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Changes in Teachers' Beliefs of Science Teaching and Learning Through Inservice Program Experiences Focusing on Student-Centeredness

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학생중심성에 초점을 맞춘 교사 연수프로그램을 통한 과학교사들의 과학수업과 학습에 대한 신념 변화 연구

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요 약: 교사들이 과학 교수학습에 대한 새로운 신념을 형성하려면, 학생들에게 제공할 것과 유사한 교수학습 방법을 직접 체험할 필요가 있다. 지구과학 교사 20명을 포함한71명의 한국 중등 과학교사들이 미국 중부 아이오와 대학교에서 실시된4주간의 여름 연수 프로그램에 참가하였고, 학생중심 수업에 대한 여러 가지 수업 및 활동을 경험하였다. 아울러 교사들은 각자 학생 역할과 교사 역할을 맡아서 모의 수업을 진행함으로써 학생중심 수업을 실제로 체험하기도 하였다. 본 연구는 교사들에게 제공된 이러한 교사 재교육프로그램에서의 경험이 교사들의 과학 교수 학습에 대한 신념에 어떤 영향을 미쳤는지를 조사하였다. 연구대상이 된 신념은 구체적으로 과학학습의 목적, 교사와 학생의 역할 그리고 수업에 대한 것으로 총 7문항으로 제시되었다. 즉 교사들의 교사중심적인 교수, 학습에 대한 신념의 양상이 학생중심으로 옮겨갔다는 점이다. 물론 그 변화가 교사중심에서 완벽하게 학생중심으로 옮겨간 것을 의미하는 것이 라기보다 교사중심에서 탈피하거나 이에 반하는 쪽으로 변화했다는 것에 의의가 있다. 한편, 연수에서 경험한 협동학습이 참여 교사들의 긍정적인 방향으로의 신념변화를 초래한 주요 요인들 중의 하나였음을 보고한다.

주요어: 교사 협동학습, 교사 연수, 학생중심성

Abstract: For teachers to develop new beliefs regarding science teaching and learning, they must undergo a process similar to what they are trying to provide their students. Seventy-one Korean secondary school teachers including 20 earth science teachers have participated in such process. In the four-week long summer workshop hosted by University of Iowa, science teachers were exposed to several activities and lectures wherein they experienced student-centered lessons by playing the roles of both teachers and learners. This study examined the influence of such experience on the teachers' beliefs about science teaching and learning. Changes in teachers' beliefs were found in seven question items on the subjects of goals of science learning, the roles of science teachers and students, and classroom practices after workshop participation; it was found that teachers' beliefs of science learning and teaching shifted from teacher-centered to student-centered. Although this shift does not denote a complete shift from one extreme to the other, it is meaningful to note that teachers' beliefs after attending the workshop were interpreted to be either anti- or contrary to teacher-centered. One of the possible factors for making such positive changes may have been teamwork or the teachers' cooperative learning experience.

Keywords: teacher cooperative learning, inservice program, student-centeredness

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Introduction

It has been well documented that teachers' beliefs about teaching and learning play an important role in how they teach in classrooms. The Fisher-Mueller and Zeidler's (2002) study revealed that science teacher beliefs regarding contemporary goals of science education are embedded in their routine classroom practices. Aguirre and Speer (2000) also reported that teachers' beliefs about the nature of teaching, learning, and mathematics influenced their practices. Especially, the teachers' beliefs became manifest when there was a particular goal shift during their classroom practices. Sometimes teachers' beliefs are considered an obstacle to educational reform. This is because they not only lead to implementation of an inappropriate curriculum but also result in resistance to acceptance of the underlying philosophy of the reform movement (Battista, 1994; Cronin-Jones, 1991). It was obvious in Cronin-Jones' study that when the teacher's beliefs concerning curriculum implementation were not congruent with the intention of the curriculum, it hampered successful implementation.

