0.0)	0(0.0)		0(0.0)	0(0.0)		2(2.7)	1(1.2)	
	A9	0(0.0)	1(1.1)		0(0.0)	0(0.0)		0(0.0)	0(0.0)	
	sub-total	17(19.1)	21(23.6)		29(31.9)	37(35.6)		17(23.3)	30(35.3)	
Emotions (B)	B1	4(4.5)	8(9.0)	.207	3(3.3)	4(3.8)	.298	6(8.2)	8(9.4)	.209
	B2	1(1.1)	1(1.1)		3(3.3)	7(6.7)		3(4.1)	6(7.1)	
	sub-total	5(5.6)	9(10.1)		6(6.6)	11(10.6)		9(12.3)	14(16.5)	
Interactions (C)	C1	27(30.3)	25(28.1)	4.570	17(18.7)	13(12.5)	4.624	18(24.7)	6(7.1)	9.560
	C2	3(3.4)	2(2.2)		0(0.0)	0(0.0)		0(0.0)	0(0.0)	
	C3	3(3.4)	2(2.2)		7(7.7)	5(4.8)		3(4.1)	2(2.4)	
	C4	1(1.1)	1(1.1)		3(3.3)	3(2.9)		0(0.0)	2(2.4)	
	C5	2(2.2)	2(2.2)		1(1.1)	5(4.8)		1(1.4)	3(3.5)	
	C6	2(2.2)	5(5.6)		5(5.5)	6(5.8)		3(4.1)	6(7.1)	
	C7	3(3.4)	0(0.0)		0(0.0)	1(1.0)		0(0.0)	0(0.0)	
	sub-total	41(46.1)	37(41.6)		33(36.3)	33(31.7)		25(34.2)	19(22.4)	
Others (D)		26(29.2)	22(24.7)	_	23(25.3)	23(22.1)	_	22(30.1)	22(25.9)	_
Total		89 (100.0)	89 (100.0)		91 (100.0)	104 (100.0)		73 (100.0)	85 (100.0)	

In the variable control stage, thoughts related to experimental activities and interaction sections had the highest frequency. For male students, interaction was higher than experimental activity, but for female students, experimental activity was higher than interaction. However, there were no statistically significant differences in experimental activities ($\chi^2 = 3.853$, $df = 8$, $p = .870$), interactions ($\chi^2 = 4.624$, $df = 6$, $p = .593$), and emotions ($\chi^2 = .298$, $df = 1$, $p = .585$).

In the conclusion drawing stage, students mainly thought about the experimental activities section, followed by the interaction, others, and emotions sections. In terms of gender, male students thought about the interaction section the most, whereas female students thought about the experimental activities section the most. Specifically, in the experimental activities section, conducting an experiment (A2) had the highest frequency for male students, followed by result prediction (A6). By contrast, result prediction (A6) had the highest frequency for female students. In the interaction section, male and female students thought about question (C1) the most. However, there was no statistically significant difference by gender at the conclusion drawing stage ($p > .05$): experimental activities ($\chi^2 = 10.413$, $df = 8$, $p = .237$), interactions ($\chi^2 = 9.560$, $df = 6$, $p = .144$), and emotions ($\chi^2 = .209$, $df = 1$, $p = .648$).

In the stage of inquiry activity, students thought about the experimental activities or interaction section the

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most and the emotions section the least. There was a slight difference in the order of the frequency of main thoughts according to gender at each stage of inquiry activity, but there was no statistically significant difference (p>.05). In addition, it can be confirmed that lower secondary school students have thoughts unrelated to class considering the high frequency of the others section. This can be related to a previous study (Kwak et al., 2020) showing that concentration on class is lowered when there is no positive experience, which is a defining achievement in inquiry activities. Therefore, it is necessary to create an atmosphere in which lower secondary school students can enjoy inquiry so that they can be interested and focus on class and improve science positive experiences.

