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Preservice Science Teachers' Previous Experience, Beliefs, and Visions of Science Teaching and Learning

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ABSTRACT

This study is to understand preservice science teachers' previous experience, beliefs about teaching and learning, and visions of themselves as future teachers. The data were collected from two individual interviews with 7 voluntary students and analyzed qualitatively for category construction. As the results of this study, we presented two cases, which showed that their different views of teaching science are strongly related to their previous experiences as learners and observers in schools, and that there is the apparent consistency between each participant's beliefs about science teaching and learning and their own visions of teaching in a science classroom. Implications for preservice science teacher education related to the results were discussed.

Key words: teacher education, student teaching, beliefs about teaching and learning, past experience, vision of teaching

I. Introduction

In Korea, new education policy includes provisions for improving the quality of teaching by encouraging both student teaching for preservice teachers and teaching experience for beginning teachers (Ministry of Education, 2002). The student teaching component includes the establishment of a cooperative system between universities or institutions and schools, and an extension of the preservice period; beginning teachers are to gain teaching experience while supported by cooperative teachers in middle or high schools on three occasions: for about two weeks before becoming teachers, for one semester after becoming teachers, and over a two week follow-up period. These plans for bolstering teaching experience assume that the teacher is an important factor in implementing successful teaching and learning activities in the classroom.

What is needed to be a successful teacher in the science classroom? Because teaching is an activity whose goal is learning, plans for teaching and learning activities should be based on an understanding of knowledge, learning and learners. Many science educators and researchers have embraced constructivism, which holds that knowledge is constructed by individuals based on their interpretations of experiences and interactions with others, and that learning is an active and constructive process strongly influenced by an individual's prior understandings and beliefs (von Glasersfeld, 1993; Resnick, 1989). Under constructivism, students have their own preconceptions about the content of science in the classroom, and these are difficult to change.

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Therefore, good science teachers would be expected to design and implement teaching and learning activities centered on knowledge construction by the students themselves.

It seems that planning and implementing teaching and learning activities based on a constructivist perspective involves considering teachers' educational beliefs, i.e., beliefs about the teaching and learning of science, rather than simply prescribing a particular mode of instruction. Research on teacher education has demonstrated that teachers hold personalized, individual conceptions and beliefs about teaching and learning science that play important roles in their classroom decisions and practices (Brickhouse, 1990; Bryan & Abell, 1999; Cobern & Loving, 2002; Dana, McLoughlin, & Freeman, 1998; Feldman, 2002; Hewson and Hewson, 1989; Osborne, 1998; Peterson & Treagust, 1998; Tobin 1993). According to Barnes (1992), "teachers who, knowingly or not, are locked into a Transmission view of teaching and learning will make little sense of teaching materials that accord a more active role to the learners"(p. 21). If teachers try to implement the science classes based on constructivism, their beliefs about teaching and learning of science might be consistent with constructivist perspectives of learning.

Professional development involves teachers developing their personally and socially constructed beliefs about teaching and learning science as well as using new teaching activities. As pointed out in the science education literature in Korea, the current preservice teacher educational system and curriculum needs improvement (Hong, Woo, & Jung, 1995; Kim & Kim, 1989; Kim, Kim, & Park, 1994; Lee, 1989; Park, 1992). Additionally, if teacher educators consider preservice teachers' beliefs about teaching and learning as something to be changed to professionalize teachers, those educators should understand the different beliefs that preservice teachers bring to the teacher educational system and curriculum.

This study assumes that preservice teachers have their own views on teaching and learning arising via various routes, including personal experience, school life, and formal knowledge. It is further assumed that teachers' beliefs about teaching and learning influence design and implementation of new teaching activities. The aim of this study is to understand preservice science teachers' previous experience, beliefs about teaching and learning, and visions of themselves as future teachers in order to provide a foundation for professionalization in teacher education.

Ⅱ. Theorectical Foundations

1. Learning and Teaching Science Based on Constructivism

This research assumed that just as students construct or reconstruct conceptions of the natural world, teachers can similarly be expected to develop their beliefs and conceptions of teaching science based on their own extensive experience as learners in teacher education.

According to constructivist accounts, knowledge is constructed or reconstructed by an individual who interacts with his or her social environment. Learners construct knowledge in ways that are coherent and useful to them and produce relatively stable patterns of beliefs. Because the construction process is, however, influenced by a variety of social experiences, the knowledge constructed by each individual is not normally completely personal and idiosyncratic (Hewson, *et al.*, 1999). Although recently constructivism has been criticized for considering the nature of knowledge in its instrumental aspect and tending to identify the process of creating new scientific knowledge and the process of learning scientific knowledge (Osborne, 1996; Phillips, 1995), the research area of science education has embraced constructivism as a theoretical framework to deepen and widen its understanding of learners and science learning (Staver, 1998). Constructivism has enabled a powerful and fruitful research program in science education and is an important basis for a coherent approach to teacher development in science education.

