

RESEARCH ARTICLE

Pre-Service Elementary School Teachers' Perceptions on Astronomical Observation and Astronomy Classes Following Astronomical Observation Experience

Hansol Kim¹ · Sungman Lim² · Seongun Kim^{3*}¹Sunchang Elementary School²Korea National University of Education³Chungbuk Carbon Neutrality Support Center

천체 관측 경험에 따른 초등예비교사의 천체 관측 및 천문 수업에 대한 생각

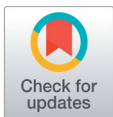
김한솔¹ · 임성만² · 김성운^{3*}¹선창초등학교 · ²한국교원대학교 · ³충북탄소중립지원센터

*Corresponding Author: auul@naver.com

ABSTRACT

This study examines the pre-service elementary school teachers' perceptions on astronomical observation and astronomy classes following astronomical observation experience. To achieve this, three classes with astronomical observation activities were developed and applied to 22 pre-service elementary school teachers. Interviews were conducted twice with nine pre-service elementary school teachers who had completed the classes. Additionally, questionnaires on astronomical teaching efficacy and astronomical experience, interview data, researchers' notes, and astronomy class design activity papers were collected as research data. The protocol extracted from this data was qualitatively analyzed through the inductive category process. First, astronomical observation connects natural phenomena and models, sets the celestial body observed with observation equipment as a new object of inquiry, and considers it an emotional experience; further, it was believed that communication should be included to increase the quality of observation. Second, the perception of the astronomy class transitioned from memorizing knowledge to applying knowledge; moreover, it was perceived that the astronomy class must consider the learner's level and that software and simulation should be used as supplementary materials for the class. This study could help confirm the starting point of pre-service elementary school teachers' astronomy class competency and propose the direction of the practical astronomy class.

Key words: Elementary pre-service teachers, astronomical observation, astronomy class, observation equipment, qualitative analysis



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Introduction

Astronomy is one of the oldest scientific disciplines (Okulu & Oguz-Unver, 2015). It is known that the ancient Greek philosophers were the first to make systematic observations of the celestial bodies. They sought to understand the world by looking at the celestial bodies with their naked eyes. Among them, Aristotle, based on the results of astronomical observations, inferred that the Earth was round rather than flat. Around the 17th and 18th centuries, scientific laws for planetary motion were established with the invention of observation tools such as a telescope (Amy & Schneider, 1994). Since then, astronomical observation technology has advanced, based on various observation tools, and has reached a level that can detect and analyze the waves optically and electrically (Trumper, 2006).

Highly specialized observation technology has become inaccessible to the general public, thereby affecting the educational perspective on astronomical observation. Today, astronomy education is being conducted using advanced devices such as webcams, smart devices, and astronomy software (Han et al., 2015; Jung, 2016; Song & So, 2018). As the number of alternatives to actual astronomical observation increases, activities such as actual moon and constellation observation are expected to actually decrease. This trend can also be found in the Korean educational curriculum. In the 2015 revised science curriculum, “Appearance of the Earth,” “The Solar System and the Stars,” and “Movement of the Earth and the Moon” sections specify that the achievement standards can be attained using photo materials, role play, model experiments, and software (Ministry of Education, 2015) in describing the alternatives to astronomical observation. In the recently announced 2022 revised science curriculum and educational process proposal, the unit name of the 3rd and 4th graders’ astronomical subject was provided as “Night Sky Observation” (Ministry of Education, 2022). The fact that the research subject of “the night sky” and the research method “observation” were specified in the unit name appears to emphasize the actual astronomical observation education rather than software or model experiments.

However, considering the nature of the field of astronomy, the celestial bodies that students can observe are far away, the same experiments as natural phenomena cannot be performed in the laboratory, and repeated experiments are impossible (Lim & Jung, 1993). Moreover, because the field of astronomy is difficult to understand directly through observation, many students find it challenging to comprehend astronomical phenomena (Lee et al., 2015). In particular, elementary school students have no other experience than astronomy-related education that they receive from school, and they often do not know where to engage in astronomical observation (Han et al., 2012). Acquiring the concept of celestial motion merely through traditional teaching and learning that do not include observation activities is difficult (Chea, 1999, 2011; Jung et al., 1995; Kim & Park, 1997). Finally, studies on pre-service elementary school teachers in the field of astronomy are also insufficient (Lim, 2011; Oh, 2017). To enable elementary school students’ engagement in astronomical observation, focusing on the teachers’ role of teachers is necessary, which has not been actively researched yet.

In astronomy classes, teachers should guide students through long-term and periodic observations of astronomical phenomena (Broadfoot & Ginns, 2005). Long-term observation of astronomical phenomena is centered on clubs led by teachers who majored in astronomy or are interested in astronomy in middle and high schools (Choi & Yoon, 2019).

This indicates that astronomical domain-specific teaching methods or strategies are necessary for long-term and periodic astronomical observation classes to be implemented.

Before constructing a new teaching method or strategy, estimating the current elementary school teachers' perception of astronomy class based on the results of previous research is possible. Of the areas in earth science, the unit with the motion of the Earth and the Moon is the most difficult (Chea, 1999; Ko, 1994; Lim, 2011), or pre-service teachers maintain their astronomy misconception until graduation (Percy, 2005; Trundle et al., 2002; Türk et al., 2015). The results of these previous study indicate that teachers' current affective competence and knowledge are insufficient to conduct astronomical observation-based astronomy classes.