Considering such dynamic connections between teacher beliefs and classroom practices, it is widely agreed that teacher beliefs about teaching and learning should be taken into consideration if classroom improvement is to occur in education reform efforts (Battista, 1994; McRobbie and Tobin, 1995; NRC, 1996; Prawat, 1992). Prawat attributed teachers being an obstacle in achieving constructivist classrooms to inconsistency between what constructivist reformers advocate and what teachers believe. According to him, this problem can be overcome if teachers are willing to rethink their views and attend to change in their own beliefs. The U.S. National Science Education Standards state this position, too, saying "Teachers can be effective guides for students learning science only if they have the opportunity to examine their own beliefs, as well as to develop an understanding of the tenets on which the Standards are based" (NRC, 1996).

The development of teacher beliefs about teaching and learning can be enhanced by a carefully designed teacher education program (Hanrahan and Tate, 2001; Watts, 1998). Unfortunately, however, traditional ways of training teachers, which consist mainly of lecture and demonstration, are inadequate to change teacher beliefs (Battista, 1994; Stofflett, 1994): that is, simply telling and showing teachers new methodologies is not sufficient to improve or change their conventional views. Therefore, for teachers to develop new beliefs of science teaching and learning, they must undergo a process which is similar to what they are trying to provide with their students.

This study explored, as one of the outcomes of the teacher workshop, the influence of teacher experiences with student-centered approaches on their beliefs about science teaching and learning.

Background

In the workshop of 2001, 71 Korean science teachers experienced a student-centered science teaching/learning approach. The workshop utilized the framework of the Iowa Chautauqua Program (ICP), which is a model of professional development and classroom reform for K-12 teachers and their students. Its success in improving both teaching and learning of science in Iowa schools has been validated by the U.S. Department of Education and approved for dissemination across the U.S. through the National Diffusion Network (Eisenhower National Clearinghouse, 1999).

Student-centered classrooms, as defined by Aaronshon (1996), are evidenced by students generating their own questions, designing their own investigations, and deciding how to present what they have learned to other students. These characteristics were emphasized throughout the workshop. The workshop programs were conducted by group based work among teacher participants. Cooperative learning was utilized as a main method of delivering the workshop programs for teachers.

In these programs, teacher participants experi-

enced a variety of teaching and learning strategies to illustrate constructivist classrooms. Also, the teachers were exposed to scientific investigations with local scientists from various fields of research. These scientists contributed to incorporating scientific methods as well as science content into science instructional modules. Brief description of scaffolding of the workshop programs is given as following:

Lectures and Hands-On Experiences on Current Science Education Reform Efforts Towards Student-Centeredness: During lectures and demonstration driven by representative presenters from each project team, teacher participants had chances to understand the SS and C (Scope, Sequence, and Coordination) Project, Project 2061, and STS initiatives that characterize reforms in U.S. and the 2000+ reforms embraced and encouraged by UNESCO. Also interdisciplinary science was introduced during these programs. Most reforms are moving science toward greater integration and coordination with technology, mathematics, and in the case of Project 2061, the social sciences. Teachers were introduced to various student activities useful in the classrooms as well as the outline and history of each project. In these sessions, teachers and the leaders discussed the practical problems related to executing the ideas and activities in their own classrooms.

In addition, the leaders of several science education reform projects including EarthComm, ChemCom, and Active Physics were studied for two days to provide firsthand experiences concerning these reforms with the teacher participants.

Working Experiences with Practicing Scientists and Lead Exemplary Teachers: Teachers also worked with research scientists for three to four days to update science content and science materials for science classes of their own. The scientists involved with this program were research scientists with an interest in science teaching. This session was designed to relate to the teaching modules that the teachers developed as a major product of the workshop. The experiences with scientists were incorporated into the teaching modules for use. Further the work in the science laboratories were used to promote teacher understanding of the constructivist learning model where teacher depicted themselves as learners with being exposed in student-centered learning environment.

Another aspect of the workshop was experience in science classrooms and school system making efforts toward student-centeredness. Several lead teachers in this area invited teacher participants and let them observe and experience indirectly how such reforms are working. Teacher participants also met parents, school principals, and in some case, students doing exemplary activities.

