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Analysis of the Program for Training Pre-service Earth Science Teachers: Focusing on College Curriculum

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Abstract: This study identified and examined earth science education department programs in Korea. Major courses provided by 11 universities and their course requirements were analyzed, and the main research results are as follows. First, many basic courses, other major requisite, and elective courses are provided in geology, astronomy, and atmospheric science. oceanography, geophysics, earth environmental science, and natural disaster and energy resources had fewer major requisite courses provided in addition to basic courses, and few elective courses were offered. Second, many courses in science education focused on earth science, while others focused on general science and there were few courses that covered education theory regarding the specific subject. Third, science course application requirements emphasized the understanding of science in general or of earth science specifically. From the above results, additional studies are proposed to reflect on the current state and supplement these programs.

Keywords: secondary science teacher, earth science teacher, teacher education program, teacher qualification certificate

Introduction

The belief that teachers' quality is the key to educational reform is generally accepted without objection like a kind of proposition. Education 2030 agenda also sets the critical target of "by 2030, substantially increase the supply of qualified teachers" to achieve all of agenda (UNESCO, 2015). In line with this trend, the Global Framework of Professional Teaching including three domains and ten standards, or standard statements in 2019, the three domains are: teaching knowledge and understanding, teaching practice, teaching relations (Education International & UNESCO, 2019: p. 5). National Professional Standards for Teachers (NPST) in Australia also sets out three domains consisting of professional knowledge, professional practice, and professional engagement, seven standards and 148 criteria (Call, 2018; NSW Eduction Standard Authority, 2014). Similarly, the National Board for Professional Teaching Standards (2014) in the United States proposes teachers embody all five core propositions in their practices, drawing on various combinations of these skills, applications, and dispositions to promote student learning. National Board for Professional Teaching Standards (2014) in the United States emphasizes teachers embody all five core propositions in their practices, drawing on various combinations of these skills, applications, and dispositions to promote student learning, in particular, has organized the standards for accomplished teachers of science into the following nine standards including 'understanding students', 'knowledge of science', 'family and community partnerships', and so on.

In the study of science education, there has been a continuing interest in the education of pre-service teachers, but the studies were mainly about difficulties encountered in class (Kang, 2009; Kang et al., 2010; Kim et al. 2011; Oh et al. 2008; Park et al. 2007; Yoon, 2004), and studies on the curriculum were not conducted much. However, since the curriculum is the most basic of pre-service teacher education, further research is needed.

In Korea, the qualification criteria are specified in

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the enforcement regulations of the Teacher Qualifications Ordinance. According to the Ordinance of the Ministry of Education, pre-service teachers are required to complete more than 50 credits including major courses, and at least 22 credits in teaching theory, teaching literacy, and teaching practice (MOE, 2020). In the detailed criteria for the Earth Science Teacher Qualification, eight areas of 'earth science education (or science education)', 'geology', 'astronomy', 'atmospheric science', 'oceanography', 'geophysics', 'earth environmental science', 'natural disaster and energy resources' are presented as basic courses. In order to acquire the Earth Science Teacher's qualification, it is necessary to complete 'earth science education', and one or more subjects in at least 6 of the remaining fields (MOE, 2020). In addition, the field of subject education include 'educational theory in subject' which is the basic course, and 'logic and essay', 'teaching material and method', 'teaching methodology', 'curriculum', and 'educational evaluation' in each subject which can be developed and operated for each teacher training institution (MOE, 2020).

According to these guidelines, there will be a lot of similarities between courses among secondary school earth science teacher training institutions, but there will also be variations among subjects organized by institutions. Kim & Lee (2006) conducted a study on the curriculum for the education of teachers in Earth Science at the college of education in 2006, but they did not cover all of the recent basic courses because they divided the subject field into geology, geophysics, oceanography, meteorology, and astronomy. However, it has been agreed that the areas designated as basic courses at the national level are essential for teaching the subject, so it is necessary to examine all of these areas. Therefore, it is very important to understand which areas of the basic courses are being provided and which are not, and how the subjects provided in universities are organized. In addition, it will be able to provide basic data on what needs to be improved science teacher education program.

It should be still considered whether it is enough just to understand the standards for earth science teacher qualification certificate. This is because they may not only teach earth science although they receive the "earth science" teacher certification. If they are hired into middle school, they should teach students not as earth science teachers but as general science teachers, and they need to know science in general if they teach integrated science even in high school. For this reason, it has been argued that theoretical and experimental courses for science subjects should be taught (Kwak, 2019). However, it is just hoped that the pre-service teachers were taught science subject based on the assumption that they teach science in the middle school or integrated science in the high school at their education program because there's no way to force them to take science courses.

There is also a study that analyzed college textbooks in four basic science subjects to find out whether teacher education programs prepare for integrated science teaching (Kim & Shim, 2015). Even if the research results are positive, however, it cannot be said to be ready to teach integrated science if it is not guaranteed that pre-service teacher are learning science subjects using these textbooks. Therefore, it will be possible to provide a more reliable solution to directly compare what standards are suggested for basic science completion by teacher training institutes.

