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교사 양성 프로그램에서 과학 교육 과목이 초등학교 예비 교사들의 과학 교수 효능에 대한 신념에 미치는 영향[1)]

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Impact of Preparatory Science Methods Courses on Korean Prospective Elementary School Teachers' Science Teaching Self-Efficacy Beliefs

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ABSTRACT

교사들의 과학 교수 효능의 신념을 조사하고 이해하는 것은 과학 교수를 향상시키는데 가장 유력한 요소가 될 수 있음에도 불구하고, 이를 연구한 사례는 거의 없었다. 본 연구의 목적은 초등학교 예비 교사들의 교사 양성 과정중 과학 교육 과목이 예비 교사들의 과학 교수 효능의 신념 즉, 자신의 과학 교수 효능감과 과학 교수 결과에 대한 기대감에 미치는 영향을 조사하는 것이다. 이를 위하여 서울교육대학교와 인천교육대학교에 재학중인 예비교사들이 한 학기동안의 과학 교육 과목을 마치고 나서 그들의 과학 교수 효능의 신념이 어느 정도 변화했는지를 측정하였으며, 이에 대한 결과를 *t*-test로 분석하였다. 연구의 결과로 미루어보아 예비 교사들이 학습한 과학 교육 과목은 그들의 과학 교수 효능감과 과학 교수 결과에 대한 기대감을 모두 향상시켰다. 그러나 앞으로는 과학 교육 과목의 어떤 요소들이 그들의 신념을 변화시키는지 구체적으로 알기 위해 질적 연구와 함께 더욱 긴 기간 동안의 연구가 행해져야 하며, 변화된 그들의 신념이 실제 초등학교 교사가 될 때까지 지속되는지를 조사하고, 지속될 수 있는 방법들이 연구되어야 할 것이다.

I. Introduction

In Korea, as in many other countries, there are a host of constraints to effective science teaching. The prominent problems constraining effective science education in Korea are the quality of teachers, the lack of development and supplying of teaching materials and tools (such as teaching methods, textbooks, and experimental apparatuses), the large number of students in classes, inadequate financial support for science education, the system of entrance examinations for high school and college, and student assessment and evaluation

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(Kwon, 1994). According to Kwon (1994), the most significant way to improve science education in Korea is to improve the quality of teachers. Educators of Korean science teachers have paid attention to the research on science teacher development, especially in preparation programs in science and training of practicing science teachers, in order to educate the best science teachers. Nonetheless, published research on Korean science teacher learning and development is limited. Only 14 articles were published about Korean teachers of science in the Journal of the Korean Association for Research in Science Education from 1978 to 1993, as compared to 333 articles published on science teachers and science teacher education from 1984 to 1991 in the United States (Hong, Woo, & Jeong, 1995). Pak (1978, 1980) has argued that although it is commonly agreed that the most important factor in improving science teaching is the science teacher, there has been little research investigating the effectiveness and quality of prospective science teachers, the science preparation programs, and the current status of practicing teachers.

While many factors have been identified to explain the problems in science education, some researchers argue that a better understanding of science teaching self-efficacy beliefs is the most powerful key to improving science teaching (Czerniak & Schriver, 1994; Enochs & Riggs, 1990; Scharmann & Orth Hampton, 1995). The results of research show that high teacher self-efficacy beliefs have been related to a high quality of teaching and to high student achievement in science (Czerniak & Chiarelott, 1990; Enochs & Riggs, 1990; Enochs, Scharmann, & Riggs, 1995; Riggs & Enochs, 1990; Watters, Ginns, Neumann, & Schweitzer, 1994). It has been argued that the suc1) cess of a science teacher education program, therefore, may be best measured by examining how it changes teachers' self-efficacy beliefs (Riggs & Enochs, 1990; Watters, Ginns, Neumann, & Schweitzer, 1994). Although research on science teaching self-efficacy beliefs is highly visible in the United States, research addressing this concern is rare in Korea. The present study was undertaken to examine Korean prospective elementary teachers' science teaching self- efficacy beliefs in the context of a required course on the teaching and learning of science.

