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Science Teacher Education in Taiwan

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ABSTRACT

This article describes the status of science teacher education in Taiwan. The pre-service and in-service science teacher training system, institutes, curricula, programs, and evaluation on the institutes were briefly introduced. The differences before and after the 1996 reform of science teacher training system were compared. Finally, the attempts and efforts that have been done through the channels of research to promote science teachers' professional development were addressed. These efforts include the Case studies of exemplary science teachers' teaching performances, the development of licensure instruments for the certification of science teachers, the use of computers and distance education for supervising student teachers, the exploration of promoting science teachers' understanding about the nature of science, the exploration of promoting science teachers' pedagogical content knowledge, the exploration of promoting science teachers' ability of increasing effective student-teacher and student-student interactions, and the exploration of effective teaching strategies.

Key words: Taiwan, science teacher education

Ⅰ. Introduction

What requirements and characteristics constitute an effective science teacher? This question has been studied by science educators for many years. Some researchers focused on distinguishing the differences between novice and expert teachers. For example, Tobin and Fraser (1990) observed exemplary science teachers' instruction and compared their classroom environment with non-exemplary science teachers' instruction; Carter *et al.* (1987) found that novice teachers and expert teachers processed and used information differently; Lantz and Kass (1987) concluded that teachers with less experience teaching chemistry regarded the officially approved curricular materials as more useful to them than did more experienced teachers. On the other hand, some researchers define the requirements of a science teacher. For example, Shulman (1986; 1987) concluded that in addition to the pedagogical knowledge (PK) of knowing students' psychology and learning theories and the content knowledge (CK) of knowing the subject matter concepts, a science teacher should equip appropriate pedagogical content

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knowledge (PCK) of knowing how to use variety of teaching strategies to facilitate student learning outcomes.

More recently, after the goal of science education has been identified in some countries (e.g., American Association for the Advancement of Science, 1989), The standards of science teaching and the standards of science teacher professional development have also been defined as national science education standards (e.g., National Research Council, 1996). These standards provide valuable references for developing curricula in training pre-service and in-service science teachers.

Education is highly valued in Taiwan. The Confucian conception of 'nothing is more important than study' is believed by most of the people. A lot of parents, teachers, and students are likely to believe that academic achievement is one of the most important things for school students. If a student has outstanding academic achievement, then all family members will be proud of her or him. In contrast, if a student fails academically, then other people, including the student himself or herself, will be very disappointed.

Chemistry, physics, biology, and earth science are regarded as important and difficult subject matters for secondary school students. Therefore, teaching effectiveness of a teacher is always a major focus of parents and school principals. If students feel they don't quite understand the concepts in these subject matters, they might go to a private tutoring school or hire a private tutor for extra hours of out of school study.

Ⅱ. Current Features of Science Teacher Education in Taiwan

1. Training System Overview

In Taiwan, the science teacher training system was changed significantly in 1995. Originally, all of the elementary school science teachers were trained by eight teacher colleges, and all of the secondary school science teachers were educated by three normal universities. The enactment of 'The Teacher Training Law' broke the monopoly and allowed all the universities in Taiwan train teachers as long as they are qualified for the business.

All the normal universities and teacher colleges are four-year universities and colleges. Before 1995, prospective pre-service science teachers study four years in an university and spend one more year for practical training as student teachers in a high school or elementary school to get a teaching certificate. Science educators in the normal universities and teacher colleges are responsible for the training and evaluation of certifying elementary and secondary science teachers.

2. Types of Training Institutes

Currently, there are 73 teacher training institutes in Taiwan. The Ministry of Education is in charge of the establishment and the evaluation of the institutes. The institutes provide at least one of the following two channels for those who are interested in becoming science teachers:

1) Regular four-year training program

For those who are the students entering the normal universities or teacher colleges through the college entrance examination, they are automatically qualified to register into the four-year science teacher training program. Those students who are in general universities or technical colleges have to apply for a science teacher training program. The screening process is usually competitive.

2) Post-baccalaureate program

For those students who have finished a bachelor's degree in science, they can apply the post-baccalaureate science teacher training program provided by any one of the universities or colleges in Taiwan. Normally, the number of applicants is much more than the number of students the universities want to recruit. Therefore, the competition of getting into the programs is intensive.