So the research questions to be solved in this study are as follows:

in department of earth science education at the college of education

1. How are the subject matter courses organized according to the national standards for teacher qualification certificate?

2. How are the pedagogical content courses relate to earth science education organized?

3. How are science subjects other than earth science completed?

By solving the above research questions, we would like to find some implications for improving the curriculum of the college of education which fosters earth science teachers.

Method

Term Definition

In this study, we will use similar concepts, so to avoid confusion, we will first define terms.

Subject: The fields of science are called subject. In other words, physics, chemistry, biology, and earth science are the subjects of science we talk about in this study.

Area: Area refer to the sub-unit of subject. In this study, it will mean the area determined nationally for obtaining a teacher's certificate, and in the case of earth science, areas are ‘earth science education (or science education)’, ‘geology’, ‘astronomy’, ‘atmospheric science’, ‘oceanography’, ‘geophysics’, ‘earth environmental science’, and ‘natural disaster and energy resources’.

Course: Course refers to classes offered in semester units. For example, among courses operated in Geology at one of the 11 universities, there is a course whose title is ‘Stratigraphy and Paleontology’. In some cases, the name of the area and the course title are the same. For example, the title of a course operated by this university’s geophysics area is Geophysics.

Basic course: Basic courses are a national level set of courses essential for obtaining a teacher’s certificate for each subject. Since each university’s course title and basic course title may not be the same, universities that can confer a teacher’s certificate have prepared a document certifying which basic courses the university’s course corresponds to (MOE, 2020). The title of the basic course of each area is the same as the area name, but the title of the course(s) operated by universities can be different.

Subjects of Analysis

The targets of this study are the departments of Earth science education and department of Science education earth science major. In Korea, there are 11 universities with these departments, which are confirmed by other studies (Kim & Lee, 2006; Kwak, 2019).

The collection of data was based on the curriculum included on each department’s website for major courses, and the university website was additionally checked for additional transfer information and basic courses for teacher certification(from now on, we will abbreviate it as basic courses).

In addition, if it is difficult to check the course title (especially in English) or the classification of course (mandatory or elective) on the websites of department and university, a comfort work was conducted to check the correct information in the university's course registration system.

The information collected in this way is the course title, course classification (required or elective/basic courses or not), and additional course requirements for majors and other introductory courses of science subjects.

Analysis of the data

For departments that confer teacher certification, students are required to complete the required credits in basic courses, education in general, and subject education, and through this, students can receive the corresponding certification (MOE, 2020). In terms of the curriculum for obtaining a teacher certification, it can be broadly opened as a major course consisting of basic courses and subject education courses, and a education courses consisting of education theory, education literacy, and educational practice (Kim, 2020), corresponding to the teaching process, consisting of cross-curricular subjects based on an understanding of overall education. Therefore, the comparison of the Earth Science Education departments aimed at in this study is limited to the analysis of courses corresponding to the major.

In the standard for applying credits for basic courses, students enrolled before 1999 are required to complete at least 9 credits (3 courses), but for those enrolled in 2000-2008, it has been increased to 14 credits (5 courses) or more. It was upgraded again to more than 21 credits (7 courses) (MOE, 2020). In addition to the basic courses, the number of major courses that must be completed for graduation at each university is far greater than that of the basic courses, so this increase in basic courses would not increase

the burden on students. However, it can be though that as the number of basic courses increased, similar courses were increased among the curriculums of earth science education departments at each university, and special courses for each university were limited to a few.

In addition, more than 3 credits require to be completed as the basic course in each area. However, it is possible to take only 3 credits, which is the minimum standard, in a specific field for each university, but in some areas, much more credits can be taken.

Courses in the subject education area are courses that correspond to pedagogy until 2008, and those enrolled before 1999 had to complete 4 credits in subjects such as subject education theory, subject textbook research, and teaching method. Students are required to take 4 credits in the subject education area of the subject, and 8 credits or more in the subject education area starting in 2009 (MOE, 2020). In other words, courses in the subject education have changed from cross-curricular to subject-specific, and the required credits have increased.

We decided to basically classify courses excluding subject education area courses among major courses according to the category of basic area, which are seven categories of 'geology', 'astronomy', 'atmospheric science', 'oceanography', 'geophysics', 'earth environmental science', and 'natural disaster and energy resources'. Excluding the subject education area, students must complete at least one course (3 credits) in at least 6 of these 7 areas in order to obtain a teacher certificate.

Just because students have to complete 3 or more credits in 6 out of 7 areas, each university may not operate only 3 credits in a specific field course. In addition, in designating a course corresponding to the basic area for each university, two or more courses may be put into one basic area, and courses of certain areas may not be operated at all. In addition, in addition to the course designated as the course corresponding to the basic area, mandatory major courses are additionally operated in the corresponding basic area, so that the number of credits that students must complete before graduation in that area can actually be (much) higher. There will be a difference among the areas. Therefore, we would like to examine this situation by classifying major courses based on the classification frame shown in Table 1.