Two uses of constructivism have significant implications for preservice teacher education: the first involves viewing the education of preservice teachers in a constructivist manner and the second involves imparting constructivist beliefs about teaching and learning science to those preservice teachers. Preservice teachers should be regarded as adult learners who construct or reconstruct actively for themselves their beliefs and conceptions about how to teach (Bell & Gilbert, 1996). Professional development also involves the teachers developing their personally and socially constructed beliefs and ideas about science education, the teaching and learning process, and teacher development. In practice, preservice teachers in the teacher development program began from different starting points in the development process and often achieved different outcomes within the broad goals of the programs, even though they had attended the same program. The teacher development programs had both anticipated and unanticipated outcomes, and the facilitators needed to be prepared for both. Therefore, the teacher development activities were designed so as to acknowledge, incorporate, and address (rather than ignore) the teachers' prior ideas, beliefs, experiences, concerns, interests and feelings about science and science education. In addition to designing preservice education according to constructivist principles, teacher education should teach preservice science teachers how to implement constructivist teaching and learning practice under current curriculum (Ministry of Education, 2002). Constructivism guides the teaching of science and the role of science teachers and should serve as a touchstone for teacher education. A teacher emerging from such training would be a facilitator of student learning rather than a transmitter of knowledge. This facilitating role implies that teachers provide an environment in which students can do what is necessary to construct knowledge of the subject matter.

This paper considers preservice teachers' beliefs about teaching and learning of science in three categories, which are drawn from science education literature about constructivist learning and teaching. First, teaching is changed from the traditional view of delivering knowledge to the students who have a blank mind, to the constructivist view of helping them to construct or reconstruct knowledge. Constructivist view of teaching relies upon a definition of learning as an active process of a learner's knowledge construction. Learning in science is more a matter of altering prior conceptions than of giving explanations where none existed before.

Second, the role of the teacher moves from transmitter of knowledge to guide and facilitator in the students' construction of knowledge (Tobin, Tippins, & Gallard, 1994). The constructivist perspective on learning leads to a new view of teaching science that requires new actions of teachers, many of whom learned science in a traditional context. However, this role does not appeal to all teachers. If teachers do not believe philosophically in teaching for understanding rather than dispensing information, this role will be rejected.

Third, students already have their own conceptions and develop them through their interaction with science content in the science classroom. Constructivism acknowledges that what is already in the learner's mind matters (Carey, 1986). A child's experiences with his or her environment form the child's knowledge base, and profoundly effect the learner's view of the world and his or her ability to accept other, more scientifically grounded, explanations. Children's learning in science may be better characterized by changes in their thinking rather than additions to their thinking (Shapiro, 1994). The process is revolutionary, involving such things as conceptual exchange (Hewson, 1981) or evolutionary, that is, students constantly revise, reorganize, and deepen understanding as they are exposed to new information (Carey, 1986; Vosniadou, 1994).

2. Teachers' Beliefs and Previous Experience

The term belief, as used in this paper, is derived from Green (1971) and describes a proposition that is accepted as true by the individual holding the belief. It is a psychological concept and differs from knowledge, which implies epistemic warrant. Knowledge generally refers to something sure, solid, dependable, and certain, and part of the knowledge base includes beliefs people are committed to (Loucks-Horsley, Hewson, Love, & Stiles, 1998). Eisenhart, Shrum, Harding, and Cuthbert (1988) describe a belief as a way to describe a relationship between a task, an action, an event, or another person, and an attitude of a person toward it. That is, whereas knowledge is cognitive, beliefs represent commitments to actions. Nespor (1987) helped define the construct by asserting that beliefs are deeply personal, stable, lie beyond individual control or knowledge, and are usually unaffected by persuasion. Beliefs create an ideal or alternative situation that may differ from reality and are stronger affective and evaluative components than knowledge.

Existing beliefs that preservice science teachers hold play a strong role in shaping what they learn and how they learn it. Studies examining the constructivist beliefs of teachers are necessary in order to understand a teacher's journey as he or she attempts to implement constructivist teaching and learning practice. Prospective teachers often lack sufficient professional classroom experience to play out their developing beliefs about constructivist teaching. Therefore, understanding what teachers' beliefs are, and how to develop their beliefs toward constructivist ideas, is of particular interest.

Beliefs are rooted in vivid memories of previous experiences. Reviewing literature on learning to teach, Richardson (1996) isolated three categories of experience influencing beliefs about teaching and learning: personal experience, experience with schooling and instruction, and experience with formal knowledge. Personal experience includes those aspects of life that go into the formation of world view: intellectual and virtuous dispositions; beliefs about self in relation to others; understandings of the relationship of schooling to society; and other forms of personal, familial, and cultural understandings. Experience with schooling and instruction accounts for the fact that students have experienced and constructed their beliefs about teaching and learning as observers in classrooms. Lortie's (2002) discussion of the apprenticeship of observation suggests that students arrive in preservice teacher education with a set of deep-seated beliefs about the nature of teaching based on their own experiences as students. Those who learn to teach have normally had sixteen continuous years of contact with teachers and professors. That contact takes place in small spaces and the interaction is not passive observation, but usually involves a relationship that has consequences for the student and thus is invested with affect. In the terminology of symbolic interaction theory, the student learns to 'take the role' of the classroom teacher, to engage in at least enough empathy to anticipate the teacher's probable reaction to his behavior. This requires that the student project himself into the teacher's position and imagine how he feels about various students' actions. Students come to teacher education programs with their own theories of teaching acquired during many years of being a student (Brookhart & Freeman, 1992). It can be speculated that these strong beliefs, in combination with the salience of the real world of teaching, create conditions that make it difficult for preservice teacher education to have the desired effect. Richardson's final category of experience, formal knowledge, describes understandings that have been agreed upon within a community of scholars as worthwhile and valid. When students enter kindergarten, and often before, depending on the nature of family and community life, they experience formal knowledge in their school subjects, outside readings, television, religion classes, and so forth. Of particular interest in the consideration of learning to teach is knowledge of subject matter, conceptions or beliefs about the nature of subject matter and how students learn it, and experiences with formal pedagogical knowledge that usually begin during preservice teacher education programs.

