

Changes in Korean Science Teachers' Perceptions of Creativity and Science Teaching After Participating in an Overseas Professional Development Program

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This study investigated changes in Korean science teachers' perceptions of creativity and science teaching after participating in an overseas professional development program. Participants were 35 secondary science teachers. Data were collected from open-ended questionnaires and interviews. Results indicated that participants showed a growing awareness that creativity can be expressed by every student; creativity can be enhanced; science has a much wider range of activities that foster creativity; and creativity-centered science teaching can be implemented in Korea. The major elements of the professional program that promoted these perceptual changes included hands-on creativity activities, observation of creativity-centered classrooms, and discussion with other teachers. Follow-up study revealed that their perceptual changes have been reflected in their teaching practices.

Introduction

Recent educational reforms in Korea aim to rear creative human beings who are well prepared for the Information Age of the 21st Century (Ministry of Education, 2000), where productivity is measured by innovation and problem-solving skills instead of by merchandise produced (Toffler, 1984). Under the assumption that scientific advancement is essential to the nation's economic competitiveness, a recent national curriculum revision in science education addressed the importance of fostering students' creativity, and "creativity-centered science teaching" has become a catchphrase among science educators in Korea. In general, creativity-centered science teaching is an instructional approach that places the focus of science instruction on the development of students' creativity, as well as their conceptual understanding of science. The research, however, indicated that Korean science teachers exhibit uneasiness about the educational reform, struggling with how to teach science to improve students' creativity (Yoo & Sohn, 2001). This appeared to mainly result from the fact that teachers themselves have never been taught creativity-centered

instruction as learners (Yoo & Sohn, 2001). Rare, indeed, is the teacher who can inspire students to do what he or she has never actually experienced.

Since a teacher is the main mediator between any curriculum reform and classroom practice, to enhance students' creativity through science education, science teachers need to develop the competency necessary to implement the creativity-centered teaching approach. Accordingly, the Torrance Center for Creativity and Talent Development at the University of Georgia (UGA) was asked to design a professional development program (hereafter called the UGA program) to help Korean science teachers develop strategies to foster students' creativity in science. This invitation followed from UGA's long tradition of development and research in the fields of both creativity and science education.

This research study evolved from the belief that initiatives to reform our schools will undoubtedly flounder if we ignore the centrality of teachers' perceptions, beliefs, and practices. Educational change must always be mediated through the minds and motives of teachers. In this vein, this study sought to identify changes in the UGA program participating teachers' perceptions of the nature of creativity and science teaching and to identify specific elements of the program that seemed to promote the perceptual changes. Research questions of this study were as follows:

1. What changes in Korean science teachers' perceptions of creativity and science teaching can be identified after they participated in the program?
2. What specific elements of the program (e.g., lectures, school visits and classroom observations, workshops, discussions) seemed to contribute to these changes?

The purpose of this study was twofold. The present study sought to identify the nature of teachers' perceptual changes after participating in a specific professional development program. This understanding was to enable us to evaluate the effectiveness of the program in terms of its goals. The other purpose was to gain a better understanding of the elements of the professional development program that promote the desired teachers' perceptual changes. Once identified, these elements can serve as crucial components of future professional development programs for creativity-centered science teaching. Accordingly, this research study contributes to the research-based design of professional development programs for science teachers in Korea.

Theoretical Background

The theoretical framework of this study is based on a review of the literature in three areas: science education, teacher education, and educational psychology. A comprehensive review of the relevant literature revealed that three lines of scholarship are particularly relevant to this study: creativity and science education, teacher beliefs and practices, and overseas professional development programs.

Creativity and Science Education

The first line of scholarship was drawn from the literature on the relationship between science education and creativity. A great deal of research has argued that

creativity plays a significant role in science (e.g., Csikszentmihalyi, 1996; Moravcsik, 1981). Popper (1992), in his book *The Logic of Scientific Discovery*, attributed the essence of scientific ability to creativity. Moravcsik (1981) asserted that creativity is a key element in science: "Without it, science turns into a sterile manipulation of set rules and their embellishment without any tangible output whether in a conceptual or a practical sense" (p. 222). One research study that examined the important factors in the different science achievement between men and women documented that creativity was a critical element for women to become successful scientists (Subotnik, 1993). Another study supported this argument by asserting that the obstacle that prevented women from pursuing careers in science was not a lack of ability, but the suppression of creativity (Innamorato, 1998).

Consistent with the importance of creativity in science, creativity has been recognized as a crucial component of school science (Perkins, 1992; Torrance, 1992). Although creativity is not confined to any particular subject area, Torrance (1992) supported the view that science has a much wider range of activities with which to foster creativity than other school subjects. This is because the process of creativity (i.e., preparation, incubation, illumination, and verification) is similar to the steps in scientific method (i.e., observation, hypothesis, experimentation, and verification; Gallagher, 1985). It is further argued that all scientific processes require creativity (Meador, 2003). Observation, for example, needs openness to experience and sensitivity, which are components of creative thinking. Resistance to premature closure and creative convergence are necessary for hypothesizing (Meador). Considering the increased focus on science, technology, and societal issues, McCormick and Yager (1989) suggested that creativity needs to be included more often than scientific information and scientific processes in science instruction.

In this regard, creativity should be one of the main goals of science education and integrated into the science curriculum. Furthermore, given that creativity is a multidimensional construct that all people demonstrate to some degree (Cramond, 2001), science teachers need to foster students' creativity through science teaching. Hence, this study provides insights into ways to help science teachers foster students' creativity through exploring the effectiveness of a specific professional development program that focuses on creativity-centered science teaching.

Teacher Beliefs and Practices

The second area of scholarship that shaped the theoretical framework of this study is the relationship between teacher beliefs and practices. Although there is no agreed-upon definition of beliefs across disciplines (Eisenhart, Shrum, Harding, & Cuthbert, 1988), most scholars have agreed that beliefs drive one's actions (Brown & Cooney, 1982; Goodenough, 1963; Nespor, 1987; Nisbett & Ross, 1980; Pajares, 1992; Richardson, 1996). In the education field, much research has suggested that teachers' beliefs act as a filter through which a number of decisions about curriculum and instructional tasks are made (Nespor; Richardson). Parallel to this, research in science education has demonstrated that teachers' beliefs strongly influence their

science teaching and the implementation of alternative forms of practice (Bryan & Atwater, 2002; Luft, 1999; Yerrick, Parke, & Nugent, 1997).