II. Background

Slef-efficacy beliefs are grounded in the field of social cognitive psychology and consist of two dimensions: personal efficacy beliefs and outcome expectancy (Bandura, 1977, 1986). According to Bandura, personal efficacy beliefs are defined as "people's judgements of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p.391), and outcome expectancy is defined as "a person's estimate that a given behavior will lead to certain outcomes" (Bandura, 1977, p.193). Human behavior is affected based on these two cognitive components, so people's behavior becomes most effective when they think that they have the ability to perform successfully, as well as when they believe that their performance will bring forth the desired outcomes. People avoid situations which they deem to be beyond their capabilities, but they choose activities which they believe they are

capable of handling. In addition to people's choice of activities, self-efficacy judgments influence people's effort expenditure and persistence, thought patterns, and emotional reactions (Bandura, 1977, 1986). People who have high-efficacy beliefs expend greater effort and persist more in overcoming difficulties.

Based on Bandura's theory of self-efficacy beliefs, Riggs (1988) developed the concepts of science teaching self-efficacy beliefs by developing and validating the STEBI (Science Teaching Efficacy Beliefs Instrument). STEBI measures two dimensions of science teaching self-efficacy beliefs. Riggs (1988) named these two dimensions "personal science teaching efficacy belief," judgment about teachers' own abilitiy to teach science, and "science teaching outcome expectancy," teachers' expectations of influencing students learning science through effective teaching.

Many science education researchers have applied self-efficacy theory to science teacher education. Research has shown that teachers' attitudes and behaviors toward teaching science are related to their science teaching self-efficacy beliefs (Czerniak, 1989; Czerniak & Schriver, 1994; Enochs & Riggs, 1990; Enochs, Scharmann, & Riggs, 1995; Gorrell & Capron, 1989; Proctor, 1994; Riggs & Enochs, 1990). The development of high science teaching self-efficacy beliefs in prospective teachers has been shown to depend on their experiences of teaching science in their preparation programs (Ginns, Watters, Tulip, & Lucas, 1995; Huinker & Madison, 1995; Scharmann & Orth Hampton, 1995; Watters & Ginns, 1995; Watters, Ginns, Neumann, & Schweitzer, 1994). This finding supports Bandura's self-efficacy theory that high self-efficacy beliefs develop primarily through the mastery of experiences (Bandura, 1982, 1986). Conclusions from this line of research suggest that understanding teachers' science teaching self-efficacy beliefs is the most important factor for improving teaching quality and practices and for evaluating science teaching preparation programs.

The significant role that science methods courses during the preparation programs play in the development of prospective science teachers' science teaching self-efficacy beliefs has been examined. The general conclusion from these studies is that well-designed science methods courses can positively effect science teaching self-efficacy beliefs (Czerniak & Chiarelott, 1990; Huinker & Madison, 1995; Scharmann & Orth Hampton, 1995; Watters & Ginns, 1995; Watters, Ginns, Neumann, & Schweitzer, 1994). Furthermore, many studies argue that only science methods courses have the ability to enhance prospective teachers' attitudes towards science and the teaching of science (Duschl, 1983; Gabel & Rubba, 1980; Ginns & Foster, 1983; Lawrenz & Cohen, 1985; Petersen & McCurdy, 1992; Pettus, 1981; Rosenthal, 1991; Strawitz & Malone, 1986; Sunal, 1980; Westerback, Gonzalez, & Primavera, 1985). Several factors of the science methods course that can positively influence prospective teachers' science teaching self-efficacy beliefs have been identified; such factors include science content orientation, science process-skill orientation, directed practice instruction, inquiry orientation, cooperative grouping learning, constructivist learning environment, and reflective approach (Czerniak & Chiarelott, 1990; Rosenthal, 1991; Watters & Ginns, 1995). All these factors were exposed as being important in enhancing science teaching

self-efficacy beliefs.