It should be noticed that the open policy of allowing general universities and colleges to train science teachers in 1995 has increased the number of certified science teachers dramatically. As can be seen in Table 1, the number of biology, chemistry, physics, earth science, and physical science teachers all increased in 1998 at least three times more than the number of certified teachers in 1997. Among them, the number of biology teachers increased from 12 in 1997 to 114 in 1998. The total of certified science teachers in 1997 is 178. The number increased into 737 in 1998. Apparently, the certified number of science teachers per year is much more than required. The Ministry of Education is trying to restrict the applications of teacher training institutes. This can be seen from the table that the total number of certified science teachers dropped from 2001's 946 to 2002's 698. On the other hand, follow-up evaluations are going on to promote the quality of the science teacher training programs.

Table 1. The number of certified science teachers in 1997-2002

Types of teacher	1997	1998	1999	2000	2001	2002
Biology	12	114	181	213	267	176
Chemistry	19	76	118	176	207	147
Physics	14	42	126	186	193	176
Earth science	14	54	43	54	60	59
Physical science	119	451	355	300	219	140
Total	178	737	823	929	946	698

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3) Curricula of the institutes

The courses that a perspective science teacher has to take include the following three fields: 1. Pedagogical knowledge, such as student psychology, measurement and evaluation, classroom management, introduction of special education, computer assisted instruction, and introduction of learning and teaching theories. 2. Content knowledge, for a perspective chemistry teacher as an example, such as general chemistry, analytical chemistry, organic chemistry, physical chemistry, and biochemistry etc. 3. Pedagogical content knowledge, such as teaching methods, teaching practicum, introduction of science education, and history of science.

For those students in the four-year training program, they have to take at least a total of 26 credits in the field of PK and PCK and 30 credits of CK. Those who are in the post-baccalaureate program have to take the 26 credits of PK and PCK, since they already had a science major.

3. Training programs and contents

After the students finish the first stage of the requirements in either the four-year or the post-baccalaureate programs, they have to spent one more year acting as student teacher in the second stage. In this year, they have to work with an expert science teacher in a secondary or elementary school to learn and practice classroom teaching. Meanwhile, university science educators would provide consultancy and help to these student teachers in regular monthly meetings. The performance of a student teacher in the practicum would be evaluated by the expert science teacher, the school principal, and the science educator.

A typical training program in the practicum includes the internship of administration, classroom management, teaching, and laboratory management. The student teachers spend two or three months in each station to get familiar with the business in each station. No matter where student teachers work, an expert science teacher is assigned to work closely with each of the student teachers.

4. Types of teachers' certificates

After the student teacher successfully finish their one-year practicum, they are going to get a teacher certificate from the Ministry of Education. For elementary school level, there is only one kind of certificate called science teacher. For secondary school level, science teachers are certified as chemistry, physics, earth science, and biology teachers. The certified teachers are required to get certain amount of in-service training hours in every five years to renew their license.

Although there is no classification for teacher certificates currently in Taiwan, the Ministry of Education is studying the feasibility of classifying elementary and secondary school science teachers as: beginning, experienced, and expert teachers. The beginning science teachers can become experienced science teacher if they follow the requirements to finish all the in-service training hours in certain amount of years. However, only those who are outstanding in teaching, administration, or research can become expert science teachers. The salary and weekly teaching load of the three levels of science teachers would be varied as well.

5. Evaluations on training institutes

The Ministry of Education conducts regular evaluations on the 62 teacher training institutes. A group of experts and scholars are invited by the ministry to review the institutes': 1. annual budget that is spent on teacher training programs, 2. academic performance of the faculty members in the programs (including the publications, article reviews, and invited speeches), 3. books and periodicals, and journals available for professors and students, 4. educational resources such as computers, laboratories, and teaching facilities, 5. curricula, teaching plans, and syllabus. The evaluation result is highly related to the amount of subsidy the institute can get from the Ministry of Education.

6. Faculty training system for the institutes

Thirty percent of university faculty members' promotion is based on their teaching performance. The evaluation committees in the department, college, and the university level review the teaching plans, syllabus, and the statistical results of the questionnaires that are responded by students regarding professors' teaching performances. In other words, despite that research is the first priority of work for university faculty members, teaching is still regarded as an important business. In order to promote faculty members' professional development in teaching, many institutes provide workshops, seminars, and demonstrations as venues to let participants interact and reflect on variety of teaching strategies and assessment techniques. Although it is not required, professors are encouraged to attend these activities.