Among recent studies related to teachers' astronomy class, Oh (2017) analyzed the difficulties experienced by pre-service elementary school teachers in the moon observation activity and suggested various teaching methods. The researcher had 31 pre-service elementary school teachers observe the moon for one month and record the observation log. In the observation log, the difficulties experienced while observing were also described, based on which, a teaching method was proposed to support elementary school students' moon observation activities. However, Oh's study did not use an observation tool such as a telescope, but merely observations with the naked eye. Considering a foreign study, for instance, Robert (2005), 77% of high school students who participated in the study also responded that they had never seen a telescope before.

Perhaps, research was conducted in the absence of observation tools owing to the lack of any statement regarding the use of observation tools in the elementary science curriculum. However, limiting the scope of the teachers' affective competence and knowledge for astronomical observation to the elementary school level is not necessary. According to Fitzgerald et al. (2015), a class that employs an actual telescope contributes to the astronomical motivation and knowledge acquisition of students who are not majoring in science. In short, deriving teaching methods and strategies from astronomical observation experiences through not only observation with the eye but also observation tools is essential to get the implication for astronomy class of elementary school teachers. Additionally, exploring the effect of the changed thinking of pre-service school teachers on the design of astronomy classes through the astronomical observation experience is required.

Therefore, this study aims to obtain implications for pre-service elementary school teachers' astronomy class by examining astronomical observation experiences (meaning astronomical observation using observation equipment) and elementary school teachers' perceptions on astronomical observation and astronomy classes. The research questions of this study are as follows.

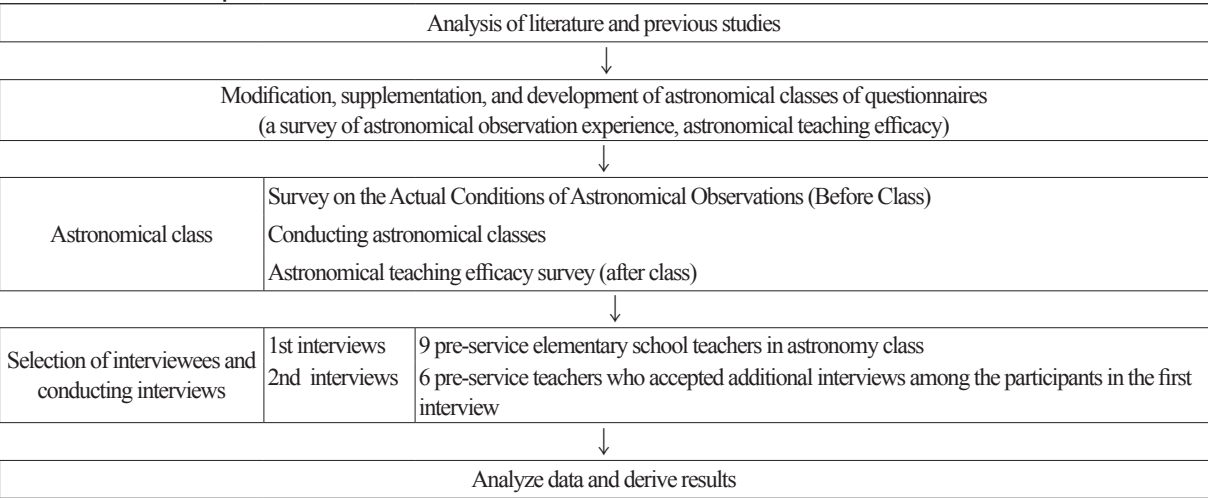
1. What are pre-service elementary school teachers' perceptions of astronomical observation that emerged following the astronomical observation experience?
2. What are pre-service elementary school teachers' perceptions of astronomy classes that emerged following the astronomical observation experience?

Methods

Research Design

Table 1 illustrates the study procedure. First, the literature and previous studies on astronomy classes and astronomical observation were analyzed. Following the analysis, the necessity to develop an astronomy class program that included astronomical observation activities for pre-service elementary school teachers was determined. For data collection, the questionnaire on the actual condition of astronomical observation (Han et al., 2012) and the questionnaire on astronomical teaching efficacy (Chea, 1999) were utilized, and the researcher developed an astronomy class program and taught it themselves. Subsequently, nine interviewees were selected and the first interview was conducted. The first interview applied an in-depth group interview (focus group interview) method and was conducted by dividing the interviewees into four groups of 2–3 interviewees each. The second interview was conducted individually with six of the participants from the first interview.

Table 1. Research procedure



Participants

The study participants comprised 22 college students from the central region of South Korea. All 22 students had the “Basic Earth Science and Experiment” course in the first semester of 2022; 13 and 9 participants were pre-service teachers in the first and second grade, respectively, majoring in science in elementary education; finally, the second graders had completed the “Understanding the Nature of Science” course in the first semester of 2021. There were no direct classes on astronomical observation, as the contents of the lecture included the concept and development of the nature of science related to science education and the creation and presentation of a free inquiry plan. None of the study participants had any experience of taking classes related to elementary earth science.

