*Eurasia Journal of Mathematics, Science & Technology Education*, 2016, **12**(7), 1863-1880
doi: 10.12973/eurasia.2016.1533a

# Pre-service Science Teacher Education System in South Korea: Prospects and Challenges

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•*Received 25 June 2015*•*Revised 8 January 2016* •*Accepted 12 January 2016*

While much is known about the high academic but low affective achievement of Korean students on international comparative studies, little is known about science teacher education in Korea. As the quality of science teachers is an important factor determining the quality of science education, gaining an understanding of science education in Korea necessitates understanding the science teacher education system and the ways of leveraging quality science teacher preparation. Korea has a unique science teacher education system in many aspects due to its unique socio-cultural background. This study critically reviews the current state of the science teacher education system in South Korea in terms of the outcomes and institutional backgrounds, such as associated law and policy, teacher education curriculum, recruiting system and examinations. A careful review is conducted of the previous literature, official documents and statistics from the Korean government, and curricular documents from some teacher education institutions. The paper concludes with a discussion on the uprising issues in science teacher education within the socio-cultural context of Korea and offers implications to the international science education community.

*Keywords*: pre-service science teacher, science teacher education, teacher education curriculum

## INTRODUCTION

As frequently commented in the literature, the quality of education cannot surpass that of the teacher's; hence, the professional development of teachers is considered the most important factor in education (Im, Yoo, & Pak, 2001; Lee et al., 2013a; Park, 2014; Treagust, Won, Petersen, & Wynne, 2015). Since professional

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ISSN: 1305-8223 http://iserjournals.com/journals/ejmste

development begins with selecting qualified teachers (Kang & Ahn, 2014), fostering high quality science teachers has been a main focus of educational reform in many countries over the past two decades. Most teacher educators worldwide have an interest in teacher preparation and certification (Cochran-Smith et al., 2015; Lee et al., 2013b). A general overview and the challenges faced by some countries from six continents were reported in a recent issue of the *Journal of Science Teacher Education* (Cofré et al., 2015; Evagorou, Dillon, Viiri, & Albe, 2015; Liu, Liu, & Wang, 2015; Ogunniyi & Rollnick, 2015; Olson, Tippett, Milford, Ohana, & Clough, 2015; Treagust et al., 2015). However, as Lederman and Lederman (2015) noted in the editorial, those were just the beginning of a dialogue about science teacher preparation, and more research is needed from unreported countries.

Teaching as a profession is a complex phenomenon that is continually impacted by contextual and political aspects and, hence, cannot be explained with simple theory (Lederman & Lederman, 2015). As Conway, Murphy, Rath, and Hall (2009) mentioned, countries across the world are dealing with teacher education cautiously. Since they are facing similar challenges but under various different political and cultural contexts, similar but different solutions have been applied according to their individual situation.

**_State of the literature_**

- Leveraging high quality science teacher prepa ration has been the main focus of educational reform in many countries over the past two decades.
- Despite Korea's leading position in worldwide math and science tests, science teacher educat ion is facing its own problems and challenges.
- Challenges facing science teacher education in many countries should be examined in terms of various political and cultural contexts of th eir individual situation.

**_Contribution of this paper to the literature_**

- Korea has a unique teacher preparation syste m in which elementary and secondary teacher education institutions are separated, and the government controls the qualification of teach ers by regulating the coursework.
- Strong tradition has emphasized the importan ce of academic bases for content knowledge a nd pedagogical content knowledge (PCK). This is often reflected in both the science teac her curriculum and the highly competitive em ployment test.
- Oversupply of science teachers in Korea is urg ent and serious for both human resources management and controlling teacher quality.

Korea established its own educational systems from the beginning of the 20th century with the commencement of modernization. Passing through the Japanese colonial era (1910-1945), Korean War (1950-1953), and industrialization (from the 1960s), the Korean education system was established and the rapid qualitative and quantitative expansion that was achieved played a key role in the subsequent economic development (Jones, 2013). Korea's internationally recognized rapid economic growth, which was achieved through education after the nation-wide destruction of the Korean War, has focused worldwide attention on the Korean education system. However, despite Korea's leading position in worldwide math and science tests, its education is also facing its own problems and challenges.

The teacher education system in Korea has been analyzed several times (Darling-Hammond & Cobb, 1995; Im et al., 2001; Ingersoll & Consortium for Policy Research in Education., 2007; Jones, 2013; Kwak, 2012) and also compared with those of other countries, including the United Kingdom (Kim et al., 2009; Noh, 2004; Shim, 2010), Japan (Kim, 2009; Kim et al., 2003), China (Liu & Park, 2013), and the United States (Kim et al., 2009). However, few studies have focused on the science teacher education system including both elementary and secondary levels.

The purpose of this study is to present an overview of pre-service science teacher preparation in South Korea, so as to highlight the main features that might initiate discussion of critical issues in the context of science teacher education nationally and internationally. For this, we conducted a literature review on the Korean teacher preparation system and global trends in teacher preparation program. At the same time, curricula of Korean teacher education institutions and the regulations for teacher certification were analyzed. National databases such as the

Korean Educational Statistics Service and Statistical Yearbook for Employment of Higher Education Graduates (Linked with Health Insurance Database) were also reviewed. As a theoretical and methodological background, we adapted a sociocultural perspective of culture (Sewell, 2005) as a framework for thinking about science teacher education, meaning that we view science education as a form of culture that is enacted as practices that can be observed as participants interact with one another. In this perspective culture can be understood as dialectic between structure and agency, where structures consist of schemas and resources existing in a dialectical relationship.