Contribution of Actions

The students' responses to whether their actions during small-group science inquiry activities were helpful are as follows (Table 6). Most of the students thought that their actions helped their inquiry activities in all stages. However, 8 students in the observation stage, 13 students in the variable control stage, and 11 students in the conclusion drawing stage thought that their actions were not helpful to the inquiry activities.

Table 6
Contribution of Actions of Internal Experience at Each Step of Inquiry

	Observation: *n*(%)			Variable control: *n*(%)			Conclusion drawing: *n*(%)		
	Male	Female	χ^2	Male	Female	χ^2	Male	Female	χ^2
Yes	36(0.9)	33(89.2)		33(82.5)	31(83.8)		33(82.5)	33(89.2)	
No	4(0.1)	4(10.8)	.136	7(17.5)	6(16.2)	.023	7(17.5)	4(10.8)	.702
Total	40(100.0)	37(100.0)		40(100.0)	37(100.0)		40(100.0)	37(100.0)	

Male and female students mostly thought that their actions were helpful in all stages of the experimental activities. However, among male students, 4 students in the observation stage and 7 students in the variable control and conclusion drawing stages thought that their actions were not helpful in the inquiry activities. In the case of female students, 4 students in the observation and conclusion drawing stages and 6 students in the variable control stage thought that their actions were not helpful to the inquiry activities. The contribution of actions for inquiry activities by gender is as follows: observation stage (χ^2 = .136, p = .907), variable control stage (χ^2 = .023, p = .881), and conclusion drawing stage (χ^2 = .702, p =.402). There was no significant difference according to gender (p>.05).

On the other hand, the results of reasons for the contribution of actions by students in inquiry activities are as follows (Table 7). Overall, regarding the reasons for responding that inquiry activities were helpful, the interactions section (54.3%) had the highest frequency, followed by experimental activities (36.4%) and emotions (8.7%) sections. Specifically, in the observation stage, the interactions section had the highest frequency, followed by the experimental activities and emotions sections. In the interactions section, behavioral participation (C5) and presentation of opinions (C3) had the highest frequency. In the experimental activities section, conducting experiments (A2) had the highest frequency. In the variable control stage, interaction had the highest frequency, followed by inquiry activities and emotions. Behavioral participation (C5), presentation of opinions (C3), and atmosphere (C6) had a higher frequency in the interaction section than in other inquiry activity stages. In the experimental activities section, experiment preparation (A1) and variable control (A5) had the highest frequency. In the conclusion drawing stage, interactions (54.4%) had the highest frequency, followed by inquiry activities (39.4%) and emotions (5.3%). Similar to other stages, behavioral participation (C5) and presentation of opinions (C3) had high frequency in the interactions section. Conducting experiments (A2) was presented most frequently in the experimental activities section.

At each stage of the inquiry activity, students presented the reasons why their behavior contributed to the inquiry activity in the order of interactions, experimental activities, and emotions. However, the interaction was higher in the variable control stage than in the other stages. In the observation stage, more students responded to emotions (i.e., positive emotions) than in other stages. In the observation, variable control, and conclusion drawing stages, interactions had the highest frequency for males and females, followed by experimental activities and

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emotions. There was no statistically significant difference according to gender ($p > .05$). In the observation stage, it was experimental activities ($\chi^2 = 3.753$, $df = 8$, $p = .879$), interactions ($\chi^2 = 2.545$, $df = 6$, $p = .863$), and emotions ($\chi^2 = .000$, $df = 1$, $p = 1.000$). In the variable stage it was experimental activities ($\chi^2 = 3.200$, $df = 8$, $p = .921$), interactions ($\chi^2 = 1.735$, $df = 6$, $p = .942$), and emotions ($\chi^2 = .000$, $df = 1$, $p = 1.000$). And in the conclusion drawing stage, it was experimental activities ($\chi^2 = 3.346$, df = 8, $p = .911$), interactions ($\chi^2 = 2.811$, $df = 6$, $p = .832$), and emotions ($\chi^2 = .000$, $df = 1$, $p = 1.000$).