Of course, some of the major courses of each department may not be classified under this classification system, but these courses are not suitable to be treated as a classification framework for the basic area, so this study will not cover them.

Subject Education, in addition to earth science education theory (or science education theory), which is included in basic courses, more than two courses are required. According to the Ordinance of the Ministry of Education (MOE, 2000), "Subject education contains basic courses for each subject teaching. Including the 'education theory by subject' notified as a basic course, 'logic and essay', 'teaching material and method by subject', 'subject teaching methodology', 'subject curriculum', 'subject evaluation methodology', etc. It can be developed and operated separately. Courses corresponding to 'logic and essay' can be organized by subject, similar subject or cross-curricular essay education, or focus on 'enhancing creativity' depending on the school level.". This study attempted

Table 1. Classification framework for Earth Science Major Courses

Sub-unit of Earth Science	Subject Matter knowledge courses	Basic Courses	Requisite for Major
			Elective for Major
		Non-Basic Courses	Requisite for Major
			Elective for Major
	Earth Science Education Courses	Basic Courses	Requisite for Major
			Elective for Major
		Non-Basic Courses	Requisite for Major
			Elective for Major

to determine which courses other than earth science education theory, are mainly operated by each university, and whether the focus is on earth science or science in general. The classification framework for subject education courses is shown in Table 1.

Result

Basic Courses & Requisite Courses

The credits allocated by each university to basic course (geology, astronomy, atmospheric science, oceanography, geophysics, earth environmental science, natural disasters and energy resources) are shown in Table 2. This does not mean that students only need to take these credits in each area. This means that a certain course for each area is designated as much as this credit, and a teacher certificate is granted by confirming that students have completed the courses.

Among the seven areas, for geology, astronomy, and atmospheric science, all universities allocate basic courses and require them to be completed. However, in the case of oceanography, 10 universities have assigned basic courses that must be completed, but students have to choose two areas among oceanography, earth environmental science, and natural disasters and energy resources in one university. And in the case of geophysics, there are five universities that have courses assigned to them, but there are also five universities that allow students to choose from two areas among geophysics, earth environmental science, natural disasters and energy resources. In addition, there were 5 colleges and universities required to complete earth environmental science, but as in geophysics, there are 5 colleges that allow students to choose from three areas. There is also one university where students can choose between oceanography, earth environmental science, natural disasters and energy resources.

Of the 7 areas, 6 of the areas have actually opened courses at all 11 universities, whereas in the case of natural disasters and energy resources, there are 5 universities that do not have any corresponding course at all. There is only one university (Univ. J) designated as a compulsory basic course.

Looking a little further for each area, in the case of geology, there are 4 universities (B, F, G, and H) that require students to complete 6 credits in basic courses. In addition, in astronomy, there are 4 universities (B, D, G, and H) in which students need to complete 6 credits in basic courses, and in atmospheric science, there are 3 universities in which students must complete 6 credits in basic courses (B, G, and H). In

Table 2. Credits for basic courses

Univ. \ Area	Geology	Astronomy	Atmospheric Science	Oceanography	Geophysics	Earth Environmental Science	Natural Disaster and Energy Resources
A[1)]	3	3	3	3	3	3	
B	6	6	6	6	6	3	
C	3	3	3	3	3*	3*	3*
D	3	6	3	3	3*	3*	3*
E	3	3	3	3	3	3	
F	6	3	3	3	3*	3*	3*
G	6	6	6	3	3*	3*	3*
H	6	6	6	3	3*	3*	3*
I	3	3	3	3	3	3	
J	3	3	3	3	3	3	3
K	3	3	3	3*	3	3*	3*

For * areas, students can complete 3 credits each in 2 of them

[1)]From the department and university websites, as well as on the course registration site, the major courses of Univ. A were not divided into requisites and electives. So, we considered all major courses of Univ. A as elective courses.

Table 3. Credit requirements in Geology

Univ.	Basic Courses		Non-Basic Courses		Compulsory in effect	Elective in effect
	Requisite for Major	Elective for Major	Requisite for Major	Elective for Major		
A	-	3	-	12	3	12
B	6	-	-	6	6	6
C	-	3	6	3	9	3
D	3	-	3	21	6	21
E	3	-	-	15	3	15
F	3	3	-	27	6	27
G	6	-	-	6	6	6
H	-	6	-	7	6	7
I	3	-	-	15	3	15
J	6	-	-	25	6	25
K	3	-	-	12	3	12

other words, it was confirmed that in the case of geology, astronomy, and atmospheric science, many credits are allocated for basic courses.

