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Teachers' Research Experiences in Labs and Fields

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Abstract: This study intended to find evidence of changes in teacher beliefs of teaching and learning and a case of infusing research experiences in teaching modules since their research participation. As part of this study, twenty three science and math teachers in Korea were provided with science research labs and field experiences in the University of Iowa for three weeks. The research units that teachers participated in for three weeks covered seven fields of subjects such as: geology, astronomy, chemistry, physics, mathematics, computer science, and environmental engineering. In the course of this study, the effectiveness of science research participation program was explored in terms of changing teacher beliefs and their production of teaching modules based on their research. This study especially focused on identifying changes of beliefs on science teaching and learning after participating in the research. A case study of a participant teacher was also conducted by comparing descriptively teaching modules before and after experiencing the program. It was found that the program affected the new modules and the research experiences affected participants' beliefs toward student centeredness.

Keywords: teacher research experiences, teacher beliefs, professional development

Introduction

The first "problem" in teacher education is that so few science teachers have any conception of what science is as a human enterprise; nor have they had any direct experience with it. Few understand the difference between science and technology and how they influence the lives of all humans. Instead most are content to define it as the information in textbooks - in many places like Korea - in the books given to them to use in their classes with no indication of all the processes used that represent the "features" of science. The real problem would be the lack of understanding, interest in, and experience with the nature, history, and sociology of science among all K-12 science teachers. Posner (1992) said that the one indispensable part of any teacher preparation program is field experience. It is during the field experience that the integration of theory into practice becomes evident to the teachers.

In summer of 2005, the University of Iowa organized and coordinated a workshop for Korean teachers from science and mathematics schools. It was designed to deal with this missing ingredient. It was supported by Korea Science and Engineering Foundation (KOSEF) and proved most interesting. It was evaluated largely by likes/dislikes of teacher participants with limited evidence of actual impact on teacher thinking or their practices that could be collected during the following academic year. The workshop focused on the following suggestion. Science might consist of several specific essential components that should be central to science teaching, namely: 1) asking questions about the objects and events in nature; 2) offering possible answers for them; 3) seeking evidence to determine the validity of the personally offered explanations; 4) presenting the evidence (experiments, logic, observations) which support the explanations; 5) communicating the results and ideas to the established academy of scientists. These science efforts are rarely found in science classrooms or made central to science education.

When we want to get students learn, we should let students experience. In the same way we want teachers to experience the essence of science with aims of better understanding of science essence. If teachers have better understanding of what science

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and mathematics are as human activities, teachers are likely to become better science and math teachers. The Research Participation program was held at the University and administered by staff from the Science Education Center for three weeks. The twenty-three teachers from science magnet high schools had participated in research programs to understand what researches on science and mathematics are. This program provided pure research participation for participant teachers. Faculty members and their research staff served as mentors, providing the guidance and background needed for them to become active members of a research team. Each participant was assigned responsibility for part of an ongoing project in a mentor's laboratory. Although the content of projects may vary, all projects were designed to be carried out within the duration of the program and to provide participants with a real-world research experience. This new idea and form of science teacher education is based on the idea of “doing science”. The research questions of this study were how teachers’ beliefs change over the research participation and what changes teachers make in their teaching modules based on their research experiences.

Research Context

Goals for the program were developed and helped staff as well as the 23 teachers to evaluate the Research Participation Program:

Experiences in Professional Research Activity

a. to experience how new knowledge is produced in science/mathematics fields and the processes used

b. to experience large scale research projects funded externally (to see collaborative research involving large numbers of diverse researchers)

c. to experience long-range reform in science education as envisioned by Project 2061 of the American Association for the Advancement of Science

Views of Science/Math

d. to meet and learn from major research scientists who are prolific contributors to new knowledge

e. to characterize the actual research occurring in the various research centers

f. to compare and contrast research in a wide spectrum of science/mathematics disciplines

Transfer of Experiences and Views into Practice

g. to maintain a record of experiences and reflections that could result in new approaches/contexts for learning science and mathematics

h. to encourage teachers to conduct Action Research as a way of testing their own ideas about effective teaching, especially appropriate for future scientists and mathematicians

i. to broaden the aims of teachers to include the way their students view science, especially in ways they live their daily lives and participate in community decision-making

j. to change the way teachers teach that engage all students in science/mathematics thinking and action in ways that affect everyday living; such thinking is a basic requirement for future researchers

The topics of the summer workshop is summarized in Table 1. These activities included laboratory research, fieldtrips, and cooperative small group learning.