Ⅲ. Methodology

1. Participants

This research was conducted at a private university located in Seoul, Korea. Among 27 science teacher education students, 7 volunteers participated in this study. At the time of this study, all participants wanted to become science teachers in the near future. The students will obtain certification to become science teachers in secondary school upon graduating from the university. Among the study participants, there were 2 students (1 male and 1 female) majoring in physics education, and 5 (1 male and 4 females) majoring in biology education.

2. Data Collection

The data were collected mainly by means of interviews. Participants were interviewed individually, twice. The interviews took about one hour, and a half-hour, respectively. All of the interviews had semi-structured formats and began with broad questions such as: *What do learning and teaching mean? How do you know when you have learned? What is the role of a teacher in the science class? Some people have suggested that many students develop their own theories to explain nature, and sometimes these theories can be substantially different from so-called scientific theories. What do you think about this suggestion?* After each participant had provided an answer, the interviewer continued the conversation by building upon each response. In this sense the interview dialogue was personal and related to each interviewee's beliefs. This allowed the interviewer to use probing questions to clarify further a preservice teacher's beliefs when a more well-defined idea was desired. Some questions were rephrased across the two interviews. The purposes of such changes were to use the students' experiences during student teaching as a context to explore their beliefs further, and to probe the students' previous experiences in schools or the university to explore any relationships with their beliefs.

For the first interview, the interview questions were developed on the basis of a conception of science teaching from Hewson and Hewson (1989), and were designed to obtain from each participant: 1) a rationale for teaching; 2) a view of knowledge, learning, and science; 3) the nature and extent of science content knowledge; and 4) pedagogical knowledge. Other questions beyond those broad questions mentioned above, consisted of: 1) What does the word science mean to you? 2) How do you think scientific knowledge has been produced? 3) Give your own metaphor or analogy for the teaching/learning process; 4) Would you teach novice students (i.e., those who are encountering formal science for the first time) any differently? If so, how? 5) What are you expecting to do in the classroom?

Through initial analysis of the data from the first interviews, the second interview protocol was designed similar to the first interview but with more emphasis on the following: students' theories and the instructional implications of those theories, participants' previous experience learning science, and participants' visions of themselves as future science teachers. All the interviews were audio-taped and fully transcribed.

3. Data Analysis

The data analysis consisted of two phases. In the first phase, statements, comments or reflections concerning beliefs about learning and teaching science and previous experience related to those beliefs were identified. The data concerning beliefs about learning and teaching of science were divided into three categories: the relationship between learning and teaching, what makes a good science teacher, and ideas about students' theories. And the visions of themselves teaching science in the classroom could be identified on the basis of their beliefs. We checked the categories individually, to enhance internal validity.

In phase two, this initial analysis was used to refine the spectrum of cases, the extremes of which might be placed on the ends of a continuum with constructivist beliefs about teaching and learning of science on the one side, and transmission beliefs on the other side. First of all, the individual data were divided into previous experience, beliefs about teaching and learning of science, and the visions of teaching in the science classroom. Secondly, the data in the category of beliefs about teaching and learning science were compared on the basis of similarities and differences across the participants. Finally, the extreme cases of constructivist and transmission beliefs were selected in order to present a portrait of how two preservice teachers' different beliefs related to vision based on previous experience. In the cases of other participants, some characteristics overlapped and this was interpreted as showing little distinction between constructivism and transmission. According to Ellen (1984), a "telling" case may be more fruitful in developing meaning than a "typical" case. Patton (1990) labels the selection of such a telling case, one type of purposeful sampling, as "extreme or deviant case" sampling. Patton argues that this approach focuses on cases that are rich in information because they are unusual or special in some way, and that unusual or special cases may be particularly troublesome or especially enlightening.

Ⅳ. Findings

In this paper, we examine two preservice teachers by comparing their school experiences, their beliefs about science teaching and learning, and their visions of themselves as future science teachers. We have chosen these students, Sua and Hoin, as telling cases because they represent two extremes of belief about the nature of teaching and learning.

Case 1: Sua

Sua was a female student who wanted to become a science teacher, particularly in a high school biology class. She was a scholarship student: she had gotten good grades (above A) in most subjects and A(+) especially in the subjects related to biology. However, she thought that she had a strong background in biology but little background in other scientific subjects. She explained that, among the four scientific disciplines of biology, physics, chemistry, and earth science, she had liked to study only biology. She expressed little confidence in teaching either "Science," a kind of integrated subject to middle school students, or "integrated Science" to 10^{th} grade students. She thought that teaching science as a kind of integrated science might require teachers to possess a well-balanced knowledge of physics, chemistry, biology, and earth science that she lacked.

Sua was not certain whether she could be a good teacher. She explained, "I am not sure what I really want to be, even though I am now thinking I hope to be a teacher. I am not sure whether I could get along with students. After I graduate from university, I want to pass the test for becoming a science teacher. However, I am not sure whether I could be a good teacher". Additionally, she wondered if she could manage a science classroom well because she thought she lacked an outgoing and dynamic personality. She was interested in classroom management issues, such as how to make students pay attention to the teacher, how to use the blackboard, and how to describe or explain the subject matter. Sua hoped that she would be a teacher who could manage the classroom skillfully and give students a very clear explanation of the science content.