Although beliefs are thought to guide actions, "experiences and reflection on action may lead to changes in and/or additions to beliefs" (Richardson, 1996, p. 104). In this regard, numerous lines of studies have investigated changes in beliefs through the experience with systematic teacher education programs at the pre- and inservice levels (Richardson, 1996). For example, Barnett and Sather (1992) organized a professional development program that consisted of extensive group case discussions in which teachers revealed their beliefs, and they, then, examined the changes in the teachers' beliefs. As a result, 16 of the 20 mathematics teachers changed their beliefs toward a more constructivist conception of teaching. Freeman (1993) traced changes in the language used by two foreign language teachers enrolled in master of teaching (MAT) programs. He found that changes in conceptions of teaching accompanied the introduction into their vocabulary of current professional concepts and premises. Tobin (1990) also demonstrated that metaphors can be used to change teachers' beliefs in professional development programs.

To answer the question of whether or not these changes in beliefs and conceptions affect teachers' practices, Richardson (1994) conducted a long-term study that examined the effects of a staff development program on changes in teachers' beliefs and practices in teaching reading comprehension. They also examined the effects of these changes on student achievement. As a result, they found that teachers changed their beliefs and teaching practices through the staff development program. Furthermore, they concluded that the students' reading achievement in the participating teachers' classrooms improved in comparison to students whose teachers had not yet participated in the process. In a follow-up study of the teachers 2 years later, they found that the teachers' beliefs had continued to change.

Consequently, it is evident that professional development programs play a role in facilitating meaningful changes in teachers' beliefs, and the changes in beliefs may lead to changes in their teaching practices. The changes in both beliefs and practices through teacher education programs, however, appear to be easier to facilitate at the inservice than at the preservice level. Practicing teachers have practical knowledge drawn from experiences as classroom teachers with which they can tie their beliefs and knowledge to classroom practices (Richardson, 1996). Although empirical work has been conducted to link professional development programs to beliefs and to practices, more efforts are required to answer unresolved problems that result from the complexity of the relationship between them (Richardson, 1996). With this in mind, this study aimed to add to the existing knowledge base of how professional development programs impact experienced teachers' thinking.

Fang (1996) reviewed literature on the complex relationship between teacher beliefs and practices and elucidated both consistency and inconsistency between them. He argued that one of the sources of the inconsistency between beliefs and practice is the context. Teachers' beliefs are situational and are transferred into instructional practices only in relation to the complexities of the classroom (Fang). Hence, the complexities of the classroom life can constrain the teachers' abilities to

attend to their beliefs and can limit instructional options that align with their beliefs (Duffy & Anderson, 1984). Against this background, a follow-up study to examine how the perceptual changes identified through the program are translated into the teachers' practices provides insights into how contextual factors influence teachers' beliefs and, in effect, their classroom practices.

Overseas Professional Development Programs for Korean Science Teachers

The third line of scholarship evolved from both the literature on overseas professional development programs for Korean science teachers and our desire to contribute to the research-based design of future professional development programs. Supported by a loan from the World Bank in the early 1980s, the Ministry of Education of the Republic of Korea developed a 5-year plan to upgrade and improve science education (Mayer & Fortner, 1991). As a part of the plan, approximately 200 high school science teachers and supervisors visited the United States (U.S.) and the United Kingdom (U.K.) to participate in five overseas professional development programs from 1985 through 1988 (Cho, Yager, Park, & Seo, 1997). The programs were about 1 month long and were mainly conducted at the University of Iowa, Ohio State University, and the University of London. Mayer and Fortner (1991), who designed and evaluated the program at Ohio State University from 1986 to 1987, stated that Korean science teachers were successfully trained in the use of laboratories and hands-on activities through the program. They also reported that Korean science teachers became confident at adapting what they experienced in the program for use in their own classrooms. Mayer and Fortner (1991) did not present substantive evidence to support these claims.

In 1994, the Ministry of Education of Korea resumed the overseas professional development programs. The University of Iowa's Science Education Center developed and conducted three workshops in 1995 and 1996. The Iowa Chautauqua Program (ICP) at the University of Iowa was implicitly designed to provide opportunities for the participants to experience the recent science education reforms of the U.S., which focus on science, technology, and society (STS) and constructivist learning (Cho et al., 1997). To evaluate the effect of the ICP on the development of teachers' constructivist philosophies, the researchers administered the *Constructivist Learning Environment Survey* (Taylor & Fraser, 1991) to participants three times: at the beginning of the workshop, at the end, and 3 months after. The study results indicated that the participants showed significantly improved perceptions of constructivist learning environments, but did not long retain the ideas acquired during the workshop (Cho et al.).

As Anderson and Mitchener (1994) pointed out, literature on these overseas professional development programs consists mostly of "one-shot" studies that give an answer to the question of whether or not a particular professional development program had a measurable impact by employing only quantitative research methods, such as Likert-type surveys or multiple-choice items. These kinds of studies have not substantially contributed to future science teacher education programs because they scarcely inform science educators of how the professional development programs

have benefited the participants. From quantitative results, we can judge whether or not significant changes in target areas occurred, but we cannot understand how those changes are meaningfully constructed in individuals' minds through their participation in the program. In this respect, this study attempts to delineate how teachers' perceptions of creativity and science teaching change through the program by using qualitative research methods. In addition, this study investigated program elements that promote teachers' perceptual changes in target areas. These elements can be used to inform the design of future science teacher professional development programs for creativity-centered science teaching. It is hoped that this research study contributes to the research-based design of future professional development programs, and ultimately offers guidance to future research on science teacher education.

Methods

Research Design and Procedures

Qualitative research methods were employed in this study. To observe the perceptual changes, we administered open-ended pre- and postprogram questionnaires to 35 secondary school teachers (22 males and 13 females) on the first and on the last day of the program, respectively. The preprogram questionnaire consisted of questions asking participants' perceptions in three areas: the nature of creativity, the relationship between science and creativity, and creativity-centered science teaching and learning. The postprogram questionnaire, identical in all other respects, contained two additional questions about the program elements that had either promoted or inhibited teachers' perceptual changes in target areas (see Appendix A). The questionnaires were developed through active discussion among the researchers to ensure their content validity.