Table 7
Gender Differences in Reasons for the Contribution of Actions

Sections		Observation: *n(%)*			Variable control: *n(%)*			Conclusion drawing: *n(%)*		
		Male	Female	χ^2	Male	Female	χ^2	Male	Female	χ^2
Experimental activities (A)	A1	1(1.6)	1(1.8)	3.753	10(16.4)	4(7.4)	3.200	2(3.7)	3(5.0)	3.346
	A2	17(27.4)	13(23.6)		1(1.6)	2(3.7)		7(13.0)	11(18.3)	
	A3	2(3.2)	2(3.6)		0(0.0)	0(0.0)		2(3.7)	2(3.3)	
	A4	1(1.6)	1(1.8)		0(0.0)	0(0.0)		2(3.7)	3(5.0)	
	A5	1(1.6)	0(0.0)		9(14.8)	5(9.3)		0(0.0)	2(3.3)	
	A6	2(3.2)	0(0.0)		3(4.9)	3(5.6)		0(0.0)	2(3.3)	
	A7	0(0.0)	0(0.0)		0(0.0)	0(0.0)		0(0.0)	1(1.7)	
	A8	0(0.0)	0(0.0)		0(0.0)	0(0.0)		1(1.9)	2(3.3)	
	A9	0(0.0)	1(1.8)		2(3.3)	0(0.0)		2(3.7)	3(5.0)	
	sub-total	24(38.7)	18(32.7)		25(41.0)	14(25.9)		16(29.6)	29(48.3)	
Emotions (B)	B1	11(17.7)	9(16.4)	.000	0(0.0)	4(7.4)	.000	5(9.3)	1(1.7)	.000
	B2	0(0.0)	0(0.0)		0(0.0)	0(0.0)		0(0.0)	0(0.0)	
	sub-total	11(17.7)	9(16.4)		0(0.0)	4(7.4)		5(9.3)	1(1.7)	
Interactions (C)	C1	0(0.0)	0(0.0)	2.545	0(0.0)	0(0.0)	1.735	0(0.0)	0(0.0)	2.811
	C2	1(1.6)	1(1.8)		0(0.0)	1(1.9)		4(7.4)	2(3.3)	
	C3	6(9.7)	8(14.5)		11(18.0)	10(18.5)		5(9.3)	4(6.7)	
	C4	0(0.0)	2(3.6)		2(3.3)	4(7.4)		0(0.0)	0(0.0)	
	C5	16(25.8)	14(25.5)		15(24.6)	14(25.9)		20(37.0)	22(36.7)	
	C6	4(6.5)	3(5.5)		6(9.8)	6(11.1)		3(5.6)	1(1.7)	
	C7	0(0.0)	0(0.0)		1(1.6)	1(1.9)		0(0.0)	1(1.7)	
	sub-total	27(43.5)	28(50.9)		35(57.4)	36(66.7)		32(59.3)	30(50.0)	
Others (D)		0(0.0)	0(0.0)	_	1(1.6)	0(0.0)	_	1(1.9)	0(0.0)	_
Total		62 (100.0)	55 (100.0)	_	61 (100.0)	54 (100.0)	_	54 (100.0)	60 (100.0)	_

Consciousness and Emotions

Gender differences in consciousness and emotion felt by lower secondary school students during each inquiry activity were analyzed (Table 8). Male students showed the highest score in "concentration" (4.18), followed by "teacher's guidance" (4.15), "help" (4.10), "interest" (4.08), and "effort" and "learning" (4.03). On the other hand, female students showed the highest score in "effort" and "teacher's guidance" (4.19), followed by "concentration"

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(4.05), "interest" (3.89), and "help" (3.86). For male and female students, "teacher's guidance," "interest," and "help" corresponded to the main consciousness felt during inquiry activities.