1. Previous Experience

Sua described herself as "a receiver learner" who might accept almost all the knowledge the teacher presented in the classroom. She thought that, as a student, she had not known anything about the content included in the science textbook, and thus had to accept what was presented. Moreover, the amount of science content that the teacher explained in the classrooms of middle and high school seemed to be too much and too difficult for her to understand within the classroom. She had to try to understand the content, not during class, but later, after school. She remembered that she had spent most of the class time writing down, rather than trying to understand what the science teacher explained. She commented:

> I tended to receive all knowledge without doubt, because I had no idea of what the teacher would teach. Most of all, the contents the teacher explained were new for me. In my case, when the class started, I began to just write down, rather than try to understand what the teacher was saying. It was not easy for me to listen and understand thoroughly all that the teacher explained. I usually copied all and examples the teacher presented. Examples helped me to be able to understand the content later after the class. So, I was almost always very busy in writing down something in the classes.

For Sua, a science teacher seemed to deliver continuously new scientific knowledge to students, and she was the newcomer to be invited into the field. In her memory, "the science teacher presented concepts, rules, principles, or theories of science new for me in the classrooms". Sometimes they were intelligible for her, sometimes they were not. Although she could not understand anything the teacher presented, she just copied them on her paper. She did not ask questions like many students in the classroom because she knew "the teacher should teach too much in limited time".

When Sua was asked to give examples of good or bad teaching in her school life, she described a university biology class she had taken a few years prior. She remembered: "when the professor taught something of biology, he had always tried to give a series of examples related to the content and explain the relation to the content. It was good for me". It seemed to be very logical and helpful for her to learn the content. As an example of bad teaching, she remembered:

> Some teachers wrote too much content on the whole blackboard and explained that quickly. In that case, I could hardly apprehend what the teacher meant. So, I had to copy quickly, before the teacher erased them.

2. Beliefs about Science Teaching and Learning

Learning, teaching, and their relationship. Describing her own analogy of learning and teaching as "a difficult task", Sua, was able to represent her thinking about learning and teaching in relation to previous experience. Consistent with her learning style described above, she described the difference between the meanings of learning and teaching like this: "I think learning means that learners study something for themselves, but teaching is something different. I guess teaching requires interactions with the teacher and the students in a classroom". She understood learning as a process separated from teaching, because teaching needed to include the interaction with students such that "teaching is an activity of delivering knowledge using various strategies for drawing the students' attention on the teachers' explanation". In a good classroom, she imagined that the teacher delivered knowledge to students, and students listened carefully to the teacher.

According to Sua, "the relationship of teaching and learning means that the teacher explains something and then students learn it". She thought that learning might depend on teaching. So, she believed that the classroom would be successful only given students' willingness to study, curiosity to know, and a positive attitude toward the teacher when the teacher explained something. Sua explained:

> If students are ready to learn in classroom, it is enough. It is the teacher who delivers knowledge to students. In other words, if students are ready to listen to the teacher and additionally are curious to know the content, whether they can learn or not depends on the teacher's explanations. That is, the better teachers explain, the better students can learn. And what I want to say is that students can learn whenever and wherever they want, if they want to know. So, I think that what is the most important to learning is a learner's readiness.

Good science teachers. Sua believed that good teaching should aim at developing students' understanding. She thought, however, that "It is hard for the teacher to know if students understood the content the teacher explained". In considering how to know if students understand, she thought "traditional assessments, such as formative or diagnostic tests using a pencil-and-paper instrument, would be appropriate in the situation of classes with many students and too much content to be taught". In saying so, she recognized that "even though those tests could not inform much of students' understanding, we have no alternative assessment". She believed that students' understanding depended upon the teachers' explanations within those situations.

According to Sua, for a teacher to be good at teaching science for understanding, the teacher should be able to explain the content logically and easily to students. She explained:

> I think a teacher needs an ability to speak logically and have a charismatic character for students to pay attention to him or her. If a teacher is to be successful, he or she needs to have those abilities, I think. So, first of all, teachers themselves know the content knowledge correctly, and then can explain it easily for students to understand it.

Additionally, she recognized the role of a good teacher as an effective communicator: the good teacher should be able to write skillfully up on the blackboard to explain the content, use funny or curious scientific stories related to everyday phenomena for inducing students' motivation of learning science and emphasize important things in textbook.

Student's theory. Sua agreed that students had their own theories in the science classrooms. For her, students' theories meant extraordinary ideas developing into new theory, like the cases sometimes discovered in the history of science, rather than preconceptions or alternative conceptions that should be changed into scientific ones. Sua said, "students can have their own theories that are different from theory the teacher presents. We can often discover similar cases in the history of science. In some cases, a scientist argued a theory different from one that contemporary scientists supported and the theory would be proved as true later". On the basis of her account, we can speculate that she did not recognize students' theories as objects to be treated in the classroom. Additionally, she did not predict that students might still have different ideas from the teacher's, after the teacher explained something. When the interviewer showed her a few examples from the literature of students' alternative conceptions, she tended not to accept those cases. She responded: "I don't think so". And she said that it is not important for teachers to consider students' theories in the classroom because "there seems to be few cases in a classroom". Sua added, "if there are many, the teacher has to explain slowly by using easy expressions. Well, but I don't think there are many". Furthermore, she believed that it was not possible for a teacher to consider students' theories in classroom the because "the time was limited and the amount of the content was too much, or other students may be confused".