As mentioned earlier, basic areas and courses are nationally determined, and universities can choose among the areas (and courses). However, for major courses, there is not only such a distinction, but also a distinction between requisite major and elective major, which is determined by the department of each university. We examined how many courses are offered for each area by universities, and how many courses are requisite, and compare them with basic courses. And through this, we would like to take a rough look at how each university actually operate courses belonging to each area.

The basic courses that students must complete and the non-basic courses that are required for their major are actually the courses they must complete. Looking at these courses, depending on the university, 3-9 credits are required. The actual mandatory is 4 universities with 3 credits, 6 universities with 6 credits, and 1 university with 9 credits. In other words, an average of 5.18 credits from 11 universities were being operated as practical mandatory courses in the geology area, and an average of 13.55 credits were operated as practical elective courses.

Although elective courses were different for each university, many courses related to geological surveys were operated by universities, and various courses such as mineralogy, petrology, mineralogy, geography, stratigraphy, and paleontology belong to the selection of majors.

In astronomy, there were 5 universities with 3 credits, 5 universities with 6 credits, and 1 university with 9 credits, and an average of 4.91 credits from 11 universities was actually required. An average of 9.27 credits is operated as practical elective courses.

There was also a post-requisite course of basic course as an elective course in astronomy, but there were many courses that added more depth, such as Solar system astronomy, Galaxies and universe, Stellar astronomy, and Astrophysics. In addition, there were also courses focusing on observation and interpretation of data, such as Observational astronomy, Astronomical information and analysis, and Practical astronomy, which cannot be sufficiently provided with basic courses alone.

Atmospheric science requires an average of 4.36 credits in 11 universities and 9.09 credits for actual electives. The actual requirements are 7 universities with 3 credits, 3 universities with 6 credits, and 1 university with 9 credits.

When atmospheric science is operated as a actual elective course, there is a large variation between universities, with 0-18 credits. Among them, there were particularly many courses such as Synoptic meteorology and Synopsis analysis, which is thought to be due to the importance of analyzing synoptic

Table 4. Credit requirements in Astronomy

Univ.	Basic Courses		Non-Basic Courses		Compulsory in effect	Elective in effect
	Requisite for Major	Elective for Major	Requisite for Major	Elective for Major		
A	-	3	-	9	3	9
B	6	-	-		6	0
C	-	3	6	6	9	6
D	3	3	-	12	6	12
E	3	-	-	17	3	17
F	3	-	-	18	3	18
G	6	-	-	3	6	3
H	-	6	-	4	6	4
I	3	-	-	12	3	12
J	3	-	-	18	3	18
K	3	-	3	3	6	3

scale in atmospheric science. In addition, a number of subjects such as weather observation and weather analysis, which are courses related to synoptic analysis, were also confirmed, and there were also several universities that teach climatology.

Oceanography is most often required to complete 3 credits as a basic course for each university (9 schools), and one university requires 6 credits to be completed. And it is one university that allows students to choose a basic course in 2 areas out of 3 areas including oceanography. As for the actual elective credits, there are 4 universities with 3 credits, and 1 university with 6 or 5 optional credits. There is also one university that does not require additional completion other than the basic course, so it was confirmed that relatively little courses was provided compared to the geology, astronomy, and atmospheric sciences discussed above.

In geophysics, 6 universities were running practically essential courses, of which 5 required 3 credits and 1 required 6 credits. However, five universities were required to take the basic courses of the geophysics area by choosing from the basic courses of the other two areas (earth environmental science and natural disasters and energy resources). In addition, in geophysics, there were only two universities that operated additional courses other than actual requisite.

There are five universities that operate as a actual requisite for earth environmental science, and six universities that allow students to choose two out of three areas (geophysics, oceanography, natural disasters and energy resources) and take courses that belong to them. Also, in most universities, only the basic course was operated, and only one university operated courses other than the basic course.

In the area of natural disaster and energy resources, there are three universities that do not have courses that belong to them, and even if there is a course, only one university operates as a requisite major course. In the rest of the universities, it is offered as an elective major course, and because it allows students to choose an additional basic course in another area, it can be said to be the least practical course. In addition, it can be said that only basic courses are operated is a characteristic of this area.

If we summarize the actual required credits for each area of universities, it can be seen that as shown in Table 6, there are a number of actually required courses in the order of geology, astronomy, atmospheric science, oceanography, geophysics, earth environmental science, and natural disasters and energy resources.

In addition, many elective courses are operated in the areas of geology, astronomy, and atmospheric science, where many compulsory courses are operated. In other words, it can be said that the courses students take as majors are concentrated in geology, astronomy and atmospheric science areas. The main elective subjects operated in these three areas are shown in

Table 5. Credit requirements in Atmospheric Science

Univ.	Basic Courses		Non-Basic Courses		Compulsory in effect	Elective in effect
	Requisite for Major	Elective for Major	Requisite for Major	Elective for Major		
A	-	3	-	6	3	6
B	6	-	-	-	6	0
C	-	3	-	3	3	3
D	3	-	3	15	6	15
E	3	-	-	12	3	12
F	3	-	-	18	3	18
G	3	3	3	18	9	18
H	-	6	-	7	6	7
I	3	-	-	9	3	9
J	3	-	-	6	3	6
K	3	-	-	6	3	6

Table 7 (Similar course titles were unified and presented as one course title, and elective courses operated only in specific universities were excluded.).