Schemas represent how humans deal with the patterns in the social and material world, such as the rules of social life or attitudes, which can be applied in or extended to a variety of contexts of interaction. Therefore, schemas are virtual things in that they cannot be reduced to their existence in any particular practice or location. For example, policies such as teacher recruitment, university requirements for teacher certification, and cultural climate in which people regard a teaching job highly would be schemas that can impact science teacher education. While schemas are virtual entities, resources exist and are either human or non-human materials. For example, knowledge about science content or science teaching theories can be thought of human resources in the contexts of science teacher education, while laboratory equipment or recruitment tests can be non-human resources. Both types of resource are media of power and are unevenly distributed.

Structures that consist of schemas and resources are held in a dialectical relationship with agency, while agency can be defined as a person's power to enact practices to meet ones goals. These structures can afford or constrain a person's ability to access and appropriate the resources needed to meet their goals, resulting in a person being agentic or not. This means that while structures can shape a person's agency, a person's agency can also shape structures (Sewell, 2005; Roth, 2005).

Taking such a sociocultural perspective into account, this paper presents a critical review of the current state of the science teacher education in South Korea with three parts: educational system, curriculum, and certification and employment. In the following section we briefly described the main features of science teacher education system as a comparison between elementary and secondary teacher preparation institutions. Next, science teacher education curriculum is discussed in terms of institutional backgrounds such as associational laws and policy. In the next section, we highlight the certification and employment of science teachers in consideration of sociocultural background of South Korea. In the following section, as a conclusion, we analyze and discuss the features of science teacher education in South Korea from a sociocultural perspective. In the last section we induce implications in the context of international science education community from a critical review of the uprising issues.

## SCIENCE TEACHER EDUCATION SYSTEMS

### Separation of elementary and secondary teacher preparation institutions, both focusing on undergraduate certification

One of the features of the Korean teacher education system is that elementary and secondary teacher education institutions are separated and independent of each other. Many other countries like the United States, the United Kingdom, France and Japan have integrative teacher education institutions which educate teacher candidates for all school levels from elementary to secondary (Park, 2002). This unique feature of Korea results from its historical background. After the Korean War (1950-1953), Korea began its industrialization in the 1960's and continued in the

1970's. At that time the number of school children was increased rapidly; however, the turnover rate of elementary teachers was also high. Korean society needed to ensure a high quality elementary teachers supply.

According to Im et al. (2001), the science teacher education system can be categorized into three different types: Focusing Undergraduate Certification of Education (FUCE), Open Undergraduate Certification of Education (OUCE), and Post Graduate Certification of Education (PGCE). FUCE refers to the system that exists within the colleges of education at the undergraduate level, which take exclusive responsibility for teacher education. OUCE refers to the system in which the undergraduate courses are open, and one can be a teacher if one takes the required teaching professional courses for the certification of education at the undergraduate or graduate level. PGCE refers to the system in which those who finish undergraduate courses and then take intensive educational courses in graduate school can obtain the certification to be a science teacher. It is similar to OUCE in the respect that the undergraduate courses are open, but is different in that the PGCE has a separate institute for being a teacher at the graduate level.

In Korea, a teaching certificate for elementary teacher can be attained only at designated universities focused on educating elementary teachers, which are FUCE according to the above categorization. In contrast, however, secondary science teacher candidates have three ways to obtain teaching certificates: FUCE in colleges of education for educating secondary teachers, OUCE in any college when students take the required teaching professional courses for teaching certificates, and PGCE when students finish undergraduate education and take intensive required educational courses in graduate school (Cho et al., 2006; Cho & Kim, 1997). Therefore, Korean science teacher preparation institutions have huge differences in elementary and secondary schools, which are separated and managed independently of each other.

Elementary teacher preparation institutions recruit one cohort of students and educate them so that they can teach all subjects taught in elementary school. On the other hand, secondary teacher preparation institutions recruit many cohorts of students in each major and educate them to be able to teach their major subject, usually one among physics, chemistry, biology and earth science.

There are 13 designated elementary teacher education institutions designed solely to supply qualified elementary teachers: 10 national universities of education (Seoul, Busan, Gyeongin, Chuncheon, Cheongju, Gongju, Jeonju, Gwangju, Daegu, Jinju national universities of education), 2 national universities (Korea National University of Education, Jeju National University), and 1 private university (Ewha Womans University). The 10 national universities of education were two-year colleges till 1981, when they upgraded their status to four-year universities to improve elementary education. Elementary teacher preparation institutions recruit students as one cohort and then set each student's major courses based on his or her preference. Elementary teacher preparation institutions have 12~14 major courses: Korean Education, Ethics Education, Education, Mathematics Education, English Education, Social Studies Education, Science Education, Music Education, Art Education, Physical Education, Practical Art Education, Computer Education, Early Childhood Education, etc. However, they emphasize elementary teacher candidates' competencies to be able to teach all elementary school subjects. Also, the freshman quota of elementary teacher preparation institutions is controlled annually by the Ministry of Education. According to the national statistics (MOE, 2015), the overall quota of freshmen from the 13 elementary teacher education institutions is 3,848.

As aforementioned, there are three ways to become secondary science teachers in Korea: FUCE, OUCE, PGCE (Cho et al., 2006). Irrespectively, if they take the required teaching professional courses based on the Teacher Certification Authorization Act (Act No. 25684) and its detailed regulations, they will obtain secondary science teacher certificates for their majors without taking any exam. Although the number of students who obtain certificates through OUCE and PGCE has increased slightly these days, students most commonly obtain certificates through FUCE. The current quota of Korean secondary science teacher education institutions from 40 departments of national universities and 14 departments of private universities is 1,156 (MOE, 2015). Although students mainly take FUCE to become secondary science teachers, the number of secondary science teacher candidates has always exceeded the demand. This oversupply of teacher candidates, especially for secondary science teachers, will be discussed later in this paper.