3. Visions of Herself as a Future Teacher

Sua envisioned herself teaching in a way that was consistent with her previous experience. It seems also that her beliefs influence her vision of classroom teaching. She imaged herself teaching science as follows:

> I will come into the class with a teaching plan. When I come into the class, students look at and say hello to me. Uhm, I am not sure whether I could call students' attentions and whether I could organize creative activities for them. I think I may just teach by lecture style. I don't think I could ask many questions to students, and instead of that I will try to describe and explain the content to be taught. Just because there will be many students in a class and I am not charismatic.

Sua hoped that she would teach students "a few selected topics deeply" but did not think it was possible because "there are many students with different motivations and levels in a class, and the curriculum includes too much content for students to study in a year". She thought that "all the students cannot be satisfied in a classroom" and that "I will feel good if about a half or even only a third of students can understand".

Sua thought that a teacher had to know various things related to everyday life, such as "how is phlegm made?" or "what causes someone to break out in a rash?" in order to motivate students to study science. She hoped she would be able to "create a good learning-teaching situation, control students so they keep quite and pay attention, explain the content of science logically and interestingly, and present it clearly for students' full understanding as a future science teacher. However, she expressed a lack of self-confidence about her own ability to do that. Sua wondered if she could teach science to students well in the classroom.

Case 2: Hoin

Hoin was a male senior, majoring in physics education, who also wanted to become a science teacher. After he will graduate from university, he hopes to pass the test for becoming a science teacher. Although he could not get grades good enough to get a scholarship, he thought himself to be applied closely to his study. At that time of his study, it seemed that Hoin had a strong motivation to become a teacher. For him it did not matter what he taught. No matter what subject he would teach, whether science or mathematics, teaching itself was the important thing. He explained his motivation as "I like teaching most of all and I think I could teach science better than other subjects because I like physics. I mean I don't want to study physics as a teacher, but I want to be a teacher through the medium of physics. So, that's why I want to be a science teacher. I like teaching. That's why I want to be a teacher".

1. Previous Experience

Since middle school, Hoin had focused on studying only those few subjects, such as mathematics or science, that appealed to him. Hoin had a unique personal history related to his fondness for learning physics. When he was young, he had suffered from brain inflammation. He said that due to the disease, he might have learned much slower than other children at the same age. He described himself as "a very slow learner in comparison with other average students" in elementary and middle school. He received low grades in all subjects, until one day his parents suggested that he study only the one subject that he liked the best. This suggestion gave him an opportunity to think seriously about what he liked to study best. He became aware that he liked to study mathematics and physics better than other subjects. For him, physics especially among the sciences seemed "to be clear to explain something because they presented conclusions with reasoning". From then onward, Hoin enjoyed learning about mathematics and physics.

However, when some teachers gave conclusions without reasons in the science classroom, Hoin had to memorize them without understanding. He thought "all the teachers with full understanding of science could not teach well". As an example of this, he recalled experiencing great difficulty in understanding in a science classroom where a teacher explained very quickly using difficult words. For him, "learning means understanding," and he remembered he used to concentrate on the teacher's explanations in order to understand in the science classroom. He explained:

> When the teacher explained a rule or something like that in physics class, I tried to listen and understand the teacher's explanation. If I could understand something, I think I knew that. Of course, I could not remember all that the teacher said, but it was enough for me to be able to study that again for myself with reasoning sometime later.

Among participants interviewed, Hoin was the only student who commented about "conceptual change" as part of his learning experience. Hoin stated he had experienced conceptual change many times in learning science. He recalled that it was very surprising to him:

> For instance, you know, nongravitation, when I was in high school, I thought the state of nongravity means that there is no gravity. But one day I was aware that it was a misconception. As learning in university, I realized that nongravity meant gravity was canceled out by the opposite force. I was surprised by the fact that the conception I believed as true was wrong. We often used to say that there is no gravity, but it was not true. That is to say, if some evidence was presented like in the court, I had to admit that. At that time, a thousand emotions crowded on my mind. I felt happy to know a correct conception, but simultaneously I felt sad to have misunderstood it before.

2. Beliefs about Science Teaching and Learning

Learning, teaching, and their relationship. Hoin described learning in the following terms: "everyone knows something.. When I perceive news related to it, I can make something new from things that I already knew.. or I can change another thing influenced by them. I think the process is learning, in other words, learning means changing of someone's cognitive structure". When the interviewer asked him the meaning of cognitive structure, he answered it was like the clusters of conceptions to be related. In relation to learning, Hoin believed that teaching science should be for "students' understanding of science". In his experience, there were many students who could not understand what the teacher said, and they had a tendency to think differently from the teacher. Hoin believed that "to teach science for students' understanding is a very difficult job, but it was most important thing in the classroom".

Hoin's analogy of 'circulation of blood' or 'digestion' as his own analogy of learning and teaching process represented his beliefs about the relationship between learning and teaching quite vividly. The analogy implied that learning and teaching had a strong interdependence with each other. He explained:

It seems that the process of learning and teaching is circulation of blood through feedback. Blood is circulated from the heart to the heart. The blood come into the heart after traveling the whole body is not the same as that which first left it. As new blood is made passing through kidney, brain, and something like that by circulation, knowledge in my mind is made in the classroom. I receive new information from the teacher, sometimes what I already knew can be changed to new conceptions. Uhm, I change my analogy. Digestion seems to be a better analogy for me. Suppose you think about eating an apple. We eat and digest an apple and then absorb good ingredients but excrete bad things. Here I can say an apple corresponds to knowledge and teaching is to give it to students. And then students chew and digest it to make it a part of their body. What can be absorbed depends on the student. And later it will be represented in solving problems or certain situations like that.