Developing Teachers' Own Teaching Modules Focusing on Student-Centeredness and Micro-Teaching: Substantial time was also allocated to work on revising current teaching modules with active science education professors. The program title was 'Changing traditional laboratory activities'. Teachers worked on this for three days. In the first session for each disciplinary group, teachers experienced and investigated sample laboratory activities providing prospects of what constructivist teaching activities should look like. Every group of four or five teachers selected two sample activities in current national curriculum. As the professor of this session worked with each group including critiques and discussion, teacher groups modified the two activities into ones which would help improve student learning. Those two activities were also used as part of the modules that they developed for use with their students.

At the end of the workshop, the teachers were asked to do 'micro-teaching'. 'Micro-teaching' is a simulated classroom environment in which teacher participants practice what they have learned by taking turns for acting as teachers and as students. In other words, micro-teaching experiences provided the

teachers with a vital opportunity to practice student-centered approaches. Micro-teaching where all participants engaged in teaching activities in order to practice what they had learned about constructivist teaching throughout the workshops programs. Each taught a group of four other teachers who took the roles of students. In this role play, a teacher tried what they had experienced with respect to constructivist teaching strategies during the workshop. For the twenty to thirty minutes of micro-teaching teachers chose a activity or one class period out of their module which they had developed to try the new approach to teaching.

Methodology

This study focused on identifying changes in beliefs held by Korean secondary science teachers who participated in the Iowa summer workshop, 2001: subject teachers were 20 earth science teachers, 20 physics teachers and 31 chemistry teachers. A questionnaire was developed by selecting items from the Teachers Pedagogical Philosophy Interview (TPPI) (Richardson and Simmons, 1997). This instrument was origianally developed for use in the pre-service teacher program. The open-ended questions in TPPI were administered in a written form rather than as a verbal interview for written responses are potentially more thought out than are verbal response (Craven,1997).

The selected items were all concerned with teachers' beliefs regarding science teaching and learning (refer to Table 1). The same set of six open-ended questions was asked before and after the workshop (i.e., pre- and post-test) and provided the basis for comparisons.

Internal validity and reliability of the TPPI was reported via qualitative methods by the authors (Richardson and Simmons, 1994). Questions from the instrument have been in numerous studies (Waggett, 1999: Craven, 1997; Salish I Research Project, 1997).

The teacher responses were graded based on the scoring guide which was created by Craven (1997) and expanded by Waggett (1999): grade 1 indicates a 'teacher-centered' belief while 5 corresponds to a 'student-centered' belief. A score of 2 is interpreted as a 'transitional' belief, which means that the statement mostly includes teacher-oriented viewpoints with some student-centered ideas. A score of 3 indicates the 'conceptual' belief, meaning a mixture of teacher- and student-centered ideas. A score of 4 refers to the 'early constructivist' belief which means the inclusion of mostly student-centered views. Mean scores for the pre- and post-tests were compared for each item by using the repeated T-test method.

Table 1. List of the Items in the Questionnaire on Teacher Belief about Science Teaching and Learning

Q1. What are the goals of learning science for students?
Q2. Describe the roles of science teacher.
Q3. Describe the roles of students.
Q4. When do you think your students learn science best?
Q5. How do you know whether your students understand?
Q6. How do you decide what to teach and what not to teach?

Results

The results of the study presented in Table 2 are as follows:

From the mean scores and statistical values provided in Table 2, it can be said that the Korean teachers' beliefs about science teaching and learning began to move from teacher-centered to student-centered ones because of the workshop experiences.

The fact that the most of post-test mean scores are getting closer to 3 implies that the teachers' beliefs were still limited to a conceptual understanding of student-centeredness. For the better understanding teachers' response, a template or a scoring guide was developed as Table 3. This scoring guide dedicated to each question item was developed with employing teachers' responses for this investigation. Previous researches done by Waggett (1999) and Craven (1997) provided the prototypes for the present template developed for this research. Therefore there

Table 2. The comparison of teacher beliefs about science teaching and learning before and after their attending workshop programs

Question	Post Mean-Pre Mean (Difference)		N	Std.Error Mean	t (p value)
Q1	2.96-2.35	(0.61)*	69	0.17	13.57(0.001)
Q2	2.04-1.72	(0.32)	69	0.1611.99 (0.051)	
Q3	2.97-2.20	(0.77)*	66	0.168	4.59 (0.000)
Q4	2.97-2.61	(0.36)*	61	0.124	2.91 (0.005)
Q5	2.50-1.47	(1.03)*	64	0.120	8.60 (0.000)
Q6	2.21-1.38	(0.83)*	63	0.154	5.34 (0.000)

Note: * indicates significance at $p<0.01$ level.