The possible integration of elementary and secondary teacher education institutions is occasionally debated in Korea. Some support the integrative teacher education system which can bring more flexible teacher supply, while others advocate the current independent system which is believed to foster quality elementary teachers (Park, 2002).

### Departmentalism in the secondary science teacher education system

Korean secondary science teacher education is usually implemented in four traditional departments of colleges of education: Physics, Chemistry, Biology, and Earth Science. When a college of education recruits students, each department separately recruits and selects freshman. Some institutions recruit students for common science, who are subsequently divided into four departments when they become sophomores. The students' teaching certificate issued by the government varies according to the department they attended.

This departmentalism is one of characteristics of the Korean secondary science teacher education system, which simultaneously features pros and cons. In middle school, one teacher teaches general science, which comprises Physics, Chemistry, Biology, and Earth Science. Even in high school, compulsory science subject is integrated according to the new national curriculum (Korea Foundation for the Advancement of Science & Creativity, 2015). Physics, Chemistry, Biology, and Earth Science only exist as elective subjects in high school. However, science teacher education is divided into four departments. Teacher candidates are highly specialized in their major within each department, but receive only minimal education about the other three science domains before they become science teachers. For example, when a pre-service teacher majors in physics in a science teacher education institution and finally acquires a 'Physics teacher' certificate and sometimes a 'Common science teacher' certificate together, the teacher has to teach not only physics but also the three other science domains, despite having relatively low expertise in these three other domains due to the physics-oriented curriculum of the physics education department (Lee, 1986, 1989; Sung & Chung, 2013).

The Korean government has tried for a long time to establish integrated science in the national education curriculum to overcome the limitations of science education departmentalism (Yang, Kwak, Han, & Noh, 2013). However, the efforts have not succeeded in schools because of the division of the science teacher education system into four departments. The government has tried to manage 'common science' teacher education curriculum to overcome this limitation but the effort was only partially successful with many institutions sticking to the old policy of the departmentalized science teacher education system.

## SCIENCE TEACHER EDUCATION CURRICULUM

### Legal standard curriculum for getting teaching certificates

Pre-service teachers can obtain teaching certificates without taking any exam if they have taken the required teaching professional courses that follow the Teacher

**Table 1.** Required credits to obtain a teaching certificate (Regulations for Teacher Certification Authorization Act, [Act No. 46, Sep 2, 2014, Partial Amendment])

| Type | Majors | Teaching Profession |
|---|---|---|
| Elementary School Teaching Certificates | 50 credits or more<br>- 50 credits or more in content specific pedagogy and subject matter<br>- Including 21 credits (7 courses) or more in Basic Required Courses* | 22 credits or more<br>- Teaching theories and accomplishments: 18 credits or more (including 6 credits or more in teaching accomplishments)<br>- Teaching practice: 4 credits or more( possible to include 2 credits or less in educational volunteer program) |
| Secondary School Teaching Certificates | 50 credits or more<br>- 21 credits(7 courses) or more in Basic Required Courses* of (certification) title subject<br>- 8 credits(3 courses) or more in content specific pedagogy of (certification) title subject | |

**Basic Required Courses are mandatory subjects for getting teaching certificate which are adduced by additional tables in the regulations.*

Certification Authorization Act (Act No. 25684) and its detailed regulations. Therefore, the curricula of elementary teacher and secondary science teacher education are mostly controlled and influenced by the government. Moreover, the government regularly evaluates teacher education institutions on certain criteria. The evaluation result is declared and used to determine differential financial support for each institution. In this context, the Korean science teacher education curriculum is controlled by the law (the Elementary and Secondary Education Act, Teacher Certification Authorization Act, Detailed Regulations for Teacher Certification Authorization Act, Detailed Legal Standards for Getting Teaching Certificates in Kindergarten, Elementary and Secondary Special Schools, etc.) and by the government. This seems natural considering that elementary and secondary education in Korea is also strongly controlled by the government and the national curriculum is highly influential.

Teacher candidates in both elementary and secondary teacher education institutions have to get 50 credits or more in their majors and 22 credits or more in the teaching profession, an average rating of 75 points or more on courses in their majors and an average rating of 80 points or more on courses in the teaching profession to obtain teaching certificates. In addition, pre-service teachers have to become suitably qualified in aptitude for teaching and personality tests provided by teacher education institutions (once in 2-year institutions and twice in 4-year institutions). Table 1 shows the regulation for credits needed to obtain teaching certificate.

Courses in the teaching profession are the same no matter which type of teaching certificate is to be obtained. The courses are composed of total 22 credits or more: 12 credits or more in teaching theories, 6 credits or more in teaching accomplishments, and 4 credits or more in Teaching Practice, etc. Courses in the teaching profession are general education courses without any specific subject: 'Introduction to Education', 'History and Philosophy of Education', 'Curriculum', 'Educational Evaluation', 'Education Methodology and Technology', 'Educational Psychology', 'Sociology of Education', 'Educational Administration and Management', and 'School Counseling and Guidance' etc. Courses in Teaching Accomplishments include 'Education for Special Needs', and 'Theories about Prevention of School Violence'. Courses in teaching accomplishments are designed to meet current social needs. For example, as school violence has emerged as a social issue, a course entitled 'Prevention of School Violence' has recently been created.