Table 8
Consciousness of Internal Experience during Inquiry Activities

Consciousness	Group	*N*	*M*	*SD*	*t*	*p*
Opportunity to choose	Male	40	3.83	.81	.347	.357
	Female	37	3.76	.52		
Importance	Male	40	3.80	.57	.354	.362
	Female	37	3.73	.92		
Interest	Male	40	4.08	.84	.838	.202
	Female	37	3.89	.99		
Difficulty*	Male	40	3.43	1.38	−.141	.444
	Female	37	3.46	.92		
Enjoyment	Male	40	3.85	1.00	.677	.250
	Female	37	3.70	.83		
Concentration	Male	40	4.18	.51	.675	.251
	Female	37	4.05	.72		
High skill	Male	40	3.30	.68	.638	.263
	Female	37	3.19	.49		
Think of something else*	Male	40	3.00	1.59	1.645	.052
	Female	37	2.57	1.09		
Goal	Male	40	3.85	.59	1.018	.156
	Female	37	3.65	.90		
Effort	Male	40	4.03	.69	−.877	.192
	Female	37	4.19	.66		
Teacher's guidance	Male	40	4.15	.59	−.222	.412
	Female	37	4.19	.60		
Fit together	Male	40	3.90	.86	.406	.343
	Female	37	3.81	1.00		
Reflection of ideas	Male	40	3.68	.84	.122	.452
	Female	37	3.65	.96		
Learning	Male	40	4.03	.69	.929	.178
	Female	37	3.84	.86		
Help	Male	40	4.10	.71	1.148	.127
	Female	37	3.86	.90		
Total	Male	40	3.81	.95	.800	.215
	Female	37	3.70	.98		

*negative item

The mean for consciousness during inquiry activities was 3.81 for male students and 3.70 for female students, and there was no statistically significant difference between male and female students ($p > .05$). As such, the present study found no statistically significant difference regarding the specific consciousness for each item between male and female students.

Table 9 shows the gender differences in emotion during inquiry activities. Emotion was measured using a

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Likert scale using contrasting adjectives to express feelings or emotional states during the inquiry process. Male students felt "successful" the most with a score of 4.40, followed by "anxious" and "competitive" (4.36), "annoying" (4.32), and "pressured" (4.24). On the other hand, female students felt "annoying" and "competing" the most with a score of 4.26, followed by "anxiety" (4.12) and "pressured" (4.06).

Table 9
Emotions of Internal Experience during Inquiry Activities

Emotions	Group	*N*	*M*	*SD*	*t*	*p*
Joyful	Male	40	3.35	1.07	−.116	.454
	Female	37	3.38	1.46		
Creative	Male	40	3.84	.81	.573	.284
	Female	37	3.71	1.06		
Pressured*	Male	40	4.27	.93	.915	.182
	Female	37	4.06	.97		
Interesting	Male	40	3.87	1.01	1.297	.100
	Female	37	3.53	1.35		
Boring*	Male	40	3.92	.85	1.555	.062
	Female	37	3.53	1.35		
Anxious*	Male	40	4.35	.90	.905	.184
	Female	37	4.12	1.44		
Annoying*	Male	40	4.27	1.09	.023	.491
	Female	37	4.26	1.05		
Competitive*	Male	40	4.32	.78	.257	.399
	Female	37	4.26	1.11		
Active	Male	40	3.81	1.16	.478	.317
	Female	37	3.68	1.62		
Curious	Male	40	3.84	.92	.171	.432
	Female	37	3.79	1.38		
Cooperate	Male	40	3.89	1.10	.519	.303
	Female	37	3.77	1.03		
Involved	Male	40	3.73	1.20	1.045	.150
	Female	37	3.47	.98		
Successful	Male	40	4.24	.97	1.811	.037*
	Female	37	3.82	.94		
Total	Male	40	3.98	1.02	1.538	.069
	Female	37	3.80	1.12		

*negative item

Male students felt "successful" the most during small-group inquiry activities, which was statistically significant compared with female students ($p < .05$). However, it was confirmed that lower secondary school students, regardless of gender, felt generally negative feelings such as anxiety or competition while conducting small-group inquiry activities ($p > .05$). Therefore, it is necessary to make efforts to reduce anxiety and negative mood that lower secondary school students feel in science inquiry activities.