Good science teachers. Hoin believed that good teaching in the science classroom meant that the teacher should be able to understand students in various aspects and to expand students' thoughts. Hoin thought that good teachers should help "students to get their eyes in understand our world through learning science". His rationale was that one of the aims of science education was to impart students with "abilities to apply scientific knowledge to other situations". And because teaching for understanding was most important in the science classroom, he believed that good science teachers should be able to teach in consideration of students' conceptions. In other words, good teachers should apprehend what students already know about the content the teacher planned to teach. He explained:

Before a teacher presents scientific knowledge the teacher needs to recognize and analyze what students know about that and then decide what and how to teach them. For example, the teacher should introduce scientific knowledge using examples or some activities for students' understanding. In doing so, the teacher can induce students to reconstruct their cognitive structures if their conceptions are something wrong.

Hoin emphasized the importance of the teacher's pedagogical mind in teaching as another condition for being a good teacher, especially the teacher's understanding of the students themselves in order to foster good relationships with them. He believed that such an understanding would greatly help the teacher to teach well.

Of course, teachers should have perfect understandings of science content. But for teachers, a more important thing is to have a good relationship with students, I think. Can a teacher who does not understand students teach well. Even though many people say that a teacher teaches well but if the teacher does not have a good relationship with students in the classroom, he or she isn't a good teacher to students. Good teachers should know what students think about their interests in general areas as adolescents, as well as in science.

Student's theory. Hoin agreed that students had their own theories in science classrooms. Hoin understood students' theories as "what they believed about their experiences". He added, "I can say we often understand things through experience by chance and believe those as true. But some understanding from experience is different from scientific theory. We can call this understanding misconception".

Unlike Sua, Hoin predicted there were many students with their own theories or misconceptions in the classrooms. He described the situation in which students might not understand what the teacher taught in the classroom by telling a story:

> I think many students have their own theories or misconceptions in classroom. Let me tell an old story. I am not sure it is true. Whenever Einstein lectured here and there, his driver had opportunities to listen to his lecture. One day, his driver suggested Einstein to give himself a chance to speak to the audience who came to listen to Einstein. Finally the driver did and after his speaking, the audience was very impressed and gave a big hand to him. But later his driver told Einstein that he didn't know anything about the lecture and just recited it from memory. Like this story, students maybe just memorize much of science content without understanding, I guess.

Hoin considered students' misconceptions as important factors affecting the learning of scientific concepts in classroom. He said that, "I think that students' theories are not completely wrong. So the teacher can lead students to achieve new understanding on the basis of misconceptions. If students are aware of their conceptions, they can compare a concept presented by a teacher with theirs. So, students' misconceptions are important to learn scientific knowledge". He added, "the teacher can ask students, for example, 'what do you think of nongravity', and then students may give various answers. Using their answers, the teacher can make it clear which part of their idea is right or wrong. In other words, it seems that the teacher gets important clues from students' ideas and uses them in teaching".

3. Vision of Himself as a Future Teacher

Hoin' sprevious experience and beliefs obviously influenced his vision of teaching. As he believed that the instruction should aim at students' understanding, he would like to "teach science for understanding to all the students if possible". He envisioned himself teaching as follows:

> If I become a teacher, I would try to introduce new concepts to students easily. There are students with different cognitive abilities in the classroom. So, it's not possible for all students to understand the science content. However, I, as a teacher, will try to explain the content of science for understanding with examples familiar to the students. I will be able to do.

Hoin stated that he would create the classroom circumstance for students to understand and learn science. He imagined the classroom where he and his students did not feel reluctant to talk about their ideas openly with each other. Hoin thought that "he as a teacher should have no misconceptions about the content of science in order to converse with students, recognize if students' conceptions represented in utterance were misconceptions or not, and then provide them with appropriate examples, problems and experiments to change their misconceptions".

V. Discussion

The two telling participants in this study, Sua and Hoin, had different experiences of learning, different beliefs about science learning and teaching, and therefore different visions of themselves as future science teachers. The cases showed that their different views of teaching science are strongly related to their previous experiences as learners and observers in schools, and that there is the apparent consistency between each participant's beliefs about science teaching and learning and their own visions of teaching in a science classroom. Summaries of the preservice teachers' previous experiences, beliefs, and visions of science teaching and learning are found in Figures 1 and 2. For the preservice teachers that were studied, it is evident and expected that their beliefs about teaching and learning science were rooted in their previous experience and influenced the new visions of themselves as future science teachers.

Sua's previous experience in schools revealed a few of her attributes as a learner. She was quiet and busy in writing down the content that the teacher presented in classrooms. She thought that she had little prior knowledge about the science content that the teacher intended to teach them. She did not want to miss anything, so she had little time to try to understand the science content while she was in the classroom. For her, the classroom meant the space where a teacher taught new and important science knowledge to students, and the teacher meant someone who already had scientific knowledge. So she tried to receive all the knowledge in science classrooms without ever questioning it. She recognized herself as a receiver learner from previous experience, and her self-concept as a learner was reflected in her beliefs about science teaching and learning. She believed that science teaching and learning was a process in which a teacher delivers knowledge to students who must be motivated to learn science and ready to receive scientific knowledge; that good science teachers should have correct content knowledge, be able to speak logically and to explain science clearly, and be charismatic enough to draw students' attention; and that, while some students had their own ideas about scientific concepts, those ideas were not significant enough to be treated as central problems for teaching in a classroom, because, she predicted, only a few students had such misconceptions. Constraints perceived by Sua contribute to her beliefs about the teaching and learning of science. She thought that, due to time pressure, too much content to learn, too many students in a class, and the possibility of confusing other students, students' own ideas didn't have to be significantly regarded in a classroom.