To further elucidate how the perceptual changes occurred, we interviewed four participants on two occasions, at the beginning and at the end of the program. Due to time constraints, we selected only four participants for interviews. All of the pre- and postprogram interviews were conducted in a semistructured way using a protocol that paralleled the pre- and postprogram questionnaires. During the interviews, the participants were allowed to tell "their own stories" and to introduce issues of which the interviewer had not thought (Smith, 1995). As a result, questions within the protocol were adapted to the specific context, and interesting emerging issues were probed further. Each interview lasted approximately 60 minutes.

Furthermore, to explore how the perceptual changes that occurred as a result of the program were reflected in their actual science teaching after returning to Korea, follow-up interviews were conducted with the four teachers via e-mail on two occasions, 1 month later and 3 months later. All of the questionnaires and interviews were conducted in Korean. All interviews were audiotaped and transcribed verbatim in Korean. Questionnaire and interview excerpts reported in this paper were translated by the first author, Soon-Hye Park, and confirmed by the second author, Soo-Young Lee, for accuracy.

Table 1
Science Background and Teaching Experience of Interview Participants

Interview participants (ID number)	Gender	Teaching level	Science background	Teaching experience in science
Kim (T4)	F	Grade 7–9	Physics	15 years
Jung (T10)	F	Grade 7–9	Chemistry	20 years
Park (T15)	M	Grade 10–12	Earth Science	4 years
Lee (T27)	M	Grade 10–12	Physics	22 years

Research Participants

Forty Korean science teachers, including 5 elementary school teachers, participated in the program. All participants were winners of regional and national awards and were selected based on their high scores on a competitive examination evaluating science subject matter knowledge and speaking and writing English ability. Considering that elementary school teachers do not specialize in a specific subject in Korea, as in most elementary schools in the U.S., we limited the scope of the participants of this study to secondary school science teachers only.

Among the 35 teachers who participated in this study, 18 teachers had taught at the middle school level (grade 7–9) and the others had taught at the high school level (grade 10–12). Twenty-two teachers were male and 13 teachers were female. The average number of teaching years was 17. We purposefully chose 4 interview participants, considering even distribution of gender and teaching level among the 35 questionnaire participants. The 4 teachers also participated in the follow-up interviews. Table 1 shows a summary of the teaching experience and background of each interview participant. We use pseudonyms for interview participants and unique ID numbers for questionnaire participants throughout this paper.

Description of the UGA Program

The program on creativity and creativity-centered science teaching was organized and facilitated by the Torrance Center for Creativity and Talent Development at UGA and sponsored by the Kyungpook Ministry of Education in Korea. The program was intensive throughout the 2 weeks' duration. Each day lasted for 8 hours, from 9:00 am to 5:00 pm. All participants in the program received a certificate of completion at the conclusion of the program.

The program adopted a traditional workshop form in that it occurred outside the teachers' own classrooms and involved leaders with special expertise and participants who attended sessions at scheduled times (Loucks–Horsley, Hewson, Love, & Stiles, 1998). The program had four major components: (a) lectures on creativity (some incorporating hands-on activities), (b) lectures on creativity-centered science

Table 2*Components of the UGA Program*

Component	Allocated time (hours)	% Total
<i>Lectures on creativity:</i>		
Overview of creativity	9.0	
Strategies for fostering creativity	6.0	
Future problem solving	1.5	
(Demonstration)	1.5	
Subtotal	18.0	23.5%
<i>Lectures on creativity-centered science education:</i>		
Creativity in science	1.5	
Strategies for creativity-centered science teaching and learning	12.0	
Gifted education in science	1.5	
Subtotal	15.0	19.6%
<i>School visits and classroom observation</i>	12.0	15.7%
<i>Experiences in American culture and heritage (Weekends, Martin Luther King Day)</i>	26.5	34.6%
<i>Social events</i>	3.0	4.0%
<i>Evaluation</i>	2.0	2.6%
Total	76.5	100.0%

education (some incorporating hands-on activities), (c) school visits and classroom observations, and (d) experiences in American culture and heritage. Park, the first author, attended all the sessions and took extensive field notes on the organization and structure of each session, on the discussion topics and activities, and on the interactions between the participants and the session leader, as well as among the participants themselves. Table 2 provides an overview of time allocation during the 2-week program.

Data Analysis

Data from the questionnaires and the interviews were analyzed based on an interpretative phenomenological method (Smith, 1995). Analysis of all the data focused on the identification of regularities or patterns in the statements made by the participants without using a preestablished system of categories or codes. Instead, we developed categories through an interactive process during which the data were constantly compared (Charmaz, 2000). Through a process of open coding (Strauss & Corbin, 1990), the first two authors read both questionnaires and interview transcripts several times and then established an agreed-upon basic set of codes. With the

set of codes, the two authors then independently coded teachers' responses to the questionnaires and the interviews. The interrater reliability was 87%. Next, we discussed and negotiated any disagreements until a consensus was reached. Patterns and themes emerging from the data were discussed and refined using investigator triangulation (Janesick, 1994).

Responses to the preprogram questionnaire were compared with those of the postprogram questionnaire to track changes in teachers' perceptions in the target areas. These perceptual changes identified formed a starting point for analyzing interview data. As perceptual changes were accumulated from the pre- and postprogram interviews, they were compared with the patterns of perceptual changes from the questionnaires. To analyze the relationship of the program components to the perceptual changes, the same procedures were employed. That is, we first analyzed the responses on the postprogram questionnaire to identify the specific components of the program mentioned by the participants. The identified components were then compared with the components identified from the postprogram interviews. In addition, data from the field notes provided additional information to better understand the elements and organization of the program and the teachers' experiences during the program. Through the analysis process, we identified four major changes in teachers' perceptions and three program elements that promoted those perceptual changes. In the following section, we will discuss our findings along with actual teacher responses that led to the findings.