Table 3. A Template of teacher response on goals of science learning

Item	1: Teacher-Cetered	2: Transitional	3: Conceptual	4: Early Constructivist	5: Student-Centered
Goals of Learning and Teaching	Acquisition of content knowledge and process skills	Creative logical thinking skills (Teacher centered values as student outcomes)	Intellectual problem solving/ Content knowledge applications to real life Appreciation of nature	Personal learning (self-esteem)/Future preparation/ Understand how scientists work in scientific community	Social learning (Citizens interpersonal skills)
Teacher Role	Deliver information concern with control and discipline/ Explain concepts/ Help students acquisition of knowledge	Present problems and help them solve/ Concern about student motivation, attitude, interest and thinking skills	Actual model of learner/ Guide student learning/ Nurture student learning skills and autonomous learning	Plan teaching based on students' interest and relevancy/ Help students solve their own problems	Student-centered / Help students reach their own learning goals
Student Role	A good listener/ Passively involved in class	Involve in class less actively/Appear much/ Presenting what students know or don't know/ Answer properly to teacher question	A hard worker who wants to learn, ask questions/ Involve in class moderately/ Reasonable interaction with teachers	Students takes responsible on their own in moderate level / Share control of classroom environment with teachers moderately	A reflective person who is willing to take risks/ Curious, creative, internally motivated learner/ Actively involved in class and in planning teaching
Student learn science best?	Listening and Repetition	Reading, verifying, memorizing/ Demonstration/ Teacher guided experiment	Apply/ Being interested/ Thinking / Experiment and Hands on Activity	Make connections questions/ Through teacher-student interaction and group work	Social interaction/ All students learn differently based on their own needs and experiences
How to know student understanding	By students' appearance, test,/ Inferences from teacher recall and paraphrasing/ Written test	By verbal interactions/ When tested through verbal conversation	Questions/ Make connections	When students can apply/ demonstrate knowledge and share it with others	By multiple ways/ When student can create something
Decide what to teach	Mandated curriculum	Teacher interest and importance	Mainly Teacher interest and importance. Also a little consideration of student relevancy	Teachers' perception on student interest and relevancy	Student team decision making process/ Conceptual approaches

were so much common among them in terms of expression and structures and there should be.

Goals of Science Learning: At the beginning of the workshop, the most frequent response to ques-

Table 4. Two most frequent responses for pre- and post- tests regarding student learning goals

	Grade	1: teacher-centered	3: conceptual
Pre-Test	Representative Responses	-Acquisition of contents knowledge, information and process skills -Application of knowledge into new contexts of problems	-Application of knowledge into students' daily lives
	Response Rates	34%	21%
	Grade	3: conceptual	2:transitional
Post-Test	Representative Responses	-Understanding Knowledge and its application into students' daily lives -Using knowledge to solve their own problem	-Better attitude toward science classes and well established motivation of learning -Logical, creative and rational thinking skills
	Response Rates	30%	22%

tion 1 ("What are the goals of learning science for students?") was acquisition of content knowledge, information, and facts: 34% of the teachers stated these terms, which was scored as teacher-centered. The second most frequent answer (21%) was 'application of knowledge to the real lives of students', which was scored as 3 which can be interpreted to be transition stage from teacher-centered to student-centered (see Table 4). The average score in the pre-test was 2.35, which was interpreted as indicating that the teachers were in the transitional stage concerning the goals of science learning. There was no significant difference among groups of teachers; groups are earth science, physics, and chemistry teachers.