This study related to the design of pre-service elementary school teachers' astronomy classes through astronomical observation experience, thus discussing class practice was necessary. Teaching efficacy (a belief in the teacher's own ability to positively influence a student's learning) is closely related to class practice (Ashoton, 1985; Bandura, 2006; Guskey & Passaro, 1994; Gibson & Dembo, 1998; Kang & Huh, 2016; Riggs, 1998; Shim, 2017; Tschannnen- Maran et al., 1998; Woolfolk, 1998) and can indirectly estimate class practice (expertise) (Kang, 2017). Therefore, this study sought to clearly explore the degree of influence of astronomical observation experience on astronomy class design by comparing students with relatively high and low astronomical teaching efficacy. But there was no marked difference.

Additionally, the second interview was conducted for some of the participants from the first interview. Table 2 provides the information of the study participants who participated in the interview.

Table 2. Participants in the study who participated in the first round of interviews

Study Participant Code	Gender	Grade	Class of Highschool	Astronomical Teaching Efficacy (Score)
AM1	Woman	Sophomore	Natural Sciences	High Rank (3.82)
AM2	Woman	Sophomore	Liberal Arts	High Rank (4.18)
AM3	Woman	Sophomore	Liberal Arts	High Rank (4.41)
AE4	Woman	Freshman	Natural Sciences	High Rank (3.91)
BE1	Woman	Sophomore	Natural Sciences	Low Rank (3.41)
BE2	Woman	Freshman	Natural Sciences	Low Rank (3.27)
BE3	Woman	Freshman	Natural Sciences	Low Rank (3.45)
BM4	Woman	Sophomore	Liberal Arts	Low Rank (3.41)
BM5	Woman	Freshman	Liberal Arts	Low Rank (3.23)

Code Explanation(A: High Astronomical Teaching Efficacy, B: Low Astronomical Teaching Efficacy, M: Liberal Arts, E: Natural Sciences, 1~5: Sequence, Underline: Participants in the second round of interviews)

Task Development

Questionnaire

The questionnaires used in this study include the ones on the experience of astronomical observation and on the astronomical teaching efficacy. The survey questionnaire on astronomical observation experience was used for 22 pre-service elementary school teachers before the astronomy class.

(1) Survey Questionnaire on Astronomical Observation Experience

This questionnaire was used to investigate the astronomical observation experiences of pre-service elementary school teachers before participating in the astronomy class. The input questionnaire was used by modifying the questionnaire (Han et al., 2012) to assess the astronomical experiences of elementary school students and elementary school teachers depending on the research situations. The range of questionnaire categories can be divided into “experience in astronomy-related education,” “knowledge and level related to astronomical observation,” and “willingness to participate in astronomical observation.”

(2) Astronomical Teaching Efficacy Questionnaire

The astronomical teaching efficacy questionnaire was administered once the participants had taken the astronomy class. The belief questionnaire on the efficacy of astronomy teaching developed by Chea (1999) was used to examine the study participants' astronomical teaching efficacy. For this questionnaire, Chea (1999) modified the Korean Science Teaching Efficacy Belief Instrument (Enochs & Riggs, 1990)—a belief questionnaire on the efficacy of science teaching for pre-service elementary school teachers developed by Park (1997), based on the field of astronomy. The range of categories of questionnaire items can be divided into “personal sense of astronomical teaching efficacy” and “expectation for the results of astronomical teaching.”

Development of Astronomical Class

The researcher developed an astronomy class (Table 3) to provide pre-service elementary school teachers with astronomical observation experience. The developed class comprised the basics of astronomical observation, astronomical observation practice, and understanding of the telescope principle; it was designed for three sessions. All the development processes of this class underwent a consultation process in a seminar wherein two science education experts and five students enrolled in a master's program for science in elementary education participated.

Table 3. Astronomy class unit composition

Period	Contents of Period	Time required
The basis of celestial observation	Celestial observation basic common sense (observation requirements, astronomical common sense, etc.)	30 min
	Celestial observations in elementary science Curriculum	
	Understanding of lunar observations	
	Understanding spring constellation observations	
The practice of celestial observation	Lunar observation practice	80 min
	Spring constellation observation practice	
Understanding the principles of telescope	Understanding the structure of a telescope	40 min
	Telescope model (James Web) assembly practice	

The basics of astronomical observation in the 1st class were conducted at an elementary level for the understanding of the basic concepts of astronomical observation and smooth performance of outdoor observation activities. It explained the environmental conditions for outdoor observation, allowing the selection of a place where outdoor observation is suitable. Moreover, basic information necessary for outdoor observation (binocular observation method, precautions for telescope observation, etc.) was explained, and preliminary information was obtained regarding Astronomical Observation and Elementary School Science Education Processes (3-1-5), Appearance of the Earth (5-1-3), The Solar System and Stars (5-2-2), The Motion of the Earth and the Moon (6-2-2), and changes in seasons and understanding the connection with the moon and constellations. For instance, moon observation can occur when the moon is in its first quarter and the craters and lunar sea can be observed readily. For constellations, the positions and characteristics of representative spring constellations were explained with a focus on the great curves and triangles of the spring season, allowing participants to draw the constellations own their own.