Sua had the image of teaching in a lecture style in which she could describe and explain the science content in the classroom. She possessed little confidence in her ability to draw and maintain her students' attention. She was generally concerned that she would have some trouble with problems related to classroom management.

The case of Hoin showed that, as a student, he usually tried to listen carefully and understand rules or principles that a teacher presented in class. He emphasized that understanding was most important in learning because knowing meant understanding for him. Looking back on his school life, he expressed that he had had many misconceptions about science, such as his confusion about weightlessness. When he was aware that his conceptions were not correct but different from scientifically accepted concepts, he felt very surprised. Hoin's beliefs about teaching and learning arose from his previous experiences in schools. He thought that learning and teaching included the change of learners' cognitive scheme, analogous to the organic process of digestion or blood circulation. In illustrating learning and teaching as the processes of 'circulation of blood' or 'digestion,' he understood that what can be learned depends on the student. For him, good science teachers were people who had not only perfect understandings of science content but also good relationships with their students. His rationale was that if a teacher would be a good teacher, she or he should consider what students wanted to know and how they know. In other words, a good teacher should teach science at her or his students' cognitive levels. To do so, the teacher must believe that students' ideas were important factors influencing teaching and should serve as the starting point for classroom learning.

Hoin foresaw himself teaching science, believing that he would teach science for understanding as much as he could and would present many appropriate examples or experiments illustrating a given scientific theory.

From the cases of Sua and Hoin, we find that two individuals may persist in his or her own beliefs about the teaching of science, particularly about science teaching and learning, the attributes of a good science teacher, and the importance of a student's theory. We also find that students' own beliefs about science teaching and learning have deep roots in their previous experience of schooling and influence their visions of teaching in science classroom. These visions, images that they have about the way things should be in their own classroom, show a strong correspondence with their beliefs about the teaching and learning of science (Barth, 1986, cited in Hamilton, 1993).