Results and Discussion

Changes in Teachers' Perceptions of Creativity and Science Teaching

All Students Have the Potential to Be Creative to Some Degree. One of the most significant changes in the teachers' perceptions of creativity after participating in the program was that they came to understand that everyone possesses a creative potential, although not necessarily to the same degree or in the same way. At the beginning of the program, the teachers had tended to view creativity as an all-or-none ability emphasizing big-C creativity (Gardner, 1993) as Jung, one of the interviewees, describes here:

Creativity is an act to produce something innovative and valuable, which leads to significant changes in the world. For example, one or two extremely creative people could feed several thousands or several millions of people in the world. So, it would be meaningful to focus on the development of creativity of a few creative students only. (Preprogram interview with Jung)

Throughout the program, however, many teachers came to appreciate *little-c* creativity (Gardner, 1993), which can be expressed in small departures from daily routines, in that little *c* creativity can contribute positively to the quality of one's daily life. This perceptual change became salient when the interview participants

were directly asked to talk about changes in their perceptions of creativity. The following two interview excerpts illustrate how the focus of the teachers shifted from Big-C creativity to little-c creativity:

The scope of creativity in my mind is getting wider than I thought before participating in this program. I used to think narrowly about creativity as making significant achievement in the science field or making remarkable products. I thought only a few exceptional people have creativity. But now I think creativity can be found in everybody and in our daily lives as well.
(Postprogram interview with Lee)

While big-C creativity can change our world and significantly influence the lives of others, everyday creativity is also important because it must be useful for everybody to enrich their lives with a positive view of life.
(Postprogram interview with Kim)

Their acknowledgment of the value of little-c creativity accompanied the recognition that everyone can be creative in some way and that science education should aim to help students develop their potential creativity in all aspects of their lives. Consider the following excerpt:

From now on, I'd like to focus on developing creativity of all students in my class, rather than one or two exceptional students because every student has the potential to be creative in different ways and to different degrees, and teachers need to help students to develop their potential.
(Postprogram interview with Lee)

Acquiring this new understanding (i.e., that every student has the potential for creativity) is a positive development. This understanding will motivate the teachers to help all of their students find and improve their potential creativity through appropriate instructional interventions. Other research supports this conclusion. Cronin-Jones (1991) identified teachers' belief about the abilities of particular groups of students as one of the four categories of beliefs that strongly influenced new curriculum implementation. Consistent with this, Borko and Putnam (1996) asserted that teachers' beliefs about students can play a critical role in determining if and how they implement new instructional ideas in their classroom. Furthermore, our research suggests that developing a broader set of beliefs regarding the creative capabilities of their students is enabling to these teachers. If teachers believe that "only a few" students have the potential to be creative, they may decide not to enact the creativity-centered instructional approach in their general science classroom for all students. Thus, the teachers' acknowledgement that every student has creative potential appears to be one of the positive effects of the program.

Creativity Is an Ability That Can Be Enhanced, Rather Than Being Innate. Another salient change in teachers' perceptions resulted from learning that creativity is an ability that can be enhanced through various means in classrooms, rather

than being an innate ability. On the preprogram questionnaire, 7 participants (T13, T20, T23, T24, T31, T33, and T34) reported that creativity is an innate ability that people are born with and that cannot be changed. On the postprogram questionnaire, however, all the 35 participants felt that creativity can be fostered through appropriate science teaching. An example is shown by this: "Creativity is a kind of ability that can be developed through school learning because I believe creativity is not a genetic disposition, but a way of thinking for problem solving" (Postprogram questionnaire response by T30). Parallel to this, all of the 4 interview participants stated that they came to recognize that creativity can be developed through various instructional strategies in science classrooms. In the postprogram interview, Kim said:

I found that strategies for creativity-centered science instruction are much more varied than I knew before, for example, brainstorming, use of discrepant events, productive questioning, project-based learning, inquiry-based laboratory activities, problem-based learning, jigsaw model, role play, science show, discussion-centered teaching, and so on. (Postprogram interview with Kim)

Among the four teachers, Park revealed dramatic changes in his perception of instructional strategies for fostering creativity over time. In the preprogram interview on the first day of the program, he emphasized that the only way to foster creativity in science classrooms is teaching a great quantity of scientific knowledge—as much and as fast as possible. Interestingly, we found that this perception was strongly related to his beliefs about the nature of science. Park regarded scientific knowledge as consisting of a set of facts and theories that held the status of absolute truth. For Park, this truth is retained as a characteristic of scientific knowledge, even though the knowledge had been discovered and accumulated over a long period of time. He assumed that the main goal of science instruction is to teach students this scientific knowledge, including facts, concepts, theories, and principles. Since scientific knowledge is absolute, Park had concluded that students cannot exhibit creativity while they are learning this body of knowledge. According to him, only when students have mastered the body of knowledge can they express their creativity based on their knowledge of science. Park arrived at the previously stated conclusion that, to foster students' creativity in science, teachers should teach basic scientific knowledge as much and fast as they can. He stated,

Science is knowledge that is absolute and has accumulated for a very long time. Science is a discipline in which people should first understand basic principles and theories and then expand the basic principles and theories based on the basic understanding. I believe that only after systematically acquiring a certain amount of scientific knowledge are students able to be creative. So, we need to intensely teach basic scientific knowledge through teacher-centered instruction first. Then, it will ultimately contribute to developing creativity. (Preprogram interview with Park)

Despite his previously stated belief about the goal of science teaching, that is, transmission of knowledge, Park began to recognize that there are many possibilities to enhance creativity, even in the process of teaching scientific knowledge. Reflecting on his knowledge-centered teaching approach in his postprogram interview, he said,

I thought the best way to teach science is teaching it in the way I had learned, so I have taught in the knowledge-centered way. I used to believe if I was thoroughly acquainted with science content knowledge, I could automatically teach students well, but I found that's not enough to deliver students the knowledge that I have. Through this program, I learned I have to change this perception and attitude and should work on how to teach differently from the way I used to teach. I learned I could give students many opportunities to develop creativity through a lot of strategies, even when I teach theories and principles. I need to open my mind more to embrace students' potentials and capabilities. (Postprogram interview with Park)

We do not know whether Park's beliefs about the nature of science had also changed along with this perceptual change because that question is beyond the scope of this research study. From the interviews with Park, however, we can sense a hint that teachers' beliefs about science teaching might influence their teaching practice, which has been suggested by many researchers (e.g., Brickhouse, 1990; Lederman, 1992). In conclusion, the perception that creativity can be enhanced through instructional inventions, we believe, will encourage the teachers to apply the strategies for fostering creativity they learned from the program to their actual classrooms. Kim supported this assumption in the postprogram interview, stating that "I really want to implement the teaching strategies I learned here and see whether they also work for my students as I experienced here."