Some researchers found that a science process-skill approach in a methods course could improve prospective teachers' attitudes to teach science, resulting in increased science teaching self-efficacy (Czerniak, 1989; Czerniak & Chiarelott, 1990; Goldsmith, 1986), others found that increased science content knowledge in their preparation could lower anxiety and enhance teacher effectiveness (Bonnstetter, Penick, & Yager, 1983; Czerniak, 1989; Westerback & Primavera, 1987). Haury (1986) and Proctor (1994) found that prospective teachers' self-efficacy beliefs were strengthened more by direct instructional models which focus on mastery learning and programmed learning. The use of open-ended, inquiry approaches in the science methods course was found to enhance prospective teachers' positive attitudes and effective behaviors (Holmes Group, 1986; Petersen & McCurdy, 1992; Westerback, 1982). Cooperative grouping learning in an elementary science teaching methods course was also found to strengthen prospective teachers' science teaching self-efficacy beliefs (Scharmann & Orth Hampton, 1995). The constructivist learning environment in the preparation program, in which prospective teachers could experience success in science and develop their thinking and learning skills and attitudes towards science and science teaching by participating in the planning, management, and assessment of their learning with their instructors and could reflect on critical issues of learning and teaching activities, might be one of the potent factors in facilitating enhanced positive science teaching self-efficacy beliefs (Huinker & Madison, 1995; Watters & Ginns, 1995; Watters, Ginns, Neumann, & Schweitzer, 1994). Rosenthal (1991) recommended a reflective approach in the science methods course in teacher preparation programs including activities such as writing self-evaluations and reaction papers, keeping a journal, dialogues between instructor and student, engaging in role playing and peer teaching activities, and writing autobiographies about their course and critical incidents. These activities allow prospective teachers to develop positive attitudes towards science and science teaching which, in turn can affect their construction of high self-efficacy beliefs.

III. Purpose of the Study

This study examined the impact of a science methods course at two Korean universities on prospective elementary teachers' science teaching self-efficacy beliefs. The changes in prospective elementary teachers' science teaching self-efficacy were examined during one of the science methods courses in their teacher preparation programs. Guiding questions of this study were as follows: 1) Is there any change in prospective elementary teachers' personal science teaching efficacy after they have completed a science methods course? 2) Is there any change in prospective elementary teachers' science teaching outcome expectancy after they have completed a science methods course?

IV. Methods

Two sources of data were utilized in this study: a science teaching self-efficacy instrument and anecdotal data and artifacts collected

during field observations. The Korean Science Teaching Efficacy Beliefs Instrument (K-STEBI) (Park, 1996) was administered using a repeated measures design. The K-STEBI was administered as a pre-test to Korean prospective teachers before the beginning of a science methods course in the early Fall 1995 semester and then as a post-test during the last week of that course in the late Fall 1995 semester. The K-STEBI measures two dimensions: personal science teaching efficacy (SE Scale) and science teaching outcome expectancy (OE Scale). For both dimensions, the means and standard deviations of pre- and post-tests were calculated and a paired *t*-test was employed to compare the means of both dimensions between pre- and post-tests. Reliability was assessed using coefficient alpha. Anecdotal data in the form of field notes and artifacts from field observations of the methods class were collected during an intensive internship in a Korean science methods course during Fall 1994 (Park, 1994). Syllabi and course materials were the same in 1995 as they were in 1994. Anecdotal data included descriptions of course's methods, content, prospective teachers' everyday activities, assignments, assessments, prospective teachers' perceptions of the methods courses, and this researcher's everyday diary. Artifacts included the course textbooks, prospective teachers' works on developing lesson plans and assignments, and a personal notebook. These data document the nature of class activities and allow for interpretation of the results from the K-STEBI analysis.