With aims of finding differences concerning teachers’ visions on current reforms, teachers’ understanding of constructivism, teachers’ personal goals for being involved, and teachers’ specific plans for pursuing research careers, data were collected during a three-

Table 1. Seven research centers and the topics for Korean teachers research experience

Mathematics	Wavelets and how they are used?
Informatics	Educational technology and instruction :GPS and nagging algorithm
Astronomy	Astronomical observation with using CCD
Physics	Plasma physics
Chemistry	Research experiences in various fields of chemistry
Environmental science	Hydroscience and engineering
Geo-science	Various techniques of geoscience research

week program.

The distinctive features and perceptions of participant teachers were analyzed to develop an effective research participation model for science and math teachers. Each participant was required to accomplish their own education module plan or outlines when they return. Teachers had an opportunity to review teaching and learning as areas where they ask researchable questions. Soon after the summer workshop, follow-up efforts for science classroom improvement were planned for collaboration between Korean teachers and the research staff. Traditional models for in-service teacher education programs are usually based on one-shot, short-lived events in which experts instruct teachers how to teach and then leave them to fend for themselves (Little, 1993).

Research Methods

Teacher beliefs of learning and teaching

During the first day and the last day, research efforts dealing with varying perceptions and practices among the participating teachers were found through PTL (Philosophy of Teaching and Learning). This instrument was employed to provide insights into the perceptions held by the teacher participants in the way they view their research works as further use in developing their teaching modules. The followings are the questions to ask their philosophy of teaching and learning

Philosophy of Teaching and Learning (PTL)

1. What learning in your classroom do you think will be valuable for your students outside the classroom?
2. What do you do to encourage your students to pursue research in science?
3. Describe the "best" teaching or learning situation that you have experienced (either as a teacher or as a student)?
4. In what ways do you try to model this best teaching/learning situation in your classroom?
5. How does this "best teaching" help produce more and better scientists?
6. How do you believe your students learn best?
7. How do you know when your students understand a concept?
8. What concepts do you believe are the most important for your students to understand by the end of the year?

The Scale for Determining the Degree of Student-Centeredness (Fig. 1) was used to investigate the teachers' perceptions regarding their past science classroom learning environments before the workshops started. The instrument for determining degree of student-centeredness is designed to enable teachers to monitor their development of constructivist approaches to teaching science. The instrument consists of 15 statements about the classroom learning environment. It was proposed by Yager (1991) as an instrument which teachers could use to determine their own level of student-centered teaching and identify areas of needed improvement. Teachers were asked to rate how each statement applied to themselves and their teaching on the continuum: strongly student-centered (10), strongly teacher-centered (0). At the end of the workshop, we collected again the teacher perceptions regarding their future classroom learning environment using the same instrument.

Teaching Modules Reflecting Research Experiences

A case of teaching modules were introduced as well as participant teachers plans for their efforts for the use in their own classes. We describe the teaching modules: one was used before participating and the other developed after.

Results and Discussion

To establish a program effectively, teacher conceiving ideas on research and its usefulness for teaching and learning were collected before and after the three-week long Research Participation Program. The developed questionnaires and a scale on their perceptions about the research participation and the comparison of a developed teaching modules with the previously using modules, the research participation program changed teachers' beliefs of teaching and

1	Teacher	*Identifies the Issue/Topic*	Student
2	No	*Issue is seen as relevant by students*	Yes
3	Teacher	*Asks the questions*	Student
4	Teacher	*Identifies written and human resources needed for information*	Student
5	Teacher	*Locates written resources for use*	Student
6	Teacher	*Contacts needed human resources*	Student
7	Teacher	*Plans investigations and other activities*	Student
8	No	*Teachers use varied evaluation techniques*	Yes
9	No	*Students use varied evaluation techniques*	Yes
10	No	*Students practice self-evaluation i.e., able to evaluate themselves*	Yes
11	No	*Science concepts are applied to new situations*	Yes
12	No	*Science skills are applied to new Situations*	Yes
13	No	*Students take actions as a result of their work*	Yes
14	No	*Science concepts and principles are sought out and used by students*	Yes
15	No	*Evidence available that shows science learning has impact out of school*	Yes

Fig. 1. Form of examining scale for determining degree of student-centeredness

learning and even affected their classrooms with incepting elements of their experiencing research.