Basic Required Courses for pre-service elementary teachers consist of 'Elementary School Ethics Education', 'Elementary School Korean Education', 'Elementary School Mathematics Education', 'Elementary School Science Education', and 'Elementary School Art Education' etc.

**Table 2.** Credit hours of curricular domains of Chuncheon National University of Education

| Curricular domains | Credits | Fields or Subjects |
|---|---|---|
| Liberal arts course | 34 | Humanities Science, Social Science, Natural Science, Sport, Music, Art, Life Information Science, Foreign Language |
| Pedagogy | 19 | History of Education, Educational Philosophy, Curriculum and Instruction, Educational Psychology, Educational Sociology, School Counseling, Educational Administration, Special Education |
| Content specific pedagogy | 49 | Moral Education, Korean Education, Social Studies Education, Education, Mathematics Education, Science Education, Practical Art Education, Music Education, Art Education, Physical Education, Computer Education, English Education |
| Creative experiential activity | 2 | Educational Drama, School Newspaper, Classic for Children, Camping, Cooking, Music for Event, Volunteer Work, Philosophy for Children etc. |
| Subject Practice | 12 | Music, Fine Art, Sport, Classroom English, Computer |
| Intensive course | 21 | Teacher candidates belong to one major among 12 and take their intensive courses according to their majors. In case of science education majors, Science inquiry, Science teaching resources, MBL experiments, etc. |
| Practicum | 4 | Field Participation Practicum (P/F, 2 weeks), Teaching Practicum (2credits, 4 weeks), School Management Practicum (2credits, 4 weeks), Educational volunteer program (P/F, 50 hours) |
| Total | 141 | |

*'Graduation thesis or task' and 'Aptitude and personality of teaching test' are also required based on P/F system*

Table 2 shows the structure of the curriculum of Chuncheon National University of Education. The curricular structures of other elementary teacher education institutions are similar to meet the regulation for obtaining teaching certificates. A total of 141 credits are required for graduation; about 19 credits in general pedagogy, 49 in content specific pedagogy, and about 21 in major course. There are 12 major courses, of which the Elementary School Science Education department is one. Therefore, if students major in Elementary School Science Education, they will get 21 credits about elementary science education including Elementary School Science Inquiry, Elementary School Science Teaching Resources, etc. On the other hand, students from different majors, for example Elementary School Music Education department, will get only about 5~6 credits of science education among 49 credits concerning content specific pedagogy before graduating.

In case of major courses in secondary teacher education institutions, at least 50 credits, including 8 (3 courses) for content specific pedagogy and 21 (7 courses) for subject matter, are required. In the Teacher Certification Authorization Act, the major curriculum consists of subject matter and content specific pedagogy. The former comprises courses dealing with specialized contents in each of the four science domains. The latter concerns pedagogical content knowledge (PCK), which was first conceptualized by Shulman (1986), and includes understanding about students, teaching methods, textbooks and curriculum. Three content-specific pedagogy courses are nominated as theory of science education, science textbook and teaching method, logics and writings on science. For example, in order to get a license for secondary physics teachers, Theory of Physics Education, Physics Textbook and Method for Teaching Physics, and Essays on Physics Education must be passed.

Credit hours of curricular domains of Daegu University, chemistry education department are shown in Table 3. The curricular structures of other secondary science teacher education institutions are also similar because course titles and their credit hours are suggested in the regulations for teaching certificates. This kind of governmental regulations might hinder the development of various curricula by the teacher education institutions. However, if the government pursues educational reform, they may change the teacher education curriculum more easily than in the absence of such regulations.

## Practicum detached from university courses

The teacher education curriculum features a practicum so as to provide an opportunity to learn *in* and *from* their own practices. In Korea, elementary teacher preparation institutions are putting more emphasis on practicum than are secondary. As shown in Table 4, most universities of education for elementary teacher candidates require 9-10-week courses of a practicum over the 4–year period. On the other hand, most colleges of education for secondary teacher candidates require only one 4-week course, mostly in the senior year.

For example, Chuncheon National University of Education requires 1 week school observation in the spring and fall terms of the sophomore year, and one of these days should be spent observing at a special education school. In the fall term of the junior year, 4 weeks of a practicum is practiced, when the teacher candidates prepare their own classes and are supervised by their guiding teacher. They also do the comprehensive practicum again in the spring term of the senior year, when they also practice general school affairs, including classroom management and writing official document, as well as teaching. Since all teacher candidates are sent to the

**Table 3.** Credit hours of curricular domains of chemistry education department, Daegu University

| Curricular domains | Credits | Fields or Subjects |
|---|---|---|
| Liberal arts course | 23 or more | Social Service, Writing, Foreign Language, Culture and Arts, History and Society, Science and Future, Basic of Humanities and Social Science, Basic of Natural Science |
| Pedagogy | 22 or more | Introduction to Education, Educational Philosophy and History of Education, Curriculum, Educational Evaluation, Educational Methodology and Technology, Educational Psychology, Educational Sociology, Guidance and Counseling, Educational Administration and Management, Theory and Practice of Teaching, Introduction to Special Education |
| Content specific pedagogy | 9 | Theory of Chemistry Education, Chemistry textbook and Method for Teaching Chemistry, Essays on Chemistry Education |
| Subject matter course | 41 or more | Physical Chemistry and Laboratory, Analytical Chemistry and Laboratory, Organic Chemistry and Laboratory, Inorganic Chemistry and Laboratory |
| Practicum | 4 | Teaching Practicum (2credits, 4 weeks), Educational volunteer program (2 credits, 60 hours) |
| Total | 140 | |

*'Graduation thesis or test' and 'Aptitude and personality of teaching test' are also required based on the P/F system*