Science Lends Itself to Fostering More Creativity Than Other Subjects. Comparing the responses between the pre- and postprogram questionnaire, more teachers reported that science has a wider scope than other school subjects with regard to its ability to foster creativity after the program. Given that all of them were science teachers and the program focused on creativity in science education, this perceptual change seems natural. The teachers, however, attributed this relative difference to three close relationships between science and creativity. First, creativity is defined as being a problem-solving ability, and science provides many opportunities to solve problems. This perception was portrayed in Lee's statement:

I think science education considers creativity more than other subject areas because of the characteristics of science; that is, science emphasizes problem-solving and experimental processes more than memorization. Science is not a simple subject, is it? It is a subject to solve complex problems we pose while observing natural phenomena, isn't it? There are many ways to solve a problem. We should help students think about various approaches to solve a problem by engaging in inquiry activities

because problems often have so many different answers. (Postprogram interview with Lee)

Second, some aspects of science, such as scientific processes, inquiry, and scientific inventions, provide science with more room for fostering creativity than other subjects. On the postprogram questionnaire, one third of the teachers (T4, T5, T6, T11, T18, T22, T23, T27, T29, and T30) said that the inquiry process in science provided students with opportunities to enhance their creativity: "Inquiry processes, such as observation, posing a question, making a hypothesis, designing an experiment, and so forth, allow students to think in an original, unique way during which they can develop creativity" (Postprogram questionnaire response by T27).

On the other hand, three teachers (T2, T3, and T7) stated that invention-centered teaching, which they thought is the most appropriate instructional strategy to develop creativity, could easily be implemented especially in science classes. Parallel to this, some teachers, including Lee and Jung, perceived that the manipulative nature of science experiments enabled students to enhance their creativity:

Science is manipulating experimental facilities and objects we can see, so students themselves can actually experience, experiment, and explore what they want to know. This seems to be very helpful to develop creativity, for example, dissecting a fresh fish, setting up chemical reactions, and sliding a toy train car, which greatly motivate students to produce creative ideas. (Postprogram interview with Jung)

Last, some teachers documented that science was closely related to everyday life, so that science was uniquely able to spur creativity. In other words, little-c creativity, everyday creativity, can be enhanced through science learning. In our everyday life, we frequently face situations that require problem solving across a wide range of sources. The teachers felt that solving these problems often requires creativity. On the postprogram questionnaire, a teacher, T25, described this view as follows:

Science presents so many problems related to students' real lives, so the students are motivated to solve those problems, and they try to apply what they learn in a classroom to their actual lives. So, they can make their lives more enjoyable. (Postprogram questionnaire response by T25)

Those perceptions of the close relationships between science and creativity led the teachers to reflect on their past teaching experiences and further facilitated the decision to implement the creativity-centered teaching approach. Jung said it this way:

I came to realize that there are so many things we can do to develop students' creativity through science teaching. I think if I opened my eyes about the importance of science in fostering creativity, I would be a better

science teacher. I feel like I have been neglectful in developing creativity of my students. But I believe even now is not too late. I truly want to play a role of motivator to my 41 students. (Postprogram interview with Jung)

Thus, this new perception (i.e., that science has much room for fostering creativity) appears to be one of the most important outcomes of the program. Through this change, the teachers came to see the possibility of fostering students' creativity through science teaching.

Creativity-Centered Science Teaching Can Be Implemented in Korea. We found that the teachers came to value creativity-centered science teaching. They also came to develop confidence that they can successfully put this approach into practice in their classrooms after returning to Korea. At the beginning of the program, the teachers raised concerns regarding whether creativity-centered science teaching will be complementary to or competing with the current mandatory national curriculum in Korea. Moreover, questions arose concerning whether creativity-centered instruction can work in educational settings in Korea that focus on standardized tests and the competition among schools and individual students. The following excerpt illustrates this concern: "What we are learning here will be useless as long as our National College Entrance Exam-centered educational system exists" (Preprogram questionnaire response by T17). Few teachers maintained those concerns, even after the program. Jung stated,

When I return to Korea, although I want to implement this project-based learning approach, which can be an effective way to help students foster creativity, frankly speaking, I am not confident in doing that in regular science classroom hours. Once a textbook is given, as you know, we have to thoroughly cover the textbook. We have to teach the textbook from the front cover to the last cover in any way. So, it is likely to be very hard to implement a project-based learning, which is often an additional curriculum to the textbook. (Postprogram interview with Jung)

However, most teachers expressed optimistic visions that they could implement creativity-centered science teaching in Korea. Along this line, quite commonly, they suggested strategies to gradually overcome the constraints of the educational system in Korea, such as collaboration with colleagues, gradual implementation, and effective time allocation. Kim summed up the suggestions of many others:

There are too many things to be taught in the science curriculum. But, I think we can try it [creativity-centered science instruction] this way; we can try to apply the strategies we learned at UGA to a part of a class, not to the whole class, for example, only at the beginning to motivate students. Besides, it is possible to practice creativity-centered science teaching several times during a year instead of in every class. If I try to do it in every class, trial and error may occur because this kind of instruction is totally new and it will cost me; I have never experienced

this kind of instruction before so that it will take some time for me to adapt the strategies. (Post program interview with Kim)

Moreover, whereas the teachers expressed a dependence upon curriculum materials produced by others and what might be labeled as a "tell us what we should do" orientation at the beginning, they demonstrated a desire to develop their own teaching strategies and materials at the end of the program. Park verified this perceptual change:

I thought I could not develop teaching materials to foster creativity by myself so that I did not even try to develop them. However, when I saw the sample curriculum materials and other teachers' work samples for fostering creativity, I realized that those are the things that I might be able to develop by myself. I realized that I just didn't think I could do it. Now, I think I can develop curriculum materials suitable for my students and my classroom environment. It would be best to develop what I need and what I can use in my class by myself with the help of my colleagues. (Postprogram interview with Park)

This change is beneficial and essential for the success of the teacher professional development program. If teachers do not have confidence in their ability to implement a new teaching approach, even if they value the approach and desire to use it, they will rarely try it out (e.g., Appleton & Kindt, 1999; Bohning & Hale, 1998). Lumpe, Haney, and Czerniak (2000) concluded that teachers' beliefs about both their capability to make changes and their science teaching context are "the more precise agents of change" (p. 288). In this regard, we believe that the increased confidence of the participating teachers in teaching creativity-centered science and developing materials is very encouraging. This confidence will translate into attempts to try out new teaching strategies they learned from the program in their own classrooms.

Program Elements That Seemed to Promote the Perceptual Changes

We found three major elements of the program that promoted the perceptual changes discussed previously: school visits, experiences as learners, and discussions. Table 3 shows the percentage of responses associated with each program element by the teachers when asked to identify the most valuable experience on the postprogram questionnaire.