Earth science education courses

A total of 8 credits (3 courses) or more, including earth science education (or science education) theory, must be completed as earth science education (or science education) courses. Therefore, earth science education (or science education) theory is opened in all universities. In one university (Univ. J), both earth science education theory and science education theory are mandatory. 7 universities open earth science education theory only and 2 universities (Univ. C and K) open science education theory only, and one university recognized as earth science education theory as a basic course along with the teaching and learning instruction of earth science and earth science education theory of the university.

Looking at the operational status of subjects other than earth science education, there are logic and writing courses, which can also be operated as science logic and writing or earth science logic and writing. Among the 11 universities, 8 universities (A, C, D, E, E, F, G, H, and J) were operated for earth science logic and writing, and 3 universities (B, I, and K) were operated by science logic and writing. Although this course was operated as a major required or elective for each university, it was operated as a course that must be completed at all universities in order to satisfy the conditions for obtaining a teacher certification.

In the case of earth science (of science) teaching materials and methods, all universities were teaching earth science teaching materials and methods, and there was one university (Univ. C) that operated science teaching materials and methods as an additional elective major course. Earth science teaching materials and methods was also operated as a major compulsory or elective major for each university, but there are cases where it is actually required because there is no other earth science (or science) education

Table 6. Actual required courses (credits) for each area

Area / Credits	Geology	Astronomy	Atmospheric Science	Oceanography	Geophysics	Earth Environmental Science	Natural Disaster and Energy Resources
Minimum	3	3	3	-	-	-	-
Maximum	9	9	9	6	6	3	3
Mean	5.18	4.91	4.36	3.00~3.27	1.91~3.27	1.36~3.00	0.27~1.91
S.D.	1.94	2.02	2.06	-	-	-	-

Table 7. Electives in the areas of Geology, Astronomy, and Atmospheric science

	Geology	Astronomy	Atmospheric Science
Mean (credits)	13.55 (about 4.52 subjects)	9.27 (about 3.09 subjects))	9.09 (about 3.03 subjects)
S.D. (credits)	8.03	6.56	5.96
Course titles	• Area excursions in Earth Science/ area Geology • Mineralogy • Petrology • Stratigraphy • Historical Geology/Paleontology • Tectonics • Geology of Korea	• Solar System Astronomy • Stellar Astronomy • Galaxies and Universe • Observational Astronomy • Astrophysics	• Synoptic Meteorology • Weather Analysis & Prediction • Climatology • Atmospheric Dynamics

courses to be taken even if it is a major elective, so at least 50% of universities require this course.

In addition to these courses, there are universities that open courses such as teaching method in earth science education, curriculum in earth science education, or evaluation in earth science education as earth science education courses, but these courses are generally operated by major electives, and compared to the 3 courses discussed above, not many universities open these courses. Among these, comparatively many universities are being educated in teaching method in earth science teaching method, which was operated under the course title of 'Teaching Experiments in Earth Science', 'Earth Science Inquiry and Laboratory' or other similar title. One of the reasons why these courses are not educated in more universities is thought to be because they can be educated in the earth science teaching materials and methods or the content science part of earth science. Also, it is believed that this is because the curriculum or educational evaluation is a subject that can be completed as a pedagogical course (teaching theory). For example, in Univ. B, when curriculum and educational evaluation are opened as teaching theory courses at the department of education, and one of these courses' classes is operated only for students majoring in science education.

Requirements for science subject courses

Some of the students who graduate from the earth science education department may become middle school teachers, or even high school teachers, who may be in charge of integrated science. In addition, because the earth science is often based on the understanding of other science subjects, we also looked at what the requirements for completing science subjects' courses other than earth science.

Universities that explicitly define the requirements for completing science courses, such as D, E, and H universities, may require an understanding of science in general. By designating specific courses that are required for all sciences as well as earth sciences, students are educated not to lack their understanding of other science subjects.

Some universities give students choices, such as B, C, G, and J. In Univ. B, as general education courses, students must complete one course in four of six subjects: mathematics, computer science, physics, chemistry, biology, earth science. In the case of Univ. C, basic science courses are offered among elective majors, and some of these basic sciences are required to be completed in order to satisfy major credits.

Some universities demand the completion of earth science introductory courses rather than the completion of other science subjects' courses, and Univ. A, F, and K are examples. These universities seem to want students to have an overall understanding of earth science before they learn each area of earth science by operating an introductory earth Science as a major or elective.

Unlike these, there is also university (Univ. I) that restrict the completion of the introductory earth science course, which is thought to be a response to the side effects that can occur when major students take earth science as general education courses.