**Table 4.** Comparison of School Practicum among teacher education institutions

| University / Practicum type | Universities of education for elementary teacher candidates: Chuncheon | Gyeongin | Seoul | Colleges of education for secondary science teacher candidate: Daegu University | Korea National University of Education | Seoul National University |
|---|---|---|---|---|---|---|
| Observation/Participatory | 1 week (P/F) +1 week (P/F) | 2 weeks (1 credit) + 2 weeks (1 credit) | 1 week (P/F) + 2 weeks (1 credit) | | | |
| Classroom teaching | 4 weeks (2 credits) | 2 weeks (1credit) | 2 weeks (1 credit) + 2 weeks (1 credit) | 4 weeks (2 credits) | 8 weeks (4 credits) | 5 weeks (2 credits) |
| Comprehensive/Practical Works | 4 weeks (2 credits) | 4 weeks (2 credits) | 2 weeks (1 credit) | | | |

  

schools at the same time, the university has to keep a good relationship with elementary schools. Chuncheon National University of Education has 10 elementary schools as cooperative schools for the teaching practicum. Professors are asked to visit elementary schools during the practicum to monitor their students (teacher candidates) practice. The government also requires teacher candidates to volunteer certain amount of hours at elementary schools, libraries, museums, and historical sites.

The practicum is more emphasized in elementary teacher education institutions than in secondary teacher education institutions, in that they have longer and more diverse practicum. However, the practicum during teacher preparation is far less emphasized in Korea than in other countries. In Korea, only two to four credits, which correspond to 1.4%~2.8% of total credits, are allocated for practicum. In Australia, 15%~28% of total credits account for practicum (Jeong, 2009), in the UK, 30%~50% (Whang, 2007). Whang (2007) summarized the problems of practicum of Korean elementary teacher education institutions as follows: a short period that is directly connected to the difficulties of newly appointed teachers, a lack of qualified guiding teachers, and insufficient evaluation on the students' classroom teaching under the cooperation of university and elementary school.

The weak connection between practicum and other university subjects was also noted and criticized (Whang, 2007). Usually practicum is managed as an independent subject, which is not connected with other university subjects. Supervision on students' teaching during the practicum period is more likely to be influenced by elementary school guiding teachers. Professor(s) are usually asked to attend teacher candidates' classes to encourage students' practice, but this is not for giving credits or teaching pre-service teachers. Usually there are no specific university subjects designed to help preparation or reflection during practicum. The disconnection of practicum with other university subjects could deepen the gap between theory and practice in pre-service teachers' teaching.

Another issue concerns the period of practicum. A 9- or 10-week practicum is insufficient to develop the teaching competency of elementary teacher candidates. Usually every teacher candidate teaches 15-20 class hours during four weeks of the practicum. However, since they are to teach 10 subjects, they teach science only 1-3 times. Therefore, elementary teacher candidates don't have enough opportunities to practice teaching science. According to the research by Yoon (2004), pre-service elementary teachers had many difficulties in teaching science, and the most difficult job was related with science practical work. As a result, the urgent challenge remains to strengthen practicum during teacher education in Korea.

In the case of the secondary teacher preparation curriculum, four weeks of the teaching practicum is mostly required regardless of the type of institution. Moreover, since most subject matter courses and methods courses are taught during the sophomore and junior years, the teaching practicum has to be done in the spring term of the senior year. Four weeks of the practicum is the only opportunity for practice, observation, teaching, and classroom management at once.

As with elementary teacher preparation institutions, secondary teacher preparation institutions are also trying to become connected with schools and encouraging professors to supervise their students. However, four weeks are too short to practice from observation to classroom management. Collaboration between schools and teacher preparation institutions cannot be achieved easily under these circumstances (Ju & Yang, 2007).

Secondary teacher preparation institutions also have educational volunteering. Every secondary teacher candidate has to volunteer at the authorized educational institutions (mostly elementary and secondary schools). Educational volunteering is in the line with the practicum and is also limited to volunteering in educational institutions. However, although teacher candidates reportedly face many difficulties during volunteering (Lee & Yoon, 2015), no help or supervision of teacher educators is provided. Therefore, this service activity has little educational value.

## CERTIFICATION AND EMPLOYMENT OF SCIENCE TEACHERS

### From certification to employment to be a science teacher

In Korea, the teaching profession is one of the most popular career choices. Teachers have been respected in the tradition of East-Asian culture (Liu et al., 2015). Job stability and competitive payment are further reasons for the desirability of teaching to many young Koreans. A teacher employed at a national or public school is treated as a civil servant, which guarantees employment till retirement and pension. In job stability and payment, there is no significant difference between teachers at private schools and public schools. Lower secondary teachers expect a mid-career salary of $52,700, much higher than the average of OECD countries (Center on International Education Benchmarking, 2015). Accordingly, highly competitive students are applying to teacher preparation courses. Especially, because the government controls the supply of elementary teachers and limits the admission spaces to elementary teacher preparation institutions, only high achieving students can apply to be elementary teacher candidates. Most teacher education institutions require high achievement in high school and take a teaching-aptitude interview. This ensures the relatively high quality of teacher candidates, especially in case of the closed system like elementary teacher education institution and teachers college in secondary level.

The general pathways for becoming an elementary teacher and a secondary science teacher are shown in Figure 1. Independent of the type of teacher education institution, teacher candidates who satisfactorily meet the graduation requirements specified by the Teacher Certification Authorization Act [Enforcement Date: Nov. 4, 2014][Act No. 25684] receive a Grade 2 Teaching Certificate from the government without examination, and the certificate has no expiration date. After a teacher candidate is employed and gains 3 years of field experience in school, he or she can acquire a Grade 1 Teaching Certificate through a series of professional development courses. This absence of any certification examination and of any certification expiration once acquired is unique, which is an advantage for teachers in terms of social credibility and teacher status (Shin, 2002), but also a disadvantage of the system in terms of stiffening the teacher assessment and management system to control the quality of in-service teachers (Chung & Oh, 2007).