1. Instrument

The K-STEBI, developed and validated by Park (1996), is based on the Science Teaching Efficacy Beliefs Instrument for prospective teachers (STEBI-B) that was developed by Enochs and Riggs (1990). Content, criterion, and construct validation processes contributed to show the validity of K-STEBI, and coefficient alpha and item-scale score correlations were used to assess the reliability of the K-STEBI. Coefficient alpha of the reliability assessment were reported as 0.8469 for the SE Scale and 0.6432 for the OE Scale (Park, 1996).

The K-STEBI used in this study measured the two dimensions of self-efficacy beliefs of Korean prospective elementary teachers about their science teaching: personal science teaching efficacy (SE Scale) and science teaching outcome expectancy (OE Scale). It consisted of twenty-two items, twelve of which were used to measure personal science teaching efficacy and the remaining ten items used to measure science teaching outcome expectancy. Responses to items were provided by subjects on a Likert-type scale as follows: 5=Strongly Agree, 4=Agree, 3=Uncertain, 2=Disagree, and 1= Strongly Disagree. The subjects were asked to indicate how much they agreed or disagreed with each item by choosing one of these numbers. These numbers were used to score the items on both scales. Twelve items in K-STEBI are negatively worded and ten items are positively worded. The negatively worded items scored the reverse of the positively worded items.

2. Subjects

The subjects completing the pre- and post-tests were comprised of 163 college

juniors which included 131 females and 32 males enrolled in a three-credit science methods course during the Fall 1995 semester. Among them were 77 prospective elementary school teachers from Seoul National University of Education, Seoul, Korea, and 86 from Inchon National University of Education, Inchon, Korea. These two Universities prepare elementary school teachers; nearly all elementary school teachers in Korea graduate from a National University of Education. Prospective teachers must complete 151 credits during four years of Teachers University to become an elementary school teacher. Among these required credits are four clusters of courses specifically for the preparation of teaching science. Those four areas of subjects include: science content courses (11 credits), science methods courses (5 credits), general pedagogical courses (21 credits), and field experiences (4 credits).

3. Methods Courses

The science methods course at Inchon National University of Education consists of a professor's lecture, prospective teachers' presentations about and actual doing science activities from the national elementary school textbooks and related textbooks with the goal that prospective teachers understand teaching and learning of elementary school science and develop their teaching methods. During the first three weeks of the semester, the professor's lectures present content on open education, the National Curriculum, Piagetian theory and the clinical interview, and Science, Technology, and Society (STS). Remaining weeks of the semester focus on prospective teachers' presentations of lesson plans and actual hands-on experiments based on the National Curriculum and the national elementary science textbooks. They also conduct science investigations based on elementary science activities and present their results in the form of a science fair.

The science methods course at Seoul National University of Education aims at understanding teaching and learning methods of elementary school science; hence, in this class, prospective teachers deal with teaching methods, assessment, and science teaching materials related to science activities with attention to children's development characteristics. This class consists of professor's lectures on children's developmental theory, teaching methods, assessments, science teaching materials and facilities, and how to prepare science lesson plans. For the last half of the semester, prospective teachers' practice science lessons in a peer teaching setting. The content of the lessons comes from content in the elementary science textbooks.

V. Results

In order to investigate the impact of a science methods course on Korean prospective teachers' personal science teaching self-efficacy beliefs and science teaching outcome expectancy, a paired *t*-test was employed to examine the changes in science teaching self-efficacy beliefs. Analysis of the means for the two dimensions, personal science teaching efficacy (SE Scale) and science teaching outcome expectancy (OE Scale), between pre- and post-tests indicated an increase in both dimensions. The mean of the SE Scale between

pre- and post-tests increased from 40.3841 to 42.5244, with a statistical significance of $p \leq 0.001$, while the mean of the OE Scale between pre- and post-tests in increased from 36.9755 to 37.7914, with a statistical significance of $p \leq 0.05$. (Table 1.)