Table 8. Classification of Earth science/Science Education Courses

Course / Univ.	Earth Science (or Science) Education Theory	Earth Science (or Science) Logic and Writing	Earth Science (or Science) Teaching Materials and Methods	Teaching Method in Earth Science Education	Curriculum in Earth Science Education	Evaluation in Earth Science Education
A	Earth Science	Earth Science	Earth Science	• Teaching Experiments in Earth Science	• Curriculum and Evaluation in Earth Science Education	
B	Earth Science	Science	Earth Science	• Earth Science Inquiry and Laboratory Teaching	*	*
C	Science	Earth Science	Science/Earth Science			
D	Earth Science	Earth Science	Earth Science			
E	Earth Science	Earth Science	Earth Science			
F	Earth Science	Earth Science	Earth Science	• Earth Science Teaching Method • Teaching inquiry in Earth Science and Practice		• Evaluation in Earth Science Education
G	Earth Science	Earth Science	Earth Science	• Teaching and Learning Methods for Earth Science**		
H	Earth Science	Earth Science	Earth Science	• Guide to Lab Work and area-trip in Secondary School Earth Science		
I	Earth Science	Science	Earth Science	• Earth Science Teaching Method	• Curriculum and Evaluation in Earth Science Education	
J	Science/ Earth Science	Earth Science	Earth Science			
K	Science	Science	Earth Science ***			

*Although Curriculum and Educational evaluation are classified as teaching theory at Univ. B, a class for students majoring in science education is in operation, and students are encouraged to complete them.
**Univ. G includes the Earth Science Teaching Method as part of the Earth Science Education Theory(as basic area course). In other words, if a students of Univ. G has completed both the Earth Science Education Theory and the Earth Science Teaching Instruction, it is regarded as the completion of the Earth Science Education Theory to acquire the teacher certificate.
***In Univ. K , there are courses of 'science textbook research and teaching method IV' in addition to 'earth science textbook research and teaching method', but these two courses appear to be the same.

Discussion and Conclusion

In this study, how the basic courses for earth science teacher certificates are operated for 11 universities with earth science education department (or science education department earth science major) in Korea, and how major courses classified based on the basic area of earth science are. In addition, we tried to find out what characteristics appear in earth science education (or science education) courses, and we also checked the requirements for introductory science courses.

Geology, astronomy, atmospheric science, and oceanography were required to be completed in most universities, but geophysics, earth environmental science, and natural disaster and energy resources were required to be taken as actual elective courses. In particular, many universities did not operate courses for natural disasters and energy resources.

In the case of geology, the number of required credits was substantially higher, and the diversity of subjects to choose was also remarkable compared to other areas, which is thought to be due to the fact that many earth science education departments in Korea started based on geology. It is believed that this is because geology is so important in secondary education.

In the case of astronomy, although a little less than geology, the variety of courses to choose from was very large. In many cases, courses that provide basic understanding of astronomy are operated as basic and

Table 9. Regulations on completion of science subject courses

Univ.	Criteria for completion of science subjects
A	General Education Courses : No mandatory science subject for Earth Science Major Students. Major Courses : General Earth Science 1~3 (3 credits each) are in the Major Course as electives, and all of them are in the recommended tracks for undergraduate majors.
B	General Education Courses Students of Science-Major must take Calculus 1 course and 4 courses from among the belows ; Calculus 2(or Honor Calculus and Practice 2), Physics 1(or Honor Physics 1), Chemistry 1, Biology 1, Earth Science, Digital Computer Concept and Practice ※ Student who takes Physics 1(or Honor Physics 1), Chemistry 1, Biology 1, or Earth Science must take the corresponding labs concurrently. Major Courses : No introductory science subject in major courses.
C	General Education Courses : Almost none science course in the General Education Courses. Major Courses : General Physics 1, 2, General Chemistry 1, 2, General Biology 1, 2, General Earth Science 1, 2, General Physics Laboratory , General Chemistry Laboratory, General Biology Laboratory, General Earth Science Laboratory, Mathematics and Science, Multimedia in Mathematics and Science Education, and Theory and Practice of Integrated Science Education are electives for all students in the division of Science Education. If a student take single major in Univ. C, he/she must earn 15 credits in the division of Science Education's common courses. It means that minimum 6 credits earned as introductory science courses.
D	General Education Courses : Students must take General Physics, General Physics Laboratory, General Chemistry, General Chemistry Laboratory, General Biology, and General Biology Laboratory. Major Courses : Students take General Earth Science and General Earth Science Laboratory as electives.
E	Major Courses : As the integrated science major was abolished from the 2019 school year, the decision regarding the completion of science-related courses will be determined as follows. 1) General Physics I, General Chemistry I, General Biology I, General Geoscience I and General Physics Lab I, General Chemistry Lab I, General Biology Lab I, General Geoscience Lab I are all required. 2) General Physics II, General Chemistry II, General Biology II, and General Geoscience II courses are required, but General Physics Lab II, General Chemistry Lab II, General Biology Lab II subjects are not required. Required for opening.
F	General Education Courses : The required courses for general education courses are not specified on the department's website, but Mathematics 1, General Physics 1, and General Physics 2 are designated as general education courses in the Department of Physics Education and, General Chemistry 1 & 2 are designated as general education courses in the Department of Chemistry Education. Because it is designated as, it is highly likely that the Earth Science Education Division also designated Earth Science 1 and 2 as mandatory. Major Courses : Among the major electives, there are general biological exploration experiments 1 and 2, earth science exploration experiments 1 and 2, general physics exploration experiments 1 and 2, and general chemical exploration experiments 1 and 2, each of which is 1 credit.
G	General Education courses : Among the general education courses, 9 credits are required to be completed on the basis of science and engineering. The basics of science and engineering include Math 1, Math 2, General Physics 1, General Physics Lab 1, General Physics 2, General Physics Lab 2, General Chemistry 1, General Chemistry Lab 1, General Chemistry 2, General Chemistry Lab 2, General Biology & Lab 1 , General Biology and Experiment 2. Since 19 credits can be designated by the department as a general education elective, the number of science courses students must complete may increase.