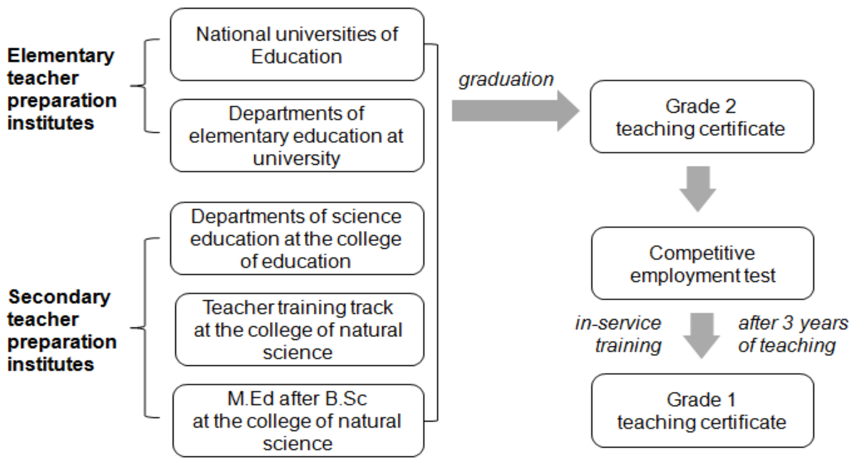


**Figure 1.** Paths to become science teachers in Korea

 

However, to become a qualified teacher with a teaching certificate does not guarantee employment at schools. Teaching certificate holders must pass the national teacher employment test to teach in public schools. Though the employment procedures at private schools vary slightly, most schools need an equivalent qualification and require the result from the national teacher employment test. Thus this test is critical for employment as a full-time teacher. The test is administered annually by the Korea Institute for Curriculum and Evaluation, a government-funded educational research institution and each Metropolitan and Provincial Office of Education. Upon passing this test, teachers gain tenure to teach in public elementary or secondary schools. Usually, this test is extremely competitive (Kwon, 2004) for the aforementioned reasons.

## Oversupply of science teachers and highly competitive employment test

The shortage of qualified science teacher is a global problem. Many countries from Latin America (Cofré et al., 2015), Africa (Ogunniyi & Rollnick, 2015), England (Burns, 2013), and China (Liu, Liu, & Wang) are facing this problem. The U.S. Department of Education (2015) also has published a "Teacher Shortage Areas Nationwide Listing" since the 1990/1991 school year. On the other hand, the oversupply of science teachers is the evident feature and serious problem in Korea's science teacher education. Although the government has been controlling the supply and demand of elementary teachers, teacher oversupply was predicted even at elementary schools decades ago due to the falling student population caused by below-replacement fertility rates since 1984 (Kim, et al., 2006). The average employment rate of graduates from elementary teacher education institutions in recent years was 64.7% in 2012, and 66.5% in 2013.

Teacher oversupply is much more evident and serious in the secondary level. According to the national tax database (KEDI, 2012; 2013; 2014), the average employment rate of graduates from the department of natural science education (math and science education) in universities was only about 35% in the last 3 years, and not all graduates got teaching jobs. For example, in 2014, the number of selecting secondary science teachers is only 448 (for math teachers 458), compared to over 2,460 graduates from math and science education departments, even excluding the graduates from teacher training courses of general universities and from graduate schools of education. Thus, even for the math and science education department of teacher's college that was established for the preparation of secondary math and science teachers, only 36.8% of graduates can be employed as a math or a science teacher, which is far below than average the university graduate employment rate of 54.8%. The competition is even higher when graduates from other tracks to become a math or a science teacher, like teacher training course in major of natural science, are considered. For example, the competition rate of the national teacher employment test in 2014 was 7.9:1 for physics, 8.5:1 for chemistry, 10.3:1 for biology, and 7.2:1 for earth science, with an average of 8.7:1 for all secondary science teachers.

The national teacher employment test has two sequential parts: a written examination and, for those who pass it, a teaching practice test with an interview.

For elementary teachers, the first examination part consists of 3 sections: essay writing on educational theory (20%), descriptive test on understanding of curriculum (80%) and Korean history (P/F). The second part consists of an in-depth interview on teaching aptitude, designing a lesson plan, and teaching practice, the most critical part of which is the descriptive test on curriculum, in which a candidate should answer 22 questions in 120 minutes for all subject matter education areas, including 3 questions in Korean language, 3 in mathematics, 2 in social study, 2 in science, 2 in English, 2 in physical education, and one question for each of moral education, practical arts, music, art, and other areas for early elementary level. To show more about the test questions in science, for example, one problem asks how and to what extent one can measure the weight of objects using spring and what kinds of inquiry skills are needed for students to implement this experiment in the context of student's inquiry about 'measuring weight'. To answer this question, a candidate should comprehend PCK in the context of instruction of inquiry and experiment, as well as content knowledge about the weight and elasticity of springs.