In the second astronomical observation practice, one can freely observe the moon, constellations, and stars with one outdoor refracting telescope, one reflecting telescope, and five binoculars. Before the observation, one recognizes the observation viewpoint (characteristics of the lunar sea and craters, locating the North Star, locating the spring season curve, locating the spring season triangle, etc.). As pre-service elementary school teachers are inexperienced in the observation method and use of the observation tool, two observation assistant instructors (elementary school teachers) accompanied the participants. One observation assistant instructor was stationed next to the refracting telescope and the other next to the reflecting telescope to support pre-service elementary school teachers in their astronomical observation.

In the 3rd session of Understanding the Principle of the Vision Telescope, the structure of the refracting telescope, terminology of its accessories, and how to use them were explained. The next activity was to assemble a model paper telescope (James Webb Telescope). The James Webb Telescope is an infrared telescope launched recently to replace the Hubble Telescope as a space telescope. As it will play a central role in astronomical observations by actual scientists in the future, it is highly likely that it will be actively used in elementary astronomy classes as well. Therefore, an activity was added to discuss the principles, structure, purpose, and expected observations of the James Webb Space Telescope.

Development of 1st Interview Questions

The interview questions were divided into the categories of “experience with existing astronomical observation” and “changes in perceptions regarding astronomy-related classes and astronomy class design.” This question was also prepared through a consultation process at a seminar in which two science education experts and five students enrolled in a master’s program for science in elementary education participated. The details are shown in Table 4.

Table 4. First round focus group interview questions

Category	Questionnaire
Existing celestial observation experience	What is the interest level in conventional celestial observations?
	- Why is there a lot? Why is there a less?
	Do you have any experience with conventional celestial observations?
	- If so, what kind of experience did you have? - What did you feel, remember, or lack?
Astronomical class and changes in thinking about astronomical class design	What do you remember about astronomy that you learned in elementary, middle, and high school?
	What did you feel or remember while taking the celestial observation basic class (first class)?
	What comes to mind when you think of existing outdoor observations?
	What did you feel or remember while taking the astronomical observation practice class (second class)?
	What did you feel or remember while taking the class of understanding the principles of telescope (3rd round)?
	What would you do if you went to the field and gave an astronomical class? If you conduct astronomical classes as planned, how are the students' satisfaction?

Production of 2nd Interview Materials and Development of Questions

The second interview was conducted to specifically examine the “perceptions on the design of astronomy-related classes and astronomy classes” of pre-service elementary school teachers. Participants in the second interview designed the astronomical class according to the achievement criteria presented by the researcher based on the response to the astronomical class design mentioned in the first interview and participated in the second interview.

In the second interview, the class design activity sheet developed by the researcher was utilized. The lesson design activity sheet consists of the achievement standards for the “Night Sky Observation” unit of the 2022 revised science curriculum, explanations of achievement standards, considerations, and a space for lesson design (Ministry of Education, 2022). The second interview questions were prepared to identify the purpose or intention of the class designed by the study participants (Table 5). This class design activity sheet and questions were also produced through a consultation process at a seminar in which two science education experts and five enrolled in a master’s program for science in elementary education participated.

Table 5. Second round interview questions

Category	Questionnaire
Organizing and teaching the activities	What is the purpose of the activities that you construct? What is the development process of the organized activities? What is the intention of the designed class method or class flow?
Class design experience	What did you feel or difficulty in designing classes based on achievement standards? What was the first perception that came to your mind when you saw the unit name and achievement standards?

Data Collection

The data collected in this study are the results of the survey (the survey on astronomical observation experience and the questionnaire on the astronomical teaching efficacy), interview data (1st and 2nd rounds), research notes of the researcher, and astronomy class design activity sheet. The astronomy class date was May 10, 2022; the first interview period was May 2022; and the second interview period was October 2022.

In the first in-depth group interview, 2–3 study participants participated in the interview concurrently, and the entire interview process was recorded. The interview duration was approximately 30 minutes per group.

The researcher recorded research notes to collect data on the overall experience of the study participants in the astronomy class from various angles. Research notes are memos of events from the beginning of the study to the end, researcher’s thoughts, and characteristics of the research participants. The researcher recorded the research notes from the following viewpoints. “What experiences do pre-service elementary school teachers have during astronomy class?” “What difficulties do pre-service elementary school teachers have while taking astronomy classes?” “What emotions do pre-service elementary school teachers feel in astronomical observation activities and what are their words and behavior?” and “What changes did the pre-service elementary school teacher exhibit after taking the astronomy class?” In addition, the researcher’s opinion on the development process of the astronomical class, observation assistant instructor’s class review, and viewpoint of analyzing the collected data were recorded. The research note writing period was from April 2022 to June 2022.