Table 9. Continued

Univ.	Criteria for completion of science subjects
H	Major Courses : Science education students enrolled before 2015 must complete the integrated science as multiple majors, and students entering science education after 2016 can select Multiple Majors in integrated science. Students who do not major in integrated science must complete the following courses Physics: General Physics and Practice, Electromagnetics Chemistry: General Chemistry and Practice, Inorganic Chemistry Biology: General Biology, Cytology Earth Science: General Earth Science, Geology
I	General Education Courses : At the university level, students in their departments are not allowed to take general education elective courses similar to their majors. In the case of the Department of Earth Science Education, Earth Science and Experiment I fall under this subject (Applied from the second semester of 2020) Since it is necessary to take four of the subjects of general education such as mathematics, Chinese characters, physics, biology, earth science, topography, and chemistry, students are likely to take science courses as general education. Major Courses : No special restrictions can be found on the Department and University website.
J	General Education Courses : As general education courses, 18 credits are required to be completed in the convergence domain. There are a total of 5 sub-domains in the convergence domain, including nature and science. Of these, 4 or more domains are required to be completed, so a maximum of 9 credits can be taken in nature and science. Subjects belonging to nature and science include many science courses at a level of common knowledge, such as physics in life, light and sound, science and technology found in life, etc.. Major Courses : Earth Science (2 credits), Earth Science I, II (3 credits each), Earth Science Lab. I, II (1 credit each) as electives
K	General Education Courses : 6 credits must be earned in the area of natural sciences as academic foundations Major Courses : General Earth Science and Lab. I, II (3 credits each) as electives

requisite courses. In addition, solar system astronomy, galactic astronomy, stellar astronomy, and galaxies and space are operated as separate elective courses to educate students to better understand each part of astronomy. And by operating subjects focusing on observation, it was found that basic courses alone compensated for insufficient laboratory practice.

It was a little less than geology and astronomy, but atmospheric science also has far more elective courses than other areas. There were also a large number of universities with climatology as an elective subject.

As such, geology, astronomy, and atmospheric science were assigned many credits as mandatory majors, and various elective courses were operated. In addition, it has been shown that a wealth of education is being conducted on practical training (geological survey, astronomical observation, meteorological observation and forecast, etc.) along with theoretical depth.

In contrast, oceanography, geophysics, earth environmental science, natural disaster and energy resources could hardly be confirmed except for basic courses. This may be because oceanography deals with atmospheric science and geophysics in geology to some extent. In addition, since earth environmental science and natural disaster and energy resource are convergence sciences, it is thought that there would have been difficulties in the composition and education of their contents. And since these areas are relatively new in the history of earth science education in Korea, so the development of courses may not be sufficient yet.

However, considering that the fact that they were presented as basic areas necessary for obtaining a teacher's certificate may be because learning these

areas were considered essential to qualify as a secondary school teacher, and these areas may be increasingly emphasized in future earth science and earth science education. Considering that there is, we think it is a matter to reconsider whether or not to be satisfied at the current elective courses level.

In the case of courses of earth science (or science) education, earth science (or science) education theory and earth science (or science) logic and writing were more specialized in earth science, but the courses for science in general were operated. Some cases were also confirmed. However, in the case of teaching materials and methods, courses on earth science were operated by all universities, and there were cases where courses for general science were additionally operated.

While the above four subjects of earth science (or science) education were operated by all universities, teaching method in earth science, curriculum in Earth science education, and assesment in earth science education were operated only in some universities. This is likely due to the fact that these courses may be taught in other courses in their major, or may be run as education theory courses.