7. Constructivist reflection on science teacher training programs

In the past twenty years, the National Science Council in Taiwan has been trying to promote the effectiveness of training pre-service science teachers through the following channels of research:

1) Case studies of exemplary science teachers' teaching performances.

In the past, researchers around the world have compared the differences between expert and novice science teachers' classroom learning environment (Tobin & Fraser, 1990) or information processing (Carter, Sabers, Cushing, Pinnegar & Berliner, 1987) or conceptions of science teaching (Lantz & Kass, 1987). Researchers in Taiwan extended their investigation through case studies to present how rich exemplary science teachers' teaching repertoires in specific topics of instruction. In addition, the repertoires were compared with those of novice science teachers'. These research findings provide models for training pre-service science teachers.

These case studies use the qualitative approach to interpret and describe the case teachers' strategies and conceptions of science teaching. The video tapes and teaching supplemental materials collected by the researchers can also be used as demonstrations for the training of pre-service science teachers.

2) The development of licensure instruments for the certification of science teachers

Variety of instruments were developed to assess student teachers' content knowledge, pedagogical content knowledge, and laboratory manipulative skills. The construct validity, content validity, and reliability of the instruments were pilot-tested and validated. Although the practical utility of these instruments have to be further examined in the future, the standards of science teachers' professional ability have been better defined in the process of developing the instruments. More importantly, some of the researchers use their licensure instruments as tools for student teachers and beginning teachers to promote their professional ability.

3) The use of computers and distance education for supervising student teachers

Supervising student teachers has been regarded as big burden by many university professors. The transportation arrangement and time consuming of visiting student teachers are two of the major concerns of the supervisors. Fortunately, computers can be served as a channel for communication between student teachers and their supervisors or as an aid for them to deliver messages. The on-line discussions, web-site forums, and emails enabled the participants to communicate in their convenient time and locations. The effectiveness of using computers to promote beginning teacher's professional development has been examined by Lin and Chiu (2000) and other researchers in Taiwan.

4) The exploration of promoting pre-service science teachers' understanding about the nature of science

There is a growing consensus within the science education community that understanding the nature of science is a critical objective of science teaching. Knowing how science works is requisite for scientific literacy (American Association for the Advancement of Science, 1989). Duschl (1990) and Hodson (1988) also claimed that teachers' understanding about the role theories play in science may influence their decision making in selecting and designing instructional tasks. In addition, research studies found that teachers' understanding about the nature of science affect their teaching practices (Brickhouse, 1990; Gallagher, 1991; Lederman & Zeidler, 1987). Unfortunately, the assessment of teachers' understanding about the nature of science revealed that many science teachers possessed the view of 'science as a body of knowledge', 'science as a manifestation of truth', and 'science as something mythical'.

The review of the above literature prompted a group of researchers conducting studies to promote teachers' understanding about the nature of science. For example, Lin and Chen (2002) use cases of history of science in teaching methods class to let pre-service chemistry teachers understand how previous scientists formulated hypotheses and validated knowledge. They found that the pre-service chemistry teachers made significant progress on their understanding about the nature of scientific theories and enjoyed the activity of integrating history of science in teaching.

The potential benefits of integrating cases of history of science in teaching have also been explored by Lin, Hung, and Hung (2002) and Lin, Chiu, and Chou (2002). Lin, Hung, and Hung found that the introduction of the development of scientific concepts is likely to promote student problem-solving ability. Moreover, Lin, Chiu, and Chou concluded that students' understanding about the nature of science is significantly related to their problem-solving strategies. The post-positivist-oriented students were able to apply reasoning skills in organizing the related concepts retrieved from their knowledge structure. On the other hand, the empiricist-aligned students tend to grab the numbers and statements in the problem and perform blind mathematical calculations and simply ignore the relationship between the related concepts to the problem.

The review of the above literature has provided alternative ways of training science teachers to promote their understanding about the nature of science. More efforts are underway to identify factors related to science teachers' view of science.

5) The exploration of promoting pre-service science teachers' PCK

Grossman defined the essential elements of pedagogical content knowledge as 1. The beliefs about student and subject matter teaching topics, 2. The ability of knowing and identifying student prior knowledge and preconceptions, 3. The knowledge of the curricula between different subject matter and within one subject matter, 4. The capability of using effective teaching strategies. Taiwanese researchers' attentions have been paid to the areas of how student teachers developed their pedagogical content knowledge (Tuan, 1996), science teachers' knowledge base of instructional representations (Lin, 1997; Lin & Yang, 1998), and the relationship between pedagogical and content knowledge (Lederman & Chang, 1997).