The second interview was conducted with six out of nine study participants who participated in the first interview. The participants in the second interview completed the astronomy lesson design activity sheet and participated in the individual interview while viewing their own lesson design activity sheet. The duration for writing the activity sheet and interview was approximately 60–90 minutes. The astronomy class design is to design two classes on the

activity sheet after reviewing the achievement standards and achievement standards explanation of the “Night Sky Observation” section presented in the 2022 revised science curriculum proposal, along with considerations when applying the achievement standards. The achievement criteria of each class are “You can enjoy the night sky observation by observing the shape and surface of the moon and changes in the phase of the moon” and “You can understand the definition of a star and learn the constellations around the North Star” among the achievement criteria of “Observing the Night Sky.” In particular, while designing the class, the activity composition and class method that can obtain the achievement standards were recorded in detail. Pre-service elementary school teachers who participated in the study did not have experience in class execution and class guidance drafting, so they designed the class based mainly on activities while excluding the interactions with students or detailed records of preparations. Following the class design, the second interview data were collected by asking specific questions about the purpose and reason of the activity composition and class method.

Data Analysis

Analysis of the research data was conducted by answering the two research questions in order. Qualitative data analysis method was used for both 1st and 2nd interview results, and the results of the questionnaire (astronomy experience survey, astronomical teaching efficacy), analysis results, and research notes were referred to during the analysis process. First, to analyze the first research question, a protocol for all the astronomical observation experiences of the research participants was defined. This protocol was classified into previous experience, experience at the time of the astronomy class based on the time of taking the astronomy class, and the experience at the time of the astronomy class was mainly analyzed. For specific analysis, meaningful sentences or phrases related to astronomical observation and astronomy classes were derived through inductive categorization analysis, and they were restated in a general format. The results of the statement were organized into theme, theme clusters, and categories (Colaizzi, 1978). For example, by analyzing the sentences related to astronomical observation, the initial eight subjects were extracted. Afterward, through a group of themes, they were integrated in the four themes of “Understanding that a model was created based on a phenomenon,” “Recognizing a celestial body viewed with an observation tool as a new object of inquiry,” “Interaction with students as necessary during observation,” and “The observed celestial body regarded as a meaningful memory.” These four themes were categorized into “perceptions on astronomical observation”. Subsequently, the subject and sheaves of subject were repeatedly reviewed and refined (Merriam, 1998). As a result, “the perceptions on astronomical observation” category was reclassified as the four theme bundles of “Astronomical observation connects natural phenomena and models”, “Setting the astronomical objects observed with observation equipment as new research subjects”, “Astronomical observation as an emotional experience”, and “Communication contributing to the improvement of the quality of astronomical observation”.

The second research question was based on the analysis results of the first and second interview data. Based on the activity sheet, how the astronomy class activities mentioned in the first interview were performed was corroborated in detail. Subsequently, based on the activity sheet and the data from the second interview, the process of clarifying the second research question proceeded similar to that of the first research question.

To secure the reliability and validity in the data analysis process, peer review and expert feedback were conducted at the topic grouping and categorization stage. In addition, through a seminar in which two science education experts participated, advice on the validity and understanding of categorized contents were continuously verified to derive the final results.

Results & Discussion

The perceptions of pre-service teachers on astronomical observation and astronomical classes were shown in Table 6, and specific results and discussions are as follows.

Table 6. Pre-service teachers' perceptions on celestial observations

Category	Theme clusters	Theme
Perception of celestial observation	Celestial observations link natural phenomena to models	Celestial observations and astronomical images from textbooks Indirect experience of a theory that is out of touch Learning from textbooks is different from actual observation
	Set objects observed with observation equipment as new target for exploration	Observations discover new exploration targets Equipment-based observations discover new exploration targets
	Celestial observations as an emotional experience	Attempt to keep observations as pictures An emotional experience such as the wonders of astronomical observation
	Communication contributes to improving the quality of celestial observations	Colleagues support each other and observe each other Observations from different perspectives can be shared
Perception of astronomy class	Transition of astronomical class from knowledge memorization to knowledge application	You can use what you learned in class right away From memorization to activity Connecting learned knowledge to life
	An astronomical class considering the learner's level	The best object for elementary school students to observe is the moon Elementary school students know the crescent moon and the full moon the best Considering the observation environment, the moon is the best target for observation Consider location and time when observing the moon
	Software simulation as an assistant to astronomy class	Utilization of stereoscopic observable stellarium program Understand the phase change of the moon over time as a time-lapse

The perception of Celestial Observation

Celestial Observations Link Natural Phenomena to Models

In the case of Participant AM3, AM1, and AE4, it was perceived that the model or photo was connected with real natural phenomena by observing the actual moon and constellations. Owing to the nature of the astronomical domain, the celestial bodies that students can observe are far away, and even if they are observed, understanding them firsthand is difficult (Lee et al., 2015; Lim & Jung, 1993). Due to time and space constraints, learning in the astronomical domain is replaced by models or photos, and learners study by memorization without questioning or recognizing problems about actual natural phenomena. Observation using observation equipment such as telescope reminded Participant AM3, AM1, and AE4 of the models or photos in books, and it is meaningful in that they understood the reality of the knowledge that they had memorized thus far.

(Participant AM3)

It was the first time I had been to an observatory in such an official manner, so the telescope was a bit big. Such things were memorable, and it was a bit amazing. Well, when I saw it in an earth science book, the moon just came out white or there was a round shape that appeared, but something like a hole in the moon or something like that could be seen very clearly despite its distance, and I could come to realize that there was such a technology that allowed me to see it in great detail.