Looking at the general education and major regulations for science subjects, some universities designate specific subjects for all four science subjects to complete these subjects, while others allow students to choose from a set of courses that include science according to their preferences. In addition, some universities allow students to complete introductory-level earth science courses, while others prohibit students to complete introductory-level earth science courses. Insufficient rules for completing science subject courses may lead to bias in specific subjects. Such bias may undermine the overall understanding of science, which will have a negative impact on students who will and will not be teachers. Therefore, as in some universities, it may be necessary to subsume course completion in all subjects of science. Of course, it will be also necessary to check the cases of various universities as to whether there will be any side effects when these restrictions are applied.

So far, we have looked at education in the department of earth science education in Korea. Our research was based on the data posted on the website of each department and university for data collection. Therefore, depending on the update level of the website, some courses that are not already operated may have been included, and there is a high possibility that the contents of the course status of major selection courses that are actually required and the contents of student guidance for each university were not sufficiently included. Also, we did not cover courses that were not classified as basic fields in our study, which was judged from the titles of the courses, so the possibility that these subjects actually belong to one of the basic fields cannot be excluded. Regardless of whether they are included in the basic courses, these courses will enrich the education of the earth science education department. Therefore, understanding and introducing these courses can be helpful in the development of earth science education, even if not generally taught at all universities. It is expected that education in the earth science education department in Korea will be better analyzed through follow-up research, and through this, the education of the earth science education department will develop in a more desirable direction for pre-service teachers.

References

Call, K., 2018, Professional Teaching Standards: A Comparative Analysis of Their History, Implementation and Efficacy. Australian Journal of Teacher Education, 43(3). (http://dx.doi.org/10.14221/ajte.2018v43n3.6)

Education International & UNESCO, 2019, Global Framework of Professional Teaching Standard.

Kang, K.H., 2009, Analysis of Difficulties Experienced by Pre-service Secondary Science Teachers in Student-Teacher Practice. Journal of the Korean Association for Science Education, 29(5), 580-591. (in Korean)

Kang, H., Kim, E., Choi, S., and Noh, T., 2010, The influences of Teaching Practices upon Preservice Elementary School Teachers' Self-images of Science Teaching. Journal of the Korean Association for Science Education, 30(2), 261-274. (in Korean)

Kim, J.-H. and Lee, K.-Y., 2006, Investigation of the Earth Science Teacher Education Programs in the College of

Education and their Improvement Plans. Journal of the Korean Earth Science Society, 27(4), 390-400. (in Korean)

Kim, K.S., Yoon, J.H., Park, J.A., and Noh, T., 2011. The Components of Pedagogical Content Knowledge Considered by Secondary Science Pre-service Teachers in Planning and Implementing Teaching Demonstrations. Journal of the Korean Association for Science Education, 31(1), 99-114. (in Korean)

Kim, N.H. and Shim, K.-C., 2015, Educational Implications for Pre-Service Science Teacher Training through the Comparative Analysis between 'Integrated Science' based on the 2015 Revised Science Curriculum and Educational Contents presented in the Pre-Service Science Teachers' Textbooks of the College of Education. Journal of the Korean Association for Science Education, 35(6), 1039-1048. (in Korean)

Kwak, Y., 2019, Secondary School science teacher education and quality control in Korea based on the teacher qualifications and the teacher employment test in Korea, Asia-Pacific Science Education, 5(1), 1-14.

Ministry of Education, 2020, 2020 Teacher Qualification Test Practice Manual. Sejong, Korea, 61 p., 105 p., 158 p., and 191p. (in Korean) (https://www.moe.go.kr/boardCnts/view.do?boardID=327&boardSeq=79925&lev=0&m=0305)

National Board for Professional Teaching Standards, 2014, Science Standards for teachers of students ages 11-18+ (3rd Edition) (http://www.nbpts.org/wp-content/uploads/EAYA-SCIENCE.pdf)

NSW Education Standards Authority, 2014, Australian Professional Standards for Teachers. Sydney.

Oh, P.S., Lee, S.-K., Lee, G., Kim, C.-J., and Kim, H.-B., 2008, Narrative Inquiry on Student-Teachers' Teaching Experiences with Extra Curricular Science Classes of a High School: Types and Characteristics of the Knowledge Constructed by the Pre-service Science Teachers. Journal of the Korean Association for Science Education, 28(6), 546-564. (in Korean)

Park, M., Lee, J., Lee, G., and Song, J., 2007, Conceptual Definition and Types of Reflective Thinking on Science Teaching: Focus on the Pre-service Science Teachers. Journal of the Korean Association for Science Education, 27(1), 70-83. (in Korean)

Yoon, H.-G., 2004, Pre-service Elementary Teachers' Difficulties in Science Lessons. Journal of Korean Elementary Science Education, 23(1),74-84. (in Korean)

UNESCO, 2015, Education 2030: Incheon Declaration and Framework for Action for the implementation of Sustainable Development Goal 4. (http://uis.unesco.org/sites/default/files/documents/education-2030-incheon-framework-for-action-implementation-of-sdg4-2016-en_2.pdf)

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