As shown in Table 3, the most salient element of the program that influenced their perceptual changes was the opportunity to observe actual science classrooms where creativity-centered science teaching was put into practice. Participants visited magnet schools and regular secondary schools. At these sites, they observed various teaching approaches, including project-based science teaching, independent study, and mentorship and internship programs. Classroom observations provided

Table 3
Program Elements That Promoted Teachers’ Perceptual Changes (N = 35)

School visits (classroom observations)	Experiences as learners	Discussions	Others
41.5%	34.1%	17.1%	7.3%

Note. The percentages indicate the frequencies of the responses included to each category.

opportunities to understand how theories and strategies learned from the program could be implemented in real classrooms.

Through classroom observations, I learned how well the theories I already knew and had learned from the program could be put into practice in the classrooms and how to implement them with students. I was convinced that it is possible to implement creativity-centered science teaching in reality. (Postprogram questionnaire response by T10)

Moreover, through the classroom observations, the teachers came to perceive that it would be hard—but not impossible—to implement creativity-centered science teaching. Kim spoke about it this way:

I concluded that we are able to do it as American teachers do here. Because I saw American teachers’ work to foster creativity with my own eyes, I learned it is not impossible. Before this program, I simply thought that we should do creativity-centered science teaching without much consideration of how, but now the program turned my mind so that I have much better and concrete ideas of how I can actually do it. (Postprogram interview with Kim)

School visits also allowed them to compare educational situations in America and those in Korea. These visits provided the teachers with an opportunity to think about how to apply what they learned to the educational situations in Korea. These situations have a number of stark differences from U.S. schools. In Korea, every secondary school student learns science from a curriculum that is standardized across the nation. Students take the National College Entrance Examinations based on the mastery of that curriculum at the end of their senior year. Since the national examinations are very competitive, teachers feel a heavy burden to prepare students for these examinations. Consequently, teachers tend to use teacher-centered and test-oriented instructional approaches to cover the curriculum and to get students ready for examinations within limited time. The school visits made the participants realize the importance of adapting the ideas they had learned throughout the program. One of the participating teachers, T11, addressed this concern:

I was surprised that an educational system to foster students' creativity is very well established here in America. School administration, facilities, and society all together support the development of students' creativity. Curriculum is very well connected to the society and everyday life of students. I saw how everything works well for fostering students' creativity. Since the school visits, I really realized we should do this, so I have been thinking deeply how to apply the new teaching approach to our country because our educational reality is very different from here. (Postprogram questionnaire response by T11)

The second element of the program that promoted the perceptual changes was the opportunity for teachers to engage in various hands-on activities that were carefully designed and well organized to foster creativity. For instance, they learned various creativity strategies, such as SCAMPER (Eberle, 1996), Six Thinking Hats (de Bono, 1985), and the Osborn/Parnes Creative Problem-Solving Process (Parnes, 1981). Utilizing those creativity strategies, then, they were engaged in solving problems associated with environmental issues, making electric circuits, or resolving the questions posed by given discrepant scientific events. Through their experiences as learners, the teachers reclaimed some of their creative potential and renewed beliefs regarding how creativity can be fostered by instructional inventions. Thus, the teachers were convinced about how they should and could employ various instructional strategies to nurture creativity in their own science classrooms. A teacher's response in the postprogram questionnaire showed how the hands-on experience influenced his perception of creativity-fostering strategies and his decision to implement creativity-centered science teaching in his classroom:

Through my own involvement in hands-on activities as a learner, I realized students' creativity can be enhanced through various classroom activities. Also, I got to know what and how we, science teachers, could do in our classrooms through being involved in those activities. I'll try those I experienced in my classroom. (Post questionnaire response by T2)

This statement supports Garet and colleagues' (2001) assertion that hands-on activities are one of the major elements of effective professional development programs. In a study investigating core features of professional development activities that have positive effects on teachers' knowledge and skills, as well as their classroom practice, Garet et al. suggested that opportunities for hands-on work are crucial to enhance teachers' knowledge and skills. In addition, they stated that enhanced knowledge and skills have a substantially positive influence on change in teaching practice.

The third element of the program that promoted teachers' perceptual change was the opportunity for reflection and discussions with colleagues. Since all participants were housed at the same facility throughout the program, they could discuss what they were learning any time before or after, as well as during the scheduled time of the program. The teachers appreciated formal and informal discussions and

reflection times with colleagues, as shown in the following excerpt: "Through discussing and sharing opinions and ideas with other teachers I was able to correct my misconceptions of creativity and science teaching and got to think from various perspectives, which helped me to develop my creative thinking" (Postprogram questionnaire response by T6).

It has been argued that discussions with other teachers participating in the same activity can provide a forum for debate and improving understanding, which increases teachers' capacity to grow (Ball, 1996). To this end, an ongoing discussion among teachers, who are engaged in efforts to reform their teaching in similar ways, can facilitate change by encouraging the sharing of solutions to problems, as well as by reinforcing the sense that improvement is possible (Garet et al., 2001). Discussion and collaboration with other teachers involved in change can also help sustain motivation (Lieberman & McLaughlin, 1992).

In particular, the impact of discussion on the teachers' perception appears to be salient in this research context, because all of the 35 participants were from the same school district and teaching the same subject (i.e., science). It can be assumed that these teachers are likely to discuss concepts, skills, and problems that arise during their professional development experiences, since they share common curriculum materials, assessment requirements, and even students. The following interview excerpt supports this assumption:

Two teachers participating in this program are from the same school as I am, and we shared a room during the program, so we talk a lot about what we have learned. Because they know a lot about the students I teach and our school system, discussions with them are very helpful and practical to think how to integrate what I have learned here into my instructional context. (Postprogram interview with Lee)

This supports the claim that professional development programs need to help teachers create a shared professional culture in which teachers in a school or teachers who teach the same grade or subject develop a common understanding of instructional goals, methods, concerns, problems, and solutions (e.g., Talbert & McLaughlin, 1993). Knapp (1997) underscored that change in classroom teaching is a problem of individual learning, as well as organizational learning, and that organizational routines and establishing a culture supportive of reform instruction can facilitate individual change efforts. Accordingly, professional development programs designed for groups of teachers from the same school district, subject, or grade level have the greater likelihood of changing teaching practice (Garet et al., 2001).