(Participant AM1)

I thought of it as one of the distant theories, but I felt like I was able to experience a lot albeit indirectly.

(Participant AE4)

Before this, to be honest, the astronomical class only looked at pictures, because even if I were to make observations, I didn't think I could teach them well, and I didn't know how to use a telescope well, so I think there might be something like that. However, having experienced it this time, looking at them through pictures or in a textbook definitely seems different.

Set Objects Observed with Observation Equipment as New Targets for Exploration

In the case of Participant AM3 and BM5, the moon observed with a telescope was set as a new research subject. The appearance of the moon observed through telescopes by Participant AM3 and BM5 was not sufficiently different from the appearance of the moon in textbooks or drawings. However, when looking at the moon through a telescope, more diverse observations were tried than when looking at the moon in textbooks. BM5 perceived that because they already had some knowledge of the moon, there was no need to observe it with a telescope. However, after observing with a real telescope, the celestial body that was seen from afar became enlarged and the topography of the moon was observed in detail. Pre-service teachers were made to recognize astronomical observation using observation equipment as a new research subject, even if it was a previously known subject.

Previous studies that concluded that acquiring the concept of celestial motion was difficult merely through traditional teaching and learning (Chea, 1999, 2011; Jung et al., 1995; Kim & Park, 1997) did not address how observational activities help acquire concepts and the underlying type of reasoning processes. However, the results of this study are significant as they show that the students' inquiry process or thinking process is different when a class that includes observation activities is implemented.

(Participant AM3)

In science books, we only learn elements and things like the composition of the moon, but seeing it with our own eyes, it seems to be a bit like that. I can say things like that are coming through my mind.

(Participant BM5)

When I looked at it, I saw it with a telescope that zoomed very closely, and it was very clear. I could see every single mark on the moon. Originally, I thought it was not really necessary to observe it through a telescope because I didn't know much about it by looking at it with the naked eye anyway; yet, upon looking at it through a telescope, I realized why we look through with a telescope.

Celestial Observation as an Emotional Experience

For Participant BE3, the astronomical observation experience seemed an emotional experience. Participant BE3 showed the will to keep the moon as an object of exploration while keeping it as a photograph. Moreover, because the observation experience itself is novel, the students perceived that such an emotional experience would have an effect. In the field of astronomy, the affective area has a relatively small proportion in research compared with the conceptual area or the area of teaching and learning data analysis and development (Jo & Sohn, 2018). Through Participant BE3's response, it was verified that the astronomical observation experience had a positive effect on the affective area as well as the knowledge and functional areas, serving as the basis for establishing teaching and learning strategies.

(Participant BE3)

Things kept flowing and I mostly wanted to keep something as a photograph.

(Participant BE3)

I've seen a lot of photos, too, and we see a lot of craters and things like that on the moon's surface in a textbook. But seeing them in person, even with an adult's sensibility, was very amusing, and I thought it would be good to do it because children's sensibility might allow them to feel it much more.

Among the studies related to the affective domain, Straits and Wilke (2003) showed that college students' general science teaching efficacy decreased after astronomy classes based on observational activities, while Slater et al. (2008) revealed a significant improvement in pre-service elementary school teachers' scientific knowledge, without any such improvement in the efficacy of science teaching and attitude toward science. The classes applied to the preceding studies above require a high cognitive level. It is a class that includes the process of teaching, repeating, or expanding on the basis of what has been learned. As the purpose of the class in this study was to directly observe the night sky and increase the motivation for the class performance for the astronomy class, it is judged that the motivation for the astronomy class increased, contrary to the results of the previous study.

Communication Contributes to Improving the Quality of Celestial Observations

Participant BE2 and BM4 emphasized communication with friends while observing astronomical objects. The communication method is to share individual observation results during astronomical observation activities. Participant BE2 and BM4 intended for elementary school students to observe or re-observe unobserved parts from a new observational perspective by sharing the observation results. As a related study, Eom and Shim (2022) showed that earth science teachers' ability to observe astronomical activities is acquired or strengthened through exchanges between teachers. Further research is needed to determine whether the results of this study are effective for pre-service elementary school teachers and elementary school students.

In addition, recent studies on astronomy education have been largely conducted based on constructivist theory (Lelliott & Rollnick, 2010). In constructivism, communication plays a pivotal role in inquiry processes such as knowledge generation and modification. Therefore, from the constructivism perspective, it can be said that the activation of communication activities such as observational experience sharing activities is timely.

(Participant BE2)

As we seem to be more active with each other, so when we go out, we ask and explain to each other if we don't know something; if we sit quietly in the classroom, we get bored. But when we go out, we try to see and search the internet when we don't know something or teach and ask each other. I was a little envious of that. When we were out for practical exercises, my friend definitely did not listen carefully during class, but when I asked my friend, they tried to research or ask other people to answer my question, so this kind of sharing was quite available.

(Participant BM4)

Then three or four people. It was said that a group was being formed, and the group was formed like this. The kids all see the moon individually. Yes, indeed, there are kids who can see everything about the appearance, but some kids can only see it as a circle, some can even see that the surface isn't really smooth, or there are kids who can see that the dark and light parts are separated. So, a little group of four people drew a picture, and later when the four of us met and compared the pictures: I saw this, either you didn't see it, or you saw something I didn't see. Whether what I saw was correct or not, I can tell when I listen to the teacher's explanation later.