For secondary science teachers, the test also consists of 2 parts similar to the elementary teacher's test: 3 sections of essay writing on educational theory (20%), and a descriptive test on understanding of subject matter (80%), in which both content knowledge and PCK are assessed. For example, one problem in a recent test dealt with lesson planning for teaching the general relativity theory with gravitational lens phenomena. To answer this problem correctly, candidates should know how to apply abductive reasoning and a thought experiment in the context of lesson planning, and also have a substantial understanding of the principle of equivalence that is fundamental in the general relativity theory. The second part is the same as that of the elementary teacher's test: in-depth interview on teaching aptitude, designing a lesson plan, and teaching practice. The difference is that the first examination part for the secondary science teacher requires much more in-depth understanding of content knowledge and PCK. This part is critical in determining the test score that affects employment. The subject matter test is composed of two parts: the understanding and application of PCK, mostly based on the theories of science education and national science curriculum (25~35%), and the understanding of content knowledge, i.e., scientific knowledge (75~65%) on major subjects designated by the regulations for Teacher Certification Authorization Act [Enforcement Date: Sep. 2, 2014] [Act No. 49 of Educational Ministry ordinance]. For example, the test for physics teachers examines the in-depth academic understanding of classical mechanics, electromagnetism, optics, thermodynamics and statistical mechanics, quantum mechanics, and modern physics. For PCK, the questions examine the understanding and application of history and philosophy of physics, physics curriculum in secondary school, theory of learning physics, teaching methods in physics, physics inquiry and experiment in the context of teaching.

As this test is highly competitive, it is designed to be difficult in order to differentiate even among highly qualified candidates, especially in the science subjects. So the test is very sensitive in its credibility, and its impartiality has occasionally become a social issue. Accordingly, most teacher candidates focus on preparing for this test even after graduation from teachers college. This is more serious for secondary science teachers than for elementary teachers. So private academies to prepare for the national teacher employment test have become widely prevalent, which may reduce the science teacher education in teachers college to merely a preparation course for the employment test.

Following the adoption of this style of employment test, many science teacher educators have debated the validity of the employment test to assess the quality of science teachers (Kang & Ahn, 2014; Lee et al., 2013b). Recently, the focus of questions in the employment test has changed from understanding of content knowledge into practice of such knowledge in the context of school science (Lee et al., 2013b).

## CONCLUSION AND DISCUSSION

Although Korea spends an average of 7.6% of GDP on educational institutions, which is higher than the OECD average of 6.3%, the governmental expenditure on educational institutions is only 4.8% of GDP, which is lower than the OECD average of 5.4% (OECD, 2013). However, the educational quality in terms of students' learning outcomes is one of the highest in the world. Especially in the area of mathematics and science, Korean students have consistently demonstrated outstanding performance in international tests of student achievement such as TIMSS and PISA. In the 2009 PISA assessments, Korea ranked second in reading, fourth in mathematics and sixth in science, and in the 2012 PISA top in mathematics and $2{\sim}4^{th}$ in science among OECD countries (OECD, 2014). Although it is very difficult to explain social features with a single theoretical perspective, a consideration of the overall context of science teacher education in South Korea can help to understand the features in elementary and secondary science education, including young students' high achievements in mathematics and science. For this, we firstly summarize the features of science teacher education in South Korea, and then discuss them through the lens of a sociocultural framework.

The unique features of science teacher education of Korea can be summarized in the following three ways. First, South Korea has a unique teacher preparation system in which elementary and secondary teacher education institutions are separated, and the government controls the qualification of teachers by regulating the coursework required for teacher certification. Second, a strong tradition has emphasized the academic importance of content knowledge and PCK, as is reflected in both the science teacher curriculum and the certification of teachers. Third, the oversupply of qualified science teachers is serious so that the highly competitive employment test may affect science teacher education.

These features can be understood in terms of South Korea's sociocultural background, which can be analyzed from the viewpoint of culture theory in dialectic relation of structure (schema and resource) and agency. Korean culture has a strong schema of teacher-respect with its Confucian tradition, similar to other Far East Asian countries like China and Japan. Typically Koreans view a good education as the key to employment, economic benefit and social success. Almost all Koreans are enthusiastic about education and desire the most complete education attainable, and even more so for their children. In this view, teachers who can provide a good education leading to success in all life avenues have traditionally been respected, not only by students by even by parents, though recently this respect tradition has been weakened.

In this structure in which education is regarded as a key factor for success in society, the strong governmental control over science teacher education system can be understood. Similar to the national curriculum system in elementary and secondary school, the science teacher education curriculum is also controlled by the government in terms of associated laws for teacher certification. The strong academic emphasis in both elementary and secondary science teacher education can also be understood as a schema interact with resources like science teacher education curriculum and employment test in which academic understanding of content knowledge is important.

Schema such as the teacher-respect tradition can consist of another facet of the structure interacting with non-human resource such as a stable job position with competitive income and guarantee for tenure. This structure has formed the unique feature in which many high achieving students are willing to be science teachers so that there are a plenty of high-quality science teacher candidates as a powerful human resource for science education in South Korea. The structure can make pre-service science teachers more agentic in that the structure affords their ability to access resources such as science teacher education curriculum of strong academic basis, which may lead to young Korean students' high achievement in science at international comparative tests.

However, at the same time, this structure can be a constraint that leads to oversupply of science teachers. The serious oversupply problem makes the national teacher employment test highly competitive, and plays a critical role in teacher education, which affects the preparation for the employment test. This may reduce the teacher education program to merely a preparation course for the employment test. This structure may constrain pre-service science teachers' ability to appropriate the resources needed to meet their goals to become teachers. The employment test as a crucial resource in this structure may greatly affect pre-service science teachers' study in science teacher preparation courses. Pre-service science teachers may be less agentic in that they are likely to study passively to prepare for the employment test but place less effort on teaching practice.