Suggestions for Making the Program More Effective

Four major suggestions to improve the program emerged from both the postprogram questionnaire and interview. First, the teachers agreed that some of the lectures were about things they had already learned. To support the recent educational reform to foster creativity through science teaching, the Ministry of Education of Korea has

provided many professional development programs to improve teachers' awareness of creativity in Korea. A number of the participating teachers had already taken part in at least one professional development program for creativity-centered teaching in Korea before attending the program; therefore, they participated in the program with prior knowledge about creativity and creativity-centered science teaching. That prior knowledge made some basic lectures on creativity neither new nor challenging to them. Consequently, many teachers expressed their dissatisfaction with the level and depth of the lectures of the program by making comments similar to the following response: "They [instructors of the program] didn't know the knowledge level of us. Some lectures were boring. If they designed the program based on the understanding of the knowledge level of teachers and educational situations of Korea, it could have been better: (Postprogram questionnaire response by T1).

This implies the importance of pre-assessments of participants' needs and prior knowledge in designing a professional development program. Through a pre-assessment of what participating teachers already know and what the teachers have learned in earlier professional development experiences, a program developer could have eliminated the content that teachers have previously mastered, saving time for more challenging learning experiences. In addition, the assessment of participants' needs enables a professional development program to be responsive to their needs and goals.

Another suggestion dealt with providing opportunities for participating teachers to connect the ideas and knowledge that emerged during the program to their actual teaching context, considering curriculum, required assessments, and characteristics of students in their schools. Jung expressed her need of contextualized experiences:

I am really impressed by the use of internship as a means to foster creativity and would like to try that in my classroom, but I think it may be impossible to implement that because of our social, educational situation. However, there must be a way to make it, if I share concerns, information, and ideas regarding internship with other teachers. So, I think, during this program, if we had opportunities to develop lesson plans or design [a] 1-year curriculum for enhancing creativity by ourselves and discuss them considering our actual classroom situation, it would have been great. (Postprogram interview with Jung)

Consistent with this statement, some teachers wished to take the idea of contextualized learning experiences even further. They suggested the addition of opportunities to develop lesson plans or instructional materials, get feedback on the plans from other teachers or experts, and discuss actual classroom implementations. Considering that teaching is context dependent, a successful instructional strategy in one context may not lend itself to straightforward generalization in another. The introduction of new instructional approaches may have different implications, depending on the curriculum in a school, specific textbooks adopted in a classroom, and required assessments in the district. In addition, the cognitive and affective

characteristics of students, materials covered in previous grades, and students' expectations for classroom instruction may affect the implementation of new teaching approaches. All of these factors combine to create a clear recognition that contextualized learning experiences should be included in a future program.

Support for reflection was also recommended by the teachers. Park stated,

I felt like I was just following the tight program schedule without thinking about what I have learned and reflecting on myself as a teacher. Of course, I could have reflection time after the scheduled time, but I usually got too tired after the program and had so many things to do during extra time, such as our district meeting, administrative work, and so on. So, I hope the program developer will specifically assign time for reflection or incorporate activities supporting reflection, such as journal writing, in future programs. (Postprogram interview with Park)

From this statement, it seems clear that if substantial opportunities for reflection had been provided, the teachers could have reframed their learning during the program and employed the reframed knowledge to ultimately contribute to changes in their teaching practice. Rippey (1981) suggested that self-assessment through reflection is essential to improving one's own teaching, because the improvement requires the recognition of personal deficiencies and the internalization of the need for change. The importance of reflection in teaching is well described by Palmer's (1998) statement:

When I do not know myself, I cannot know who my students are. I will see them through a glass darkly, in the shadows of my unexamined life—and when I cannot see them clearly, I cannot teach them well. (p. 2)

In addition to the need for reflection, nine teachers (T5, T6, T7, T10, T24, T25, T26, T27, and T33) specifically documented the need for more unique experiences that they would not experience in Korea. These experiences included local school visits, science institution visits, and field experiences. Although the teachers visited several schools during the program, there were frequent statements regarding the desire to visit more schools, more regions of the state, more different descriptions of schools, and so forth. As one proponent of this view, Lee made the following suggestions:

I think, even without coming to the U.S., we could have learned the theories we learned here through a professional development program or reading relevant articles in Korea. Therefore, instead of learning theories, I wanted to have more practical experiences that I could experience only if I came here, America—for example, observing how they [American teachers] put theories into practice or how special programs to foster creativity work here, visiting exemplary schools and observing exemplary science

*teachers, and field experience of natural heritages unique in Georgia.
(Postprogram interview with Lee)*

Considering that overseas professional development programs are costly and have time constraints, Lee's suggestion provides significant insight into ways to improve the efficiency of a future program. One possible way is that of using on-line lectures whereby teachers can master basic concepts and theories in their country before participating in an overseas professional development program. That will help save time for practical experiences.

Follow-Up Study

To understand how the teachers' perceptual changes are being reflected in their actual science teaching after returning to Korea, we conducted follow-up interviews with the four teachers who participated in the pre- and postprogram interviews. The follow-up interviews were conducted via e-mail on two occasions: 1 month and 3 months after the program. The follow-up interview protocol (see Appendix B) was developed to explicate the following three research questions: (a) In what ways do Korean teachers' experiences during the program influence their practice in a science classroom? (b) how do their students respond to the changes (if any) in their science teaching? and (c) what are the barriers for teachers to conduct creativity-centered instruction within a school science context in Korea?

As a result, we found that the perceptual changes identified in this study have been highly related to the participants' report of their teaching practices. The teachers commonly described that the most salient change related to their increased attempts to implement various student-centered teaching approaches, such as inquiry-based laboratories, effective questioning periods, and more discussions than before. Lee's statement 3 months after the program is a representative example:

Reflecting on my teaching after the program, I want to first say that I try to have time for a whole-classroom discussion as much as I can. I try to ask questions to elicit students' creative thinking and let them talk without judging their answers, while I try not to talk much. I also attempt to get students to engage in inquiry-based lab activities much more, though I have done inquiry-based activities before the program. Every time I plan classes, I focus on how I can help students improve their creativity, as well as how I can help them understand science concepts. That's a big change through participating in the program.

Those changes in teaching appear to be further promoted or inhibited by responses from students. A middle school teacher, Kim, stated that she was surprised with student enjoyment beyond her expectations when she implemented creativity strategies she learned from the program. She reported 3 months after the program:

Right after coming back from the U.S., I used de Bono's six thinking hats as a warm-up activity, and I was surprised by the level of students' engagement in that activity. I did not expect they would enjoy it that much. I found even some kids, who used to just sit in the class without involvement, actively participated in that activity. That worked. Thus, I plan to implement that kind of activity more often.