After the workshop, however, 30% of the teachers responded that the goals of science learning included 'student using knowledge to solve their own problems' and 'understanding science content in a social context'. For instance, a teacher stated in the pre-test that students learn to solve problems in exam situations. His response to the same item was changed at the end of the workshop to "students need to use scientific knowledge to solve problem in their own out-of-school contexts". Such a change was also evident when the mean scores of the teachers were compared.

The roles of science teacher and students: In the pre-test, 49% of the teachers viewed their role as that of a director of the class activities or a dispenser of information. After the workshop, 41% of the teachers indicated that they continued to feel the same way while 29% of the teachers believed that teachers should help students learn science well by providing opportunities for them to apply scientific concepts. However, no statistically significant difference was found between pre- and post-test. In previous researches, it was found that it was hard for teachers to share 'classroom control' with their students even after utilizing teaching modules based on constructivist learning model (*Shin, 2000*).

Concerning student roles in science learning, there was a positive shift in the teachers' beliefs. In the pre-test, one-third (34%) of the teachers responded that students should be good listeners. This was believed to be the way they could acquire scientific knowledge. In the post-test, however, the most frequent answer (42%) to the same question was that students should be allowed to construct their own understanding as active learners (25%) and to taste what scientists do their researches as working to solve students' own problems (17%).

It is interesting to note that two results seemed not coherent. At the first glance, teacher and student role should be revealed the same way. Teachers might more easily change the picture of classes in terms of student actions than of their own actions. Rather teachers might feel some difficulty in losing full range of control over their students in any rate. Most of all, it is due to lack of their experiences in their own classroom yet.

Classroom Practices: The last three question

Table 5. Two most frequent responses for pre- and post- tests regarding teacher and student roles

Teacher Role	Grade	1:Teacher-Centered	2:Transitional
Pre-Test	Representative Responses	-Helper or guide for student learning (more director and dispenser)	-Present problems and help student solve
	Response Rates	49%	14%
	Grade	1: Teacher-Centered	3:Conceptual
Post-Test	Representative Responses	-Helper or guide for student learning (more director and dispenser)	-Helper or inquiry guide
	Response Rates	41%	29%
Student Role	Grade	1:teacher-centered	3:Conceptual
Pre-Test	Representative Responses	-Memorize content knowledge -Good listener and follower of teacher	-Solve students problems for themselves (problems given in textbooks)
	Response Rates	34%	14%
	Grade	3: conceptual	4:Early Constructivist
Post-Test	Representative Responses	-Active learner and hard worker	-Learning knowledge and use them to solve their own problems
	Response Rates	25%	17%

items more closely tied themselves together for all of them were with regard to classroom practice. The first item of "When do you think your students learn science best?" was especially pertaining to teacher perception on how students worked in classes. To this item, 70% of the teachers in the pre-test responded that it happened when they used a variety of instructional methods and strategies, including hands-on experiments. In post-test, 64% of them indicated a similar response. There was no significant difference between pre- and post-test. Before learning about student-centered classroom, teachers presumed that people learn best when they need the knowledge for their use. In other words, it is when the motivation of learning is high enough for students to eager to learn. These responses will be based on their own learning experiences in the context of their daily lives.

However such results seemed to be not in the same wavelength with their responses to other question items. It implicated that teachers had not firmed ideas about science learning and teaching. For instance, in pre-test, teacher stated that one of the teacher's roles is dispensing and directing classes. It is not difficult to accept that notion of dispensing knowledge is an opposite position of caring and creating student learning motivation. It was found that such idea of caring students' needs and interest was getting coherent with other dimensions of science learning and teaching after the workshop.

The next two of "ow do you know whether your students understand?" and "How do you decide what to teach and what not to teach?" focused on teacher-action. Respectively the former is related to teacher assessment of student learning and the latter to teachers' own decision making of what and how to teach.

In contrast, there were statistically significant changes in the teachers' responses to items 5 and 6. Regarding the method for assessing science learning (item 5), 52% of the teachers provided teacher-oriented responses in the pre-test, saying that they usually used some kinds of written tests focusing on science content (See Table 6). The 'conceptual' belief -a mixture of teacher- and student-centered ideas was found in the post-test, where 36% of the teachers stated that multiple ways of assessment should be used with a focus on student performances and problem solving abilities in various contexts.