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Discussion

Most of the external experiences of grade 6 students in the Republic of Korea during inquiry activities were related to class activities, but there were many internal experiences unrelated to inquiry activities. In the stage of inquiry activity, approximately 1% of other actions and thoughts were unrelated to the inquiry activity, including personal actions, small talk, game thoughts, and break time thoughts, which are external actions (Table 4). On the other hand, the frequency of others (D) in internal experience was 23%–27% (Table 5). This means that students experience the inquiry in action but think about thoughts that are unrelated to the inquiry. In other words, about 1/4 of all students are unable to concentrate during small-group inquiry activities and engage in small talk, jokes, or personal actions and thoughts that are unrelated to the inquiry activities. These results indicate that many lower secondary school students feel that the inquiry activities are not enjoyable or interesting. Comparing this finding to the results of Kim and Yang (2005), inquiry activities can act as one of the causes of disliking science.

In terms of external experience, students mainly conducted experiments with peers or conversed with peers about experiments rather than listening to the teacher's directives. nevertheless, approximately 20% of the external experiences experienced by students listened to the teacher's directives as the main action. This means that the main focus is on the inquiry under the directive of the teacher, rather than on the self-directed inquiry by the student. Therefore, a method to guide students to self-directed inquiry activities is required. In addition, verbal interaction (i.e., conversation with peers about experiments) frequently occurred in the variable control stage. Consistent with previous studies (Yu & Choi, 2012), students' spontaneity and high social interaction are required in the variable control and experimental design stages. Accordingly, it could be inferred that this was because one of the reasons for the low verbal interaction of students during inquiry activities was that they did not proceed with the variable control stage (Kim & Kim, 2012; Kwon & Kim, 2016).

In the results of the main actions of external experiences at each stage of inquiry, students in the Republic of Korea have a low level of variable control ability formation; in the case of lower secondary school students, many lack variable control ability (Kim & Kim, 2012). Thus, there is a high possibility of feeling negative emotions. The lack of awareness of variables can act as a cause of experimental performance failure (Germann et al., 1996). Since students can learn the contents related to simple variable control and training is effective (Lawson & Wollman, 2003), it is necessary to provide and implement a program for the variable control stage for lower secondary school students.

On the other hand, it was confirmed that students did not perform activities related to conclusion drawing, such as conducting experiments or conducting observations, in the conclusion drawing stage. This finding is consistent with that of Lim et al. (2011), who found that lower secondary school students have difficulties in interpreting data and drawing conclusions. Data interpretation is a high-level inquiry function and is a scientific literacy required of students in relation to the rapid increase in the amount of information in modern society (Gotwals, 2006). Moreover, data interpretation must be preceded in order to draw conclusions (Lim et al., 2011). Therefore, it is necessary to support activities such as cultivating the ability to identify the relationship between two variables (Kanari & Millar, 2004) or enhancing data interpretation skills through experience in graph interpretation (Choi et al., 2001) for lower secondary school students to perform data interpretation and conclusion drawing.

Students were engaged in activities that did not correspond to the inquiry stage. For example, in the observation stage, there was a student who prepared an experiment, conducted an experiment, and predicted the result of the experiment. There were students who did not design the experiment, but rather prepared and performed the experiment in the variable control stage and made predictions in the conclusion drawing stage. This is because students do not clearly distinguish which activities need to be or do not need to be performed at each stage of inquiry.