On the other hand, Park, a high school teacher, expressed disappointment with students' responses to his new teaching approaches, stating 1 month after the program:

I used to teach science in a teacher-centered way, but after the program, I decided to try new strategies I learned. However, students' responses frustrated me. One day, I tried a problem-solving strategy by having students brainstorm about the geological timeline, and when the class approached toward the end, one student asked me, "Are you going to do this next time? If so, how can we cover all the textbook content?" At that moment, a lot of thoughts came to my mind. The College Entrance Exam is very important to them. I am not sure whether I will continue to use this approach.

From both Kim's and Park's statements, it is obvious that feedback from students is a key factor in influencing the change of teaching (Bell & Pearson, 1992). Furthermore, it is evident that covering the mandatory curriculum and preparing students to be successful on the high-stakes examination are major concerns for the teachers, which ultimately restrict their implementation of the new teaching approach. Therefore, special efforts should follow the program to help the teachers implement what they learned and overcome the restraints they encounter in school settings.

In short, the follow-up interviews revealed that what the participating teachers learned from the program was reflected in their actual teaching in various ways. However, we recognize that there are possible inconsistencies between what the teachers report and what they do in their lessons. We acknowledge the significance of examining beliefs in the context of action, that is, beliefs not only as they are professed, but also as they are enacted in practice (Luft, 1999; Simmons, et al., 1999). Thus, we recognize the fact that not observing participants' actual teaching practices in Korea serves as a limitation of this study.

Implications

Based on our findings, we suggest several implications for future professional development programs. First, we identified four major changes in the participating teachers' perceptions of creativity and science teaching. We have argued that those perceptual changes seem to be very positive in that they seem to motivate the teachers to employ creativity-centered science teaching in their classrooms. Freeman (1991)

argued that an important aspect of teachers' professional development is the process of making implicit belief systems explicit and, thereby, developing a language for talking and thinking about their own practice, questioning sometimes contradictory beliefs underpinning their practice, and taking greater control over their own professional growth. There is a growing awareness that, for educational reform efforts to succeed, the teachers' beliefs, intentions, and attitudes need to be taken into account (Haney, Czerniak, & Lumpe, 1996), because those components of teacher cognition show a strong correlation to teachers' classroom practices (Richardson, 1996). In this regard, the conceptual changes identified from this study can serve as goals of future professional development programs for creativity-centered science teaching. This proposition is supported by several studies that showed that teachers participating in professional development programs that focused on a particular teaching method accepted the new practice only if their beliefs do not contradict the underlying assumptions of the new method (Feldman, 2002; Mitchener & Anderson, 1989; Rich, 1990).

Second, before designing a professional development program, needs and prior knowledge of participants should be assessed and the results should be reflected in the program. Third, sustained time and support for reflection should be systematically developed and included in a professional development program. Fourth, to facilitate sharing of concerns and ideas and encourage discussion among participants, professional development programs need to be designed for groups of teachers from the same school, department, or grade level. Fifth, since discussions with other teachers play a significant role in developing teachers' knowledge and skills, strategies for encouraging continuing professional communications among teachers should be employed. Sixth, professional programs should provide more opportunities to link the skills and ideas introduced during the program to the teaching context in which the teachers actually work. Last, and most important, overseas professional development programs need to provide participants with unique skills that they cannot experience in their own country.

By and large, the UGA program was very effective in bringing positive changes in the participating teachers' perceptions of creativity and science teaching. According to Torrance (1981), teachers who make a difference are those who enable their students to hold on to their creativity. From the follow-up study, we found the teachers' perceptual changes might make a difference in their instructional practice. We envision that this difference may further influence students' science learning. However, we should be aware that substantial educational change is generally a result of systemic, rather than isolated, individual efforts. That is, it is not a result of any one action for improving education, such as inservice education only. A professional development program by itself may have a dramatic effect on educational improvement as an essential ingredient in larger systemic efforts. Nonetheless, other ingredients of systemic efforts, such as development of innovative curriculum and support structures while implementing the curriculum in the classroom, should also be underscored in a relation to each other, and every ingredient should work concurrently to address the larger systemic efforts.

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Appendix A: Pre- and Postprogram Questionnaires and Interview Protocol

- I. Teacher Information
 1. Name
 2. Teaching level
 3. Teaching subject
- II. The Nature of Creativity
 1. In your mind, what is creativity?
 2. What do you think the relationship between creativity and intelligence is?
 3. What do you think the characteristics of creative students are?
 4. Can creativity itself be taught without subject matters? Or can creativity be developed through teaching a subject by using particular instructional methods/strategies? Please explain your answer.

- III. Creativity and Science Education
 - 1. Do you think that science education has much wider scope to foster and encourage creativity than other subject areas? If so, in what ways, do you think science is a more suitable subject to foster and encourage creativity than other subject areas?
 - IV. How to teach science for fostering creativity
 - 1. Could you give examples of strategies, methodology, etc. to teach science fostering creativity?
 - 2. To encourage students' creativity in science classroom, what is required for teachers? (Characteristics, attitudes, knowledge, methodology, etc.)
 - V. (Postprogram questionnaire and Postprogram interview only) Factors Which Either Promote or Hinder the Teachers' Perceptual Changes in the Nature of Creativity and Teaching Science to Foster Creativity
 - 1. To what extent and in what way have your perception of creativity been influenced by: (a) lectures, (b) school visits and classroom observations, (c) your experiences (doing, activity?) during workshops, (d) discussions with professors and colleagues, and (e) other factors?
 - 2. To what extent and in what way have your perception of teaching science with creativity been influenced by: (a) lectures, (b) school visits and classroom observations, (c) your experiences (doing, activity?) during workshops, (d) discussions with professors and colleagues, and (e) other factors?
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Appendix B: Follow-Up Interview Protocol

- 1. Can you give a specific example of how you have changed your science teaching as a result of experiences during the inservice training program?
 - a. What did you do in a science classroom before you engaged in this program? What are you doing in a science classroom after engaging in this program?
 - b. Can you describe how strategies you implemented are intended to encourage creativity among students as compared to strategies not specifically aimed to creativity?
 - 2. Can you tell me about your students responses when you enact science teaching to encourage students' creativity?
 - a. What is the new response that your students did not show before?
 - b. What is the new action that your students did not display before?
 - 3. What are challenges you have encountered trying to implement science teaching centered on creativity within school science context?
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