Table 1,

Results of Paired *t*-Tests

Personal Science Teaching Efficacy (SE Scale)

(N=163)

	Mean	SD	t
Pre-Test	40.3841	6.273	-5.52***
Post-Test	42.5244	6.373	

*** $p \leq .001$

Science Teaching Outcome Expectancy (OE Scale)

(N=163)

	Mean	SD	t
Pre-Test	36.9755	4.001	-2.32*
Post-Test	37.7914	4.158	

* $p \leq .05$

The data were also analyzed for the two universities separately. Table 2 shows the results of a paired *t*-test on both scales for the subjects (N=86) of Inchon National University of Education. There was a significant increase in the mean of both scales between pre-and post-tests. The mean of the SE Scale increased from 41.1609 to 43.9655 with a statistical significance of $p \leq 0.001$, and the mean of the OE Scale increased from 37.6163 to 39.1977 with a statistical significance of $p \leq 0.001$. However, only the SE Scale showed a significant change between pre- and post-tests for the subjects (N=77) of Seoul National University of Education. The mean of the SE Scale changed from 39.5065 to 40.8961 with a statistical significance of $p \leq 0.05$. The mean of the OE Scale showed no change. The results of a paired *t*-test on both scales for Seoul National University of Education are shown in Table 3.

Table 2

Results of Paired *t*-Tests

of Inchon National University of Education

Personal Science Teaching Efficacy (SE Scale)

(N=86)

	Mean	SD	t
Pre-Test	41.1609	6.403	-5.21***
Post-Test	43.9655	6.051	

*** $p \leq .001$

Science Teaching Outcome Expectancy (OE Scale)

(N=86)

	Mean	SD	t
Pre-Test	37.6163	4.374	-3.29***
Post-Test	39.1977	3.779	

*** $p \leq .001$

Table 3

Results of Paired *t*-Tests

of Seoul National University of Education

Personal Science Teaching Efficacy (SE Scale)

(N=77)

	Mean	SD	t
Pre-Test	39.5065	6.045	-2.53**
Post-Test	40.8961	6.373	

** $p \leq .01$

Science Teaching Outcome Expectancy (OE Scale)

(N=77)

	Mean	SD	t
Pre-Test	36.2597	3.427	-0.08
Post-Test	36.2208	4.018	

VI. Discussions

Changes in prospective teachers' science teaching self-efficacy beliefs due to taking a science methods course was revealed through analysis of data obtained from the K-STEBI. The anecdotal data and artifacts collected during this researcher's internship may provide additional insight into which factors within a methods course were important in effecting these changes.

Discussions about Inchon National University of Education are as follows. The significant changes in self-efficacy of both dimensions between pre- and post-tests at the Inchon National University of Education could have been due to several contents in the science methods course. The content that prospective teachers do hands-on experiments with inquiry in the methods course might influence their science teaching efficacy beliefs. The results of research have shown that the methods course, emphasizing a hands-on experiments component positively influence, prospective teachers' personal efficacy and outcome expectancy (Czerniak & Chiarelott, 1990; Huinker & Madison, 1995; Ramey-Gassert & Shroyer, 1992). For nearly all prospective teachers of Inchon, this marks the first time they have encountered hands-on experiments, since most high school and even college curricula emphasize science knowledge and facts and do not contain a hands-on component. The experience of doing hands-on experiments possibly allows prospective teachers to reflect and construct a vision of how to teach science based on their own personal experience in coming to comprehend science experiments. Dealing with science materials personally seems to instill prospective teachers with confidence in their ability to teach science, and may help to dissipate anxiety and fear about conducting experiments and handling experimental apparatuses.