Moving toward student-centeredness after research participation

To determine the reliability of the instrument, internal consistency was estimated using coefficient alpha will be. The values of coefficient alpha range from 0, indicating poor reliability, while value close to one suggest a reliable instrument (Green et al., 1997). This scale consists of 15 items and they were divided into odd numbers and even numbers of questions. Internal consistency was measured by comprising odd items and even number items of the scale using coefficient alpha as calculated using SAS version 6.1. The scores for each item fro the pretest results of all subjects were used for attaining internal consistency. The overall coefficient alpha was 0.839 which was high enough to insure the reliability of the instrument. Table 2 is a summary table for each sub-scale of Student-Centeredness for Korean Teachers with t-test analyses between pre and posttests. The t-score for Korean Science Teachers indicate statistical significance in all sub-scales. After teachers attended the research program, they moved toward student centered views of teaching and learning.

Teachers perceived more constructivists

The 2005 summer workshop was successful in improving the teachers' beliefs regarding science teaching and learning. Among eight questions in PTL, question 1, 7 and 8 did not show any changes in teacher responses. Table 3 presents the Korean teachers' ideas as examined by means of open-ended questionnaire surveys for the items of 'not much changed' after the workshop completed. However teachers beliefs about best teaching and that helping their students produce more and more scientists and mathematicians were clearly different whey the program was over (Table 4). The general response indicates that as a result of participating in the workshop, the teachers developed positive attitudes toward student-centered and reform-oriented classroom practices. The PTL was modified from the Teachers Pedagogical Philosophy Interview (TPPI) (Richardson and Simmons, 1994). This instrument was originally developed for use in the pre-service teacher program. The open-ended questions in PTL were administered in a written from rather as a verbal interview for written responses are potentially more thought out than are verbal response (Craven, 1997).

Internal validity and reliability of the questionnaire was reported via qualitative methods by the authors (Richardson and Simmons, 1994). Questions from the instrument have been in previous studies (Waggett, 1999; Craven, 1997). The teachers responses were sorted based on the scoring guide which was created by Craven (1997) and Waggett (1999); level 1

Table 2. The results of t-test between pretest and posttest of Korean science teachers for student-centeredness

Subscale	Mean difference (pretest)	Standard error	t-value
Identify issue	-1.65 (3.69-5.34)	0.52	-3.17*
Relevance by student	-1.13 (6.35-7.48)	0.48	-2.32*
Ask questions	-1.96 (4.74-6.70)	0.34	-5.73*
Identify resources needed for information	-1.83 (3.39-5.22)	0.60	-3.03*
Locate resources for use	-2.22 (4.00-6.22)	0.41	-5.43*
Contact needed human resources	-1.30 (4.26-5.56)	0.55	-2.36*
Plan investigation	-2.17 (4.04-6.21)	0.46	-4.72*
Varied evaluation technique -teachers	-1.09 (6.82-7.91)	0.50	-2.19*
Varied evaluation technique -students	-3.46 (3.68-7.14)	0.46	-7.60*
Students Practice Self-Evaluation	-4.30 (3.30-7.60)	0.41	-10.64*
Science concepts are applied to new situation	-2.01 (6.43-8.44)	0.53	-3.94*
Science skills are applied to new situations	-2.26 (6.30-8.56)	0.40	-5.60*
Students take actions as a result of their work	-3.91 (3.87-7.78)	0.61	-6.46*
Science concept and principles are sought out by students	-3.65 (4.22-7.87)	0.50	-7.28*
Science learning has impact out of school	-3.61 (4.57-8.18)	0.51	-7.03*

*significance at alpha = 0.05.

indicates a' teacher-centered' belief which 5 corresponds to a 'student-centered' belief. A level of 2 is interpreted as 'transitional' belief and 3 'conceptual' belief. A level of 4 refers to the early constructivist belief. Previous research done by Waggett (1999) and Craven (1997) provided the prototypes for the present template based on teachers' responses. This study escaped from scoring them and rather tried to find changes not in a statistical concern but in descriptive way.

Based on the level template, teacher responses for the items in Table 3 were rated as' level 2 or 3 which is transitional and conceptual. That means teachers have some idea on student-centeredness but not have a clear vision or agenda to utilize in their classes. In that matter, Table 4 indicated that teachers' beliefs on the best teaching and learning were dramatically changed. In most answers of pre-test, teachers responses included aspects of lectures and teacher-prepared lessons and guidelines. But in post-test, teachers used more the term, 'research' and 'student centered' in their responses. From these findings, the results from the scale was also supported by the PTL instrument results.