The Perception of Astronomy Class

Transition of Astronomical Class from Knowledge Memorization to Knowledge Application

Participants AM1, AM2, and AE4 considered the existing astronomy class as one where knowledge is to be memorized. After the astronomical observation experience, Participant AM1, AM2, and AE4 all changed and embraced the perception that astronomy classes were practical and activity oriented. This change of thinking is because the existing classes only emphasize the juxtaposition of limited knowledge (Sohn, Kim & Kim, 2014).

Thus far, pre-service elementary school teachers have focused only on memorization, considering astronomy knowledge as knowledge that has nothing to do with them and to not exist around them. However, they showed a willingness to actively apply the astronomical knowledge that they had memorized following astronomical observation experience, as well as deliberate on how that knowledge was actually used.

In addition, Participant AM1 and AE4 responded positively to the fact that the contents learned before astronomical observation and astronomical observation activities connected with each other right away. This means that astronomy classes should not simply include astronomical observations. Before astronomical observation, students should be provided with an opportunity to familiarize themselves with the knowledge and skills related to observation such that they can check and apply the knowledge they have attained.

(Participant AM1)

This is not a specific framework, but the reason the stars twinkle is due to some kind of refraction. You explained it in such a way. But what I liked was that it was not the knowledge presented in the order of textbooks, but rather the knowledge that we can actually observe, and I thought explaining such phenomena that we can observe in this way is knowledge that we can think about, remember, and make a practical use of. So, I think it would be better to explain a bit about the phenomena that can be directly observed and proceed in that way, rather than a theory that is a bit too rigid.

(Participant AM2)

I thought it would be better to focus on activities a little bit because I thought that if I used a green laser or something while watching the stars directly, children can enjoy the experience while walking away from the thought of memorization. Because I also strongly believed that it was a subject that needed too much memorization, but trying the constellation like this was so much fun.

(Participant AE4)

I mean, based on what I learned in the original book, I go out with the background knowledge to observe and practice it myself. So, if children usually study the content presented in a book, then why do they learn it and what do they use it for? I think that is what most people think, and if they go out, identify with their own eyes, and experience, they can realize that it is very closely related to their lives and they would feel amazing, and become more interested, so I think their level of satisfaction would be high when they have a learning experience.

Chea's (1999) study showed the justification for the transition of astronomical classes with astronomical observation. At that time, pre-service teachers' astronomical teaching efficacy was about 3.6 points. Astronomical teaching efficacy of current pre-service teachers surveyed by the researcher also showed similar scores. This implies that astronomy classes conducted from 20 years ago to the present have hardly changed, further suggesting that a paradigm shift in astronomy classes must be made.

An Astronomical Class Considering the Learner's Level

Participant BE3 and BM5 perceived that astronomy classes should be designed by considering learners' level. It was confirmed that the level of experience and understanding of the moon of elementary school students perceived by pre-service teachers were "full moon" and "crescent moon." Based on this, an observation perspective was presented when designing an astronomy class that included astronomical observation. Participant BE3 designed the class after deciding to observe only the moon between the moon and constellations. Participant BE3 excluded constellations because it was difficult to see even the moon due to the poor observation environment in the city. When observing the moon in the long-term, Participant BM5 selected the place and time of the moon as elements that elementary school students can observe. As such, when designing the astronomy class, the pre-service teachers considered the learner's level to design an appropriate astronomical observation activity. To summarize, the pre-service teachers organized their activities around

characteristic celestial bodies (full and crescent moons) in the night sky and presented observational perspectives. This is different from the astronomical observations experienced by pre-service teachers, and it can be said that the lessons are designed assuming that elementary school students' observation experiences are at an elementary level.

(Participant BE3)

I think it might be boring for them again if it's too long, and the full and crescent moons are probably the biggest thing that students can perceive, so I want to allow students to at least observe them during the period from the crescent moon to the full moon, and if there are a lot of students interested in such changes, I would like to have them observe it during the full month-long period.

(Participant BM5)

I think the crescent and full moons are what the children know the best.

(Participant BE3)

I wrote it down here, but when I get home, even the moon is really hard to see because it is obscured by the buildings, and the constellations would be probably too difficult to see. So the moon is what they probably can observe at least, and the constellations would be hard to observe.

(Participant BM5)

First, shape change was the criterion for achievement. So, once I put in the shape, the moon ... perhaps the most intuitive difference would be the place and the time the students saw.

Participant BE3 determined the level of astronomical knowledge of elementary school students based on their own observation experience. This result is similar to previous studies that state that the existing experience is used when designing activities other than experiments as teaching and learning activities (Yang, Lee & Noh, 2014). However, there is no guarantee that elementary school students' level of astronomy knowledge matches that predicted by pre-service elementary school teachers; thus, additional research should be conducted to draw implications.

Software, Simulation as an Assistant to Astronomical Class

As supplementary materials for the astronomy class, both Participant AM2 and BM5 included software such as Stellarium, simulation using timelapse, and models using umbrellas in the class design. Participant AM2 and BM5 used software and simulation to view the night sky with a wide field of view or the movement of celestial bodies over time after observation activities. Pre-service teachers recognized that astronomical observation activities had temporal and spatial limitations. In addition, it can be seen that supplementary materials are used to learn related astronomical concepts such that the class does not become a simple observation experience level class.