Futhermore, the fact that the methods course of Inchon National University of Education deals with almost all the content and hands-on experiments which are presented in the elementary school science textbooks as used in the National Curriculum may give prospective teachers the confidence to teach science and increase their expectations of student achievement in science, since they have already been through the materials they will be required to teach from the perspective of a student (Park, 1994). Exercises in developing lesson plans during the methods course may also help to boost confidence, and comparisons with peers' lesson plans may serve as an opportunity for prospective teachers to evaluate themselves. The introduction of Science, Technology, and Society (STS) issues might foster the development of a flexible point-of-view in prospective teachers (Park, 1994). The methods class assignments covering Piaget's clinical interview also can have an impact on prospective teachers' construct of how to teach science by exposing them to children's developmental processes and likely misconceptions of science. This, in turn, can help prospective teachers to understand how science experiments should be tailored to children's developmental levels. Visits to the open-education elementary classroom during the methods course may serve to

help prospective teachers envision how to create and control their future classroom environments.

Discussions about Seoul National University of Education are as follows. The results of this study show that prospective teachers of Seoul National University of Education have changes in their personal science teaching efficacy. It is assumed that peer teaching which is one of the prominent factors in the methods course at Seoul National University of Education may have a positive effect on prospective teachers' personal efficacy beliefs. Peer teaching is another form of hands-on science, and therefore is likely responsible for the positive changes in attitudes towards science teaching, as well as increased confidence and reduced anxiety (Pedersen & McCurdy, 1992; Rosenthal, 1991; Westerback, 1982). As a part of these exercises, prospective teachers develop lesson plans, assess the hands-on activities presented in the elementary textbooks, reflect on what they should do at specific junctures during their teaching, and receive feedback about their practice teaching from the instructor and from their peers.

The results of this study show that prospective teachers at Seoul National University of Edcation have no changes in their science teaching outcome expectancy. It is not cretain which factors of a methods course in Seoul National University of Education influence prospective teachers' science teaching outcome expectancy. It should be noted that the present study only collected data for one semester of methods courses. Therefore, future studies of changes in self-efficacy beliefs should be longitudinal, and qualitative encompassing multiple semesters of courses over at least a year's time in order to better assess specific programmatic factors that may influence beliefs.

VII. Conclusions & Implications

Based on the guiding questions, this study concludes that there is a significant change in prospective teachers' personal science teaching efficacy after they have completed a science methods course at both Inchon and Seoul National Universities of Education. There is also a significant change in prospective teachers' science teaching outcome expectancy after they have completed a science methods course at Inchon National University of Education, however, that was not the case for the prospective teachers at Seoul National University of Education.

Future studies attempt to determine which specific factors within a science methods course influence science teaching self-efficacy. In order to do so, first, it would be beneficial to examine changes in self-efficacy on a long-term basis, such as across multiple semesters of preparation program.

Second, further research in this area must combine quantitative and qualitative approaches in order to better understand factors that influence beliefs. The quantitative research method employed in the present study provided limited insight into the specific factors contributing to the evident changes in self-efficacy beliefs. This quantitative research may be augmented with qualitative information including interviews, observation, use of videotape, photographs, personal documents, memos, and other official records, which have tremendous potential in helping to determine

which aspects of a science methods course contribute most to enhancing prospective teachers' teaching abilities and confidence. Qualitative approaches in future studies can allow data to be gathered on the relative importance and personal impact of aspects of a methods course among individual prospective teachers. It is further anticipated that qualitative approaches can point out variables, such as the existence of other pedagogical and science content experiences which might have an influence on prospective teachers' self-efficacy beliefs.

It is hoped that the increase in prospective teachers' self-efficacy beliefs found during this study to be caused by the science methods courses carries through to the time that these prospective teachers become real teachers in the elementary school classroom, but it is not beyond question whether these increased self-efficacy beliefs are maintained until that time. Thus, it is suggested that educators in science education preparatory programs be aware that it is necessary to foster self-efficacy beliefs and to sustain them during the entire preparation program and attempt to determine which aspects facilitate a lasting increase in teachers' self-efficacy beliefs.

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