Science education as a culture is composed of multiple structures that can intersect, and the structure of science teacher education can interplay and overlap with other structures such as secondary science education. The heavy focus on testing is one of the problematic features of the Korean education system. Even the high performance among Korean students is often undervalued and interpreted as a result of the standardized education that heavily focuses on testing at the expense of students' engagement, motivation, and interest in study. It is very similar to teacher education. Although teacher candidates with academic excellence can be employed through this highly competitive test, a high score in the employment test does not guarantee teacher quality.

## UPCOMING ISSUES AND CHALLENGES

The quality of the teacher is the major determinant of student engagement with science (Osborne, Simon, & Collins, 2003). Therefore, recruiting and retaining science teachers of the highest competency is considered a critical factor in improving and sustaining the quality of school science education. Recruiting and retaining science teachers have different nuances in Korea's unique environment. In Korea, the recruitment issue is related to how to manage the oversupply of competent science teachers, and the retention issue is related to how to control the qualification of science teachers. As recruiting and retaining science teachers are the urgent upcoming issues of science teacher education, not only in Korea but also in the international context, we critically review these issues based on our description and analysis in this paper.

The oversupply of science teachers seems to be unique in Korea compared to the endemic undersupply of science teachers worldwide (Ogunniyi & Rollnick, 2015; Olson et al., 2015; Treagust et al., 2015). Many competent teacher candidates are wasted due to the lack of school positions. This is urgent and serious not only in terms of human resources management but also for controlling teacher quality. However, this problem cannot be solved by a short-term approach but should be carefully approached with long-term planning in consideration of its inherent complexity with social structure. The teacher oversupply is systematically related to various educational factors. As we discussed through the lens of sociocultural perspective in the above section, this issue could and should be understood in the context of a unique cultural background, that is, in terms of the schemas and resources of Korean structure. Therefore, any educational reform movement to resolve this issue must be discussed in consideration of Korea's cultural perspective. In the tradition of Korea, where teachers are educated mainly by teachers college, however, social pressure has increased to open the door to become a teacher. This request is valid for many reasons, not to mention the worldwide trend of the teacher preparation system. But, in the structure of science teacher education in South Korea, this may deepen the oversupply problem, so this problem should be solved within the present science teacher education system focusing on teachers college. The fundamental solution should be a rational adjustment of the supply of science teachers based on future demand. As a structural approach, the Korean government has recently reinforced the accreditation process for all kinds of teacher education program.

On the other hand, this issue raises concerns about how to assess the quality of science teachers in the employment test. As described above, oversupply has induced very high competition in the employment test. This might raise the quality of teachers who are employed in some sense, but the fundamental question remains of defining the quality of a science teacher. According to OECD (1994), the quality of a teacher is defined in five dimensions: knowledge of curriculum and content, pedagogical skill and the ability to utilize it, self-reflection and self-criticism, empathy for others, and management skills in and out of the classroom. However, of course, a high score in the written test on science content and education theory does not guarantee such criteria of teacher quality. Many scholars and experts doubt that the employment test appropriately assesses the quality of science teachers (Lee et al., 2013a). Rather, such a high-stake test can often distort any kind of education. As discussed earlier, such a high-stake employment test as a resource for all stakeholders in science teacher education, including pre-service teachers and teacher educators, comprises the unique structure of science teacher education in Korea, and which can shape stakeholders' agency dialectically so as to produce subsequent practices. For example, science teacher education can be considered merely a preparation step toward the employment test, which has tended to lower public trust in the teaching profession. Similar to young students' achievement in the TIMSS and PISA tests, the heavy focus on testing may lead teacher candidates to lose their engagement, motivation, and interest for teaching science as practice. Even for recruiting good quality science teachers, the oversupply of science teachers should be dealt with as an urgent issue and approached in thoughtful consideration of institutional and social influences.

Retaining well-qualified science teachers is not presently a serious problem in Korea, because the teaching profession is highly regarded due to its social credibility and the teacher candidate ratio is high. The Korea government has controlled the qualification of teachers in detail, even in terms of the completion of subjects required to obtain a teacher certificate, similar to the national curriculum system in elementary and secondary schools. Instead, a teacher certificate, even without any expiration date, can be issued without further qualification examination, once the required program regulated by the government has been completed. Therefore, the governmental regulation of the teacher education program is unique and important. This might be a strong point of the teacher education system in Korea, which maintains the quality of education.

On the contrary, however, this governmental control may restrict the retention of the quality of science teachers by hindering the development and implementation of active curriculum or trials for various alternatives in the level of each teacher education institution with its own tradition or characteristics. Especially in present society where social and material environments are rapidly changing, such a lack of flexibility is more critical. For example, more attention should be paid to the problem of out-of-field teaching, effective teaching for students with special needs, and utilizing ICT skills, which are upcoming environments in school science teaching worldwide. Hence, the effectiveness and contradiction of the governmental control system in teacher education and certification remains debatable. One possible suggestion is to follow national 'standards' rather than detailed regulation, while retaining more flexibility in science teacher education.

This paper has described the main features of science teacher education in Korea and discussed some of the relevant issues, especially from a sociocultural perspective. The discussion in the light of a cultural theory may be intrinsically confined to the unique context of South Korea. However, the issues raised from this paper may be important in that the quality of science teacher education is regarded as urgent among international science education community. This paper may offer insight into dealing with each country's own issues in consideration of its unique structure of culture. Further review of the different contexts of science teacher education such as in Korea may afford global insight into the fundamental tasks of recruiting and retaining high quality science teachers. In the absence of 'any definitive and comprehensive view of science teacher education throughout the world' (Lederman & Lederman, 2015), we hope this paper may contribute to enlarging our collective understanding of science teacher education.

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