(Participant AM2)

Stellarium is something very three-dimensional. So if you learn it separately, you won't see it all at once, but if you look at it three-dimensionally at a glance, it gets organized. So I feel like, rather than learning each separately, if I look at the constellations all at once from a three-dimensional perspective, it becomes more organized. And because they twinkle and twinkle so much, children like them and they can look up the constellations they want while touching them, and they can also position them like this, you know. But even if you can't use that, you can still do it at home or do it again by letting them know about this app. So I thought it would be good to do so.

(Participant BM5)

If you look at the timelapse, something like the change in the shape of the moon appears over a long period of time, and we can't be looking up the sky all the time. I wonder if it suddenly changed one day, but now when I look at the timelapse like this, I can understand it very well intuitively because I can see everything.

Astronomical observations must consider weather conditions, and especially for elementary school students, safety and level of physical development must be considered. Astronomy education programs using technologies such as augmented reality, simulation, and astronomy software (Taasobshirazi et al., 2006; Yen et al., 2013) may be a good alternative to astronomical observation. However, to provide astronomical education focusing on astronomical observation experience, it is appropriate to use the above programs as supplementary tools for astronomical observation.

Methods using advanced technologies such as web and simulation are reported to be generally effective in achieving the learning goal of understanding astronomical knowledge (Barnett & Morran, 2002; Cid & Lopez, 2010; Han et al., 2015; Hollow, 2005; Jung, 2016; Kim & Jung, 2004). However, if classes are conducted mainly on model experiments and simulations that are presented as alternatives to astronomical observation activities, it does not conform to the 2022 revised science curriculum intended for the actual "Night Sky Observation" activity. Therefore, in elementary school astronomy classes, using various supplementary tools with a focus on astronomical observation activities is desirable.

Conclusions & Implications

In this study, data were collected and analyzed from various angles to evaluate the pre-service elementary school teachers' perceptions on astronomical observation and astronomy class that emerged after the astronomical observation experience.

The conclusions drawn through the research results are as follows.

First, after the astronomical observation experience, the elementary school pre-service elementary teacher's perception of astronomical observation was considered to be an emotional experience by connecting natural phenomena and models, and setting celestial bodies observed with observation equipment as new objects. In particular, it was perceived that communication should be included to improve the quality of astronomical observation.

Second, after the astronomical observation experience, the elementary pre-service teacher perceived that the conversion from knowledge memorization astronomy class to knowledge application astronomy class, and an astronomical class considering the learner's level, software and simulation as astronomical class assistance.

The implications of the study are as follows.

First, astronomy class must be conducted to observe the celestial body with observation equipment. Although there is no statement that the current curriculum requires the use of observation equipment such as telescopes, the use of observation equipment facilitates the connection between natural phenomena and models or photographs in textbooks. As a result, one can change their thinking of an astronomy class as knowledge memorization to knowledge application, and can fully experience the scientific inquiry process. In addition, when observing a celestial body with observation equipment, it was recognized as a new object of exploration even though the knowledge of the celestial body was already present to a certain extent. This can be the basis of various teaching and learning methods and strategies in astronomy classes using observational equipment. Furthermore, the experience of using the observation equipment itself led to a positive response to the affective areas such as pre-service elementary school teachers' willingness to observe astronomy. It suggests that astronomical observation experience is related to interest and attraction in astronomy as well as understanding the practicality of knowledge.

Second, it is necessary to examine elementary school students' experiences with observing astronomical objects. Pre-service elementary school teachers designed their classes by predicting elementary school students' astronomical observation experience and astronomical knowledge level. However, this is a prediction of the experience and knowledge level of elementary school students based on the pre-service elementary school teacher's own astronomical experience. If the general elementary school students' astronomical observation experience and knowledge level are identified, it will help teachers to create an appropriate teaching and learning strategy that can be used when designing or implementing an astronomical observation class.

Third, communication with colleagues should be facilitated in the process of astronomical observation. Communication processes such as sharing observational results expand observational perspectives and increase an interest in astronomy. Additionally, by acquiring a new observational perspective, it provides an opportunity to experience the research process of scientists such as observation and question generation. Therefore, in the course of astronomical observation, designing a class that induces active communication is necessary to talk about experiences and develop perspectives with colleagues based on personal observation experiences.

The recommendations of this study are as follows. If a follow-up study on how to organize and operate astronomical classes when the pre-service teacher who participated in the study becomes an in-service teacher in the future, it will be possible to present implications for more detailed astronomical classes.

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Authors Information

Kim, Hansol: Sunchang Elementary School, Teacher, First Author.

ORCID: <https://orcid.org/0000-0001-8708-8196>

Lim, Sungman: Korea National University of Education, Assistant Professor, Co-author.

ORCID: <https://orcid.org/0000-0002-6958-2913>

Kim, Seongun: Chungbuk Carbon Neutrality Support Center, Head of Team, Corresponding Author.

ORCID: <https://orcid.org/0000-0001-7455-6077>