Students thought that their activities were helpful to their peers in inquiry activities. This can be inferred from the result that the main activity is the progress of the experiment with the peers or the conversation about the experiment accounted for more than 70% (Table 3). However, more interaction took place in the variable control stage than in the other exploration stages (Table 4). In other words, a variable control step should be included to increase the interaction between students during inquiry activities.

As the result of internal experiences, "teacher's guidance", "interest", and "help" were included regardless of gender in the consciousness and emotions. This is in line with the results of previous studies (Hofstein & Lunetta, 2004; Yang et al., 2006) that inquiry activities help increase interest in and understanding of science.

Students often felt negative emotions, including anxiety, during the inquiry activities regardless of gender. This is consistent with the results of previous studies on scientific anxiety (Jeong & Kim, 2011; Kim et al, 2014). Positive emotions lead to emotional and psychological actions than negative emotions and act as factors that

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increase patience and creativity, giving individuals the strength to adapt well to new and unfamiliar experiences (Ko, 2016). Also, the lower the level of negative emotions such as anxiety or aggression in the small-group inquiry activity, the more positive the perception of the small-group inquiry activity, and the more active the interaction (Yeo & Kim, 2005). Furthermore, it is necessary to make efforts to reduce anxiety and negative mood that lower secondary school students feel in science inquiry activities. In particular, female students were relatively less likely to feel more successful than male students. Therefore, it is necessary to find a way to provide female students with the experience of success in inquiry activities. In addition, it is very important to help lower secondary school students adapt to new and unfamiliar topics through scientific inquiry activities and have positive emotions about the inquiry activities in order to perform well.

Conclusions and Implications

This study analyzed the external and internal experiences experienced by lower secondary school students at each stage during small-group science inquiry activities. First, there was no difference in the external and internal experiences of male and female students in each stage of the inquiry activity. In addition, the main activities performed in the process of inquiry activities were activities related to colleagues and experiments.

Second, there were many cases during inquiry activities in which activities in other stages of inquiry were carried out in addition to the activities that were mainly performed in the corresponding stage. For example, students answered that conducting the experiment was the main action performed in the observation stage, and experiment preparation was performed more than experiment design in the variable control stage. In addition, students responded that they did more experiment preparation, conducting experiments, and observation activities in the conclusion drawing stage (Table 4).

Third, approximately 27% of students said that they had internal experiences unrelated to inquiry during inquiry activities. Also, some students thought that their main actions were not helpful to the inquiry activities. In particular, this was relatively more common in the variable control stage and conclusion drawing stage, which requires a high-level inquiry function, compared with the observation stage, which requires a simple inquiry function. It is considered that there are many cases in which students are unable to participate in inquiry activities that require high-level inquiry skills such as designing and interpreting experiments and interaction with peers. Therefore, it is required to guide all members in the process of inquiry so that they can participate in inquiry activities. Through this, it is hoped that students will become interested in science through inquiry activities.

Fourth, there was little difference between genders in the internal and external experiences experienced in the process of conducting scientific inquiry, but female students were found to have relatively fewer internal experiences that made them feel more successful than male students. This may lead to differences in science-related attitudes between male and female.

Based on the results, it is suggested to include a variable control step in designing the experiment to allow students to actively interact during inquiry activities. However, some differences emerged in attitudes toward science, such as feeling successful about science. This difference in attitudes toward science despite the same experience can adversely affect the success of scientific inquiry. Therefore, it is necessary to provide female students with a successful internal experience to increase their confidence and attitude toward science, while equal inquiry activities that do not discriminate according to gender are carried out. Moreover, as 20% of the students considered listening to the teacher's directive as their main activity, it is expected that the inquiry activity will become a student-centered inquiry activity. Since this study analyzed experiences in open-ended inquiry, it is expected that the analysis will be conducted in various forms of inquiry, such as guided inquiry.

Declaration of Interest

The authors declare no competing interest.

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