The same trend was found regarding the last question item. In the pre-test, the most frequent answer to the question (48%) was that the teacher decisions were typically based upon the mandated

Table 6. Two most frequent responses for pre- and post- tests regarding classroom practices

Know whether students understand	Grade	1: Teacher-Centered	1: Teacher-Centered
Pre-Test	Representative Responses	When evaluated with written tests focusing on recalling facts types of questions	Appearance of student
	Response Rates	52%	14%
	Grade	3:Conceptual	2:Transitional
Post-Test	Representative Responses	-Multiple way of assessments/ Assessment focus toward student performances and making connections -Problems solving in various contexts of tests	-Conversation with students/ Report and tests
	Response Rates	36%	33%
Decide what to teach	Grade	2:Transitional	1: Teacher-Centered
Pre-Test	Representative Responses	-Mandated curriculum and students' interest	-Mandated curriculum and focus on the national college entrance exam
	Response Rates	48%	24%
	Grade	3:Conceptual	1:Teacher-Centered
Post-Test	Representative Responses	-Students' interest, experiences and personal relevancy	- Mandated curriculum and focus on the national college entrance exam
	Response Rates	29%	28%

curriculum. After the workshop, however, 29% of the teachers responded that when deciding what to teach, they were going to consider student interests, ideas, and experiences to find the relevancy of the instruction to the students.

Discussion and Conclusion

This study reveals that workshop experiences with student-centered approaches in a context of inservice education results in changes in teacher beliefs about teaching and learning. According to Kowalski (1984), the most potent motivator in adult learning is an internal pressure, not an external influence such as good grade. Teacher beliefs can be used as an internal pressure to motivate the teacher to make an effort to improve his or her classroom practices. In this sense, the results of this study are positive. We observed the meaningful shifting of teachers' beliefs from teacher-centered to student-centered.

What have made them think differently during the workshop? First of all, the workshop provided them doing by themselves instead of telling them what to do. A typical type of programs for inservice teachers was lectures. However this workshop tried not to let teachers sit on chairs in a lecture-room. They went out to visit lead teachers in terms of executing 'student-centered classroom' and observed how it worked in the Iowa lead teachers' classrooms. Next, lectures were proceeded with lots of discussions focusing on whether participant teachers' own classes, as reflected by themselves, were defined as 'teacher-centered classes'. If so, the discussion topics continued to move onto whether it could be a problem. After those lectures and discussions, teachers started their project of developing their own teaching modules with an emphasis on moving toward "student-centered". These works were done in groups of three or four teachers. For developing their own modules, teachers again met with Iowa lead teachers who experienced the former workshop programs as well as adopted 'student-centered classes'.

Positive changes in teacher belief could be explained by a component of the workshop program called 'Micro-Teaching'. Teachers practiced

their new teaching methods with a unit out of their own developed teaching modules. They tried 'wait-time', 'eye-contact', and 'how to provoke students' learning motivation and enhance students' participation both in body and mind'.

Lastly cooperative learning experiences during the workshop could work even in teacher education or adult education. Recently effects of cooperative learning have been investigated in the field of student learning researches (Hewson et al, 1998; Lumpe and Staver, 1995; Housel et al, 1995; Bykerk-Kauffman, 1995). Most activities and works including Micro-Teaching and module-developing provided by the workshop in this study were typical group-based works. In later researches and planning teacher workshop programs, teacher cooperative learning experiences should be considered.

All apparently positive changes in six items on teachers' beliefs after teachers' participating the workshops, however, were not supported statistically. In roles of teacher and student, only student role was viewed differently without any statistically significant changes in teacher role. Meanwhile, teachers beliefs on teacher action were changed even though ones on student action remained the same as before the workshop. Likewise, such delicate differentiation among items would be another topic of further researches.

Reporting results of the present study with drastic changes of teachers' believes should not be misread as it indicated that the change of teacher beliefs would be a precursor of better practice. Rather, further investigations and follow-up studies are needed to see how their classroom will be changed to improve students' learning as well as tracking changes regarding teacher beliefs in the longer term.

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