The above studies suggest that science educators should focus more on promoting pre-service science teachers' reflection ability and the conceptualization of subject matter knowledge, encouraging the use of multiple teaching strategies and authentic assessments, and addressing the nature of science.

6) The exploration of promoting pre-service science teachers' ability of increasing effective student-teacher and student-student interactions

It is believed that classroom teacher-student and student-student interactions are likely to have a major influence on students' interest in and career choices in sciences. Some researchers in Taiwan focus on promoting pre-service science teachers' awareness and skills of questioning skills (e.g., She, 1998; She, 2000). It was found that for junior high school students, boys answered four times as many to teacher-initiated questions than did the girls, and that boy's call-out responses to teacher's questions were much more than that of girls. Moreover, teachers tended to give boys more feedback than did girls.

The results of the domestic studies conducted in Taiwan remind science educators that in addition to the questioning skills of waiting time and inquiry-based open-ended questioning strategies emphasized by previous studies, science educators should encourage pre-service science teachers pay attention on the gender equity issue in teaching.

7) The exploration of effective teaching strategies

Effective teaching strategies are many and varied. One of the strategies explored by Taiwanese researchers is the multi-situated teaching module. The theory of situated learning (Brown, Collins & Duguid, 1989) and the Bruner's spiral curriculum (Bruner, 1960) were combined as the rationale of the module. It is believed that if student can learn by playing (Brooke & Solomon, 1998), their inner motivation for learning could be inspired and motivated. Each unit in the module consisted of a series of hands-on activities to let children observe experiments, discuss with group members, and apply concepts in solving problems. For example, in learning the properties of carbon dioxide, students were explored to the discrepant events of "raisins dancing in the 7-up soda water and "volcano". Following the discrepant events, several hands-on activities were designed to let students conduct inquiry investigations. The students were guided from playing for fun to meaningful learning. Chang (2001) found that the feedback from the participating students were fruitful. For the thirteen activities she developed, all were rated above 4 in a 5-point scale of satisfaction.

Another teaching module was developed by Chang and Cheng (2000) in earth science instruction. They combine cooperative learning and creative problem solving together and found that the student taught by this module performed as good as the lecture interactive teaching method. The long-term impact on student scientific creativity would be investigated in the future.

Other effective teaching strategies explored include concept mapping and teaching with analogies. All together, the sample activities and examples of teaching materials described in these studies provide alternative ways of training pre-service science teachers.

Ⅲ. Conclusion

Based on the brief review of the studies conducted by Taiwanese science educators, it reveals that tremendous efforts in research have been done to improve the status of science teacher training system and procedure in Taiwan. These researchers are trying to integrate the science teaching and learning theories into practices that are suitable for domestic elementary and secondary schools. Research findings in international journals are important for references. However, cautions should be taken when the suggestions in these literatures are taken for actions. This is simply because of the culture and education systems are different in many countries.

For the pre- and in-service science teacher training, science educators in Taiwan have focused on the issues of developing science teachers' effective teaching strategies, understanding about the nature of science, and promoting the pedagogical content knowledge and the ability of creating gender-equity positive learning environment. Many of the research findings are put into practice to improve the quality of science teacher training. More efforts are underway to integrate research findings into books, which are written in a way that can be understood by pre-service and in-service science teachers. In other words, the parts of research methodology and statistical tables are omitted in the books and the creative innovations in teaching strategies or teaching materials are emphasized.

In addition to the reform of training system, the elementary and secondary school science curricula have also been greatly changed in Taiwan. The new curricula integrate biology, chemistry, earth science, physics, and technology into a single subject matter, which is called as 'science and technology' for grades 1 through 9. Before 2001, only the elementary school students study the science that is integrated as one subject. The junior high school students study biology, physical science, and earth science while the senior high school students study biology, chemistry, earth science, and physics. Currently, not only the elementary but also the junior high school students study the single subject matter of 'science and technology'. This big change has caused a lot of inconveniences for in-service science teachers. For instance, they have to develop appropriate supplemental teaching materials by themselves instead of relying on the textbooks heavily as they did before. In order to ease the road of reform, the Ministry of Education is encouraging teacher training institutes to provide appropriate in-service training programs.

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