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 (2002) revealed that science teacher beliefs

Table 3. Examples of the Korean teachers' beliefs regarding science teaching and learning in items of not much changed

Survey questions: Examples	Teacher responses: Examples
What learning will be valuable for students outside the classrooms?	• Dealing with materials in real life. • Teaching concepts. • Students have more chances to apply their knowledge in real life problem.
How do you know when your students understand a concept?	• I am going to use a set of questions that increase in difficult spirally. • I am going to evaluate student performance of project. • I am going to use student essays, discussions and reflections, presentations, and performance assessment. • I am going to elicit questions from students and use them. • I am going to observe individual students more carefully.
What concepts are the most important for your students by the end of the year?	• Concept understanding • Better attitude • Process skills

Table 4. Most frequent responses of the Korean teachers' beliefs changes from pre-test to post-test

Survey questions	Most frequent responses of teachers
What do you do to encourage your students to pursue research in science and math?	Pre-test: -Keep telling students that science and math are very important and valuable, and encourage them to pursue in those fields. -Let students learn more concepts and have more confidence on the subjects Post-test: -Let students experience real research and its components by problem based learning
Describe the best teaching or learning that you have experiences?	Pre-test: -Well structured lecture -Solving lots of problems Post-test: -Learner centered classes where students initiated their own project and finish with presenting their results.
In what ways do you try to model this best teaching/ learning ?	Pre-test: -Various teaching methods including lectures, student discussion, hands on activity and experiments Post-test: -Student oriented research
How does the best teaching help produce more and better scientists and mathematicians?	Pre-test: -Try to make lectures fun and interesting Post-test: -Using research as a teaching materials -Self-regulated learning
How do you believe your students learn best?	Pre-test: -Higher score in tests-Better attitude Post-test: -Finding and pursuing students' own research questions

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. This study reveals that research experiences resulted in changes in teachers beliefs about teaching and learning. According to Kowalski (1984), the most potent motivator in adult learning is an internal pressure, not an external influence. 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 to student centered.

Teachers plan to use their research experiences and differentiated teaching modules

Teachers evaluated that the Research Experience Program 2005 was useful in that they obtained many ideas for the Research and Education (R&E) and the research topic which they may do with students. The ideas of teachers are summarized in Table 5.

The teachers' beliefs became manifest when there was a particular goal shift during their classroom practices. In this study we found changes in their beliefs before and after the research participation. Teachers working with research scientists and mathematicians and at their labs and fields would help them to have better perception on research and update academic content and teaching materials for classes for their own. In this way, teachers were asked to develop modules that can be implemented in their own classrooms. We selected a participant teacher (T7) and her modules in compute science for 9th graders as an example to find how the research experiences were reflected in the new modules.

The old and a new version of modules were compared by goals, student action, teacher action and content. The instrument to compare these two modules was selected from items of Secondary Teaching Analysis Matrix-(STAM) science version (Gallagher and Parker, 1995). Teacher action included methods and kinds of assessment. Student action was evaluated

Table 5. Research plans that participant teachers do with students when be back in their classrooms

Research Area	Plan
Math	The utility of mathematics using math lab
Informatics	The program development with problem solving
Astronomy	The use of robotic telescope
Physics	The development of Problem solving with plasma
Chemistry	The role of oxygen in chemical reaction
Environmental Science	The program development about environmental issue
Geology	The isolation of mineral using electro magnetic

by student initiated activity. Content was regarding structure of content and connection with real world or research.

Goals and Teacher Action

The old and new teaching modules pursued the same topic of 'understanding of C-programming language', while the old one had a goal of 'students acquire knowledge of C-programming language' and the new one was 'students can create real-life problem and find their own solution'. That is the goal has been shifted from letting them learn to let them need the knowledge.

Teaching methods was lecture and drills with exemplary test questions in the old modules but in the new one, students are exposed with real life problem. And a small group of students cooperate in define the problems, find the solution with teachers limited explanations. Finally each group proved their own hypotheses and present their final products. The assessment tool was only a written test in the old. More various tools were used in the new one such as final presentation, group report, and student reflections.

Student Action and Content

Student initiated activity was not found in the old module. In the new, each group of students needed to prepare their own way to solve the problem. Therefore it can be defined as student initiated activity. In content wise, overall contents tended to be explanatory with conceptual content organized around key ideas. The new module emphasized more investigations driven by students. Also real world examples were merely found in the old, while connections constructed by students were related to investigation, data analysis and concept building in the new.

The ultimate value of the program will be how the 23 teachers use the experience to enhance what they do with their students. This research tried to figure something out of teachers' pure research experiences which improve their teaching and students' learning including changing their beliefs of teaching and learning and modules. Further investigation are needed to see how the classrooms of 23 teachers will be changed to improve students' learning as well as tracking changes regarding their beliefs in the long term.

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