Ⅳ. Implications For Preservice Science Teacher Education

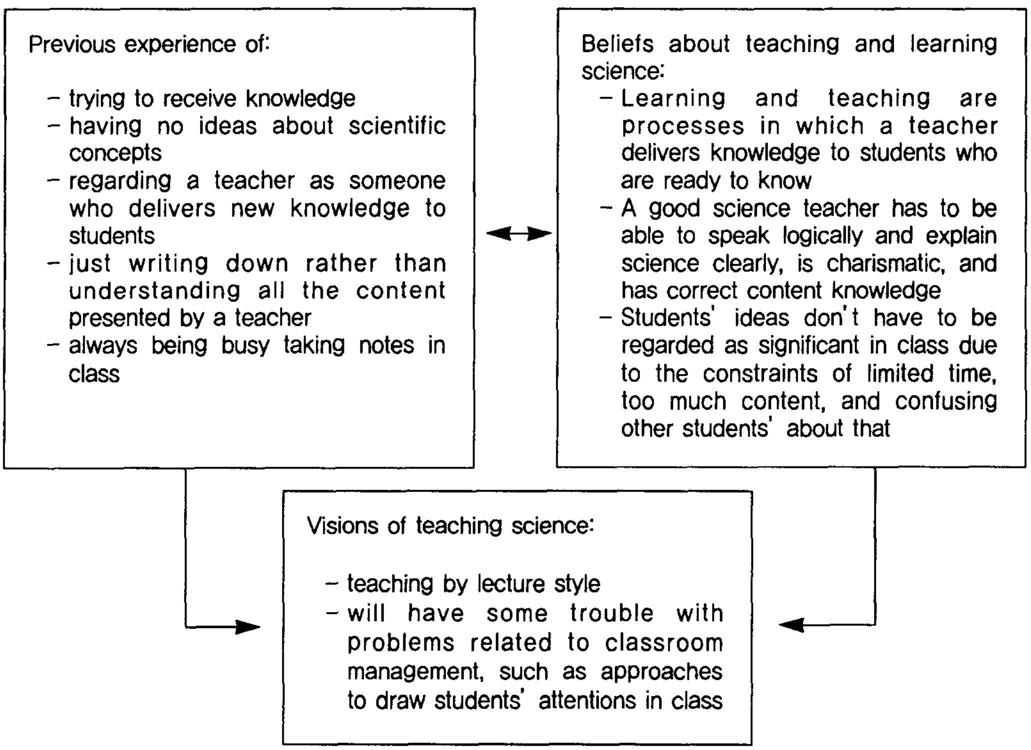

Fig. 1. Sua

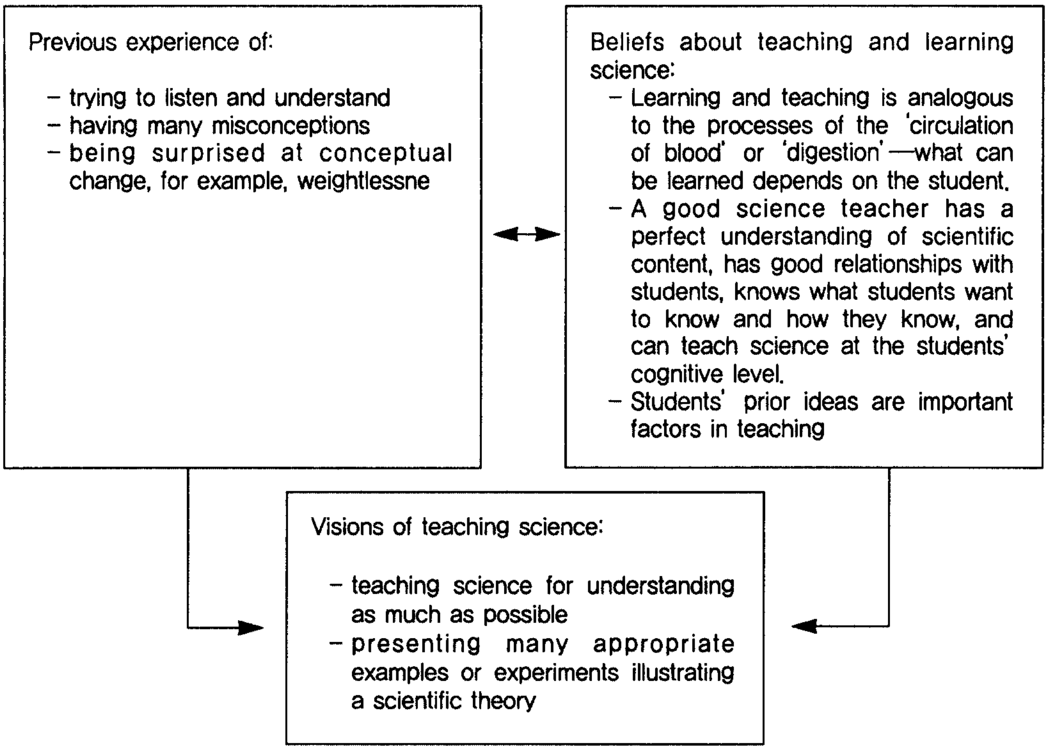

Fig. 2. Hoin

Teachers are recognized as the central determining factor in successful implementation of science curriculum in classrooms (Bybee, 1993; Levitt, 2001). Reform in science education in Korea calls for a new way of thinking about the teaching and learning of science. Constructivism provides the philosophical foundation for reform in science education (Levitt, 2001). Transition to teaching practices that support a constructivist approach to learning first requires "a new vision of teaching and learning," a paradigm shift for those in the educational community (Bybee, 1993; Tobin, Tippins, & Gallard, 1994).

A teacher's vision of teaching science might be based on that teacher's beliefs about teaching and learning. If teachers are to have new visions of teaching in the science classroom, they must adjust their existing beliefs toward new beliefs consistent with the vision for which the novel curriculum aims. However, as some researchers have indicated, such a change of beliefs does not occur easily. Indeed, the necessary change of beliefs is not evolutionary, but rather a gestalt shift.

It can be speculated that Hoin's beliefs about teaching of science are more appropriate to a constructivist perspective than Sua's. If one assumes that teachers' beliefs influence successful implementation of curriculum, one expects that Hoin would design and implement classroom activities compatible with constructivism as a foundation of current curriculum. The success of the new program of science education depends on teachers' ability to integrate the current philosophy and practices of science education with their existing philosophies, extant practices, and established district models (Bybee, 1993). Teachers tend to practice teaching consistent with their beliefs in cases where the curriculum reflects a philosophy different from the teachers'.

The dilemma, then, is that implementation of current science education reform requires considerable adaptation of teachers' beliefs in order to align requisite practices with the philosophy of reform. If teachers' beliefs are incompatible with the philosophy of science education reform, a gap develops between the intended principles of reform and the implemented principles of reform, potentially prohibiting essential change. Therefore, it is essential that teachers develop beliefs about the teaching and learning of science that are compatible with the philosophy of the current science curriculum.

In research on teacher education, it is recognized that the change of teachers' conceptions and beliefs about teaching and learning during learning to teach takes time and occurs in strong relation to practice teaching. Implications for preservice science teacher education in the cases of Hoin and Sua were related to the question of "what can be done to change and develop student teachers' conceptions and beliefs about teaching and learning of science?"

Teacher educators should gain a fuller understanding of preservice teachers' conceptions and beliefs about teaching and learning science in order to establish a knowledge base. Research in the area of preservice teachers' conceptions and beliefs should consider various factors beyond this study, such as personal and cultural factors. The conceptual ecological approach can be a useful framework for understanding what individual conceptions and beliefs are, how they are related to other factors within their conceptual ecologies, and how they act in combination with each other for decision-making in classroom activities. Most importantly, studies of beliefs within the context of culture are needed to understanding teachers' actions and choices in the classroom. Explorations of cultural factors can provide a means of more fully understanding the teacher's decision-making processes and the motives behind certain beliefs and actions. To develop teachers' professionalism, teacher educators can understand and distinguish similarities and differences among preservice teachers' conceptions and beliefs to design programs focused on change of teachers' conceptions and beliefs.

Applying conceptual change theory to teacher education aiming at the change of teachers' conceptions and beliefs suggests that preservice teachers should represent their conceptions and beliefs, be aware of them, and then compare theirs with peer students' or teacher educators'. Just as this study revealed the cases of Hoin and Sua, who have different views on the teaching and learning of science, preservice teachers need to recognize that people have different ideas about education and to learn to adopt more beneficial ideas on teaching science students in classroom by talking about them with others. This process needs to be explicitly metacognitive. By reflecting on their beliefs and conceptions about teaching and learning, preservice teachers become able to "step back" from one or more ideas held by themselves or others in order to think about them and express opinions about them (Hewson, et al., 1999). Teacher educators should provide preservice teachers with the opportunities to justify their visions for themselves as future teachers in comparison with alternative visions.

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