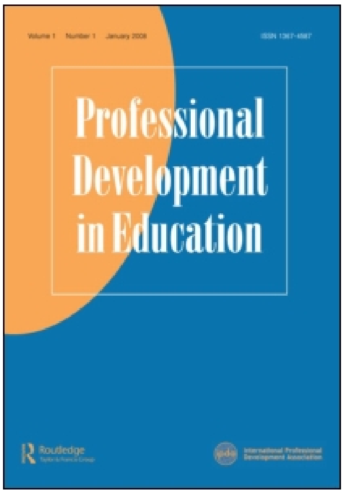

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Research experiences for teachers: influences related to expectancy and value of changes to practice in the American classroom

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Research experiences for teachers: influences related to expectancy and value of changes to practice in the American classroom

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This qualitative study examines one professional development program and how this experience affects teachers' thoughts about planning and science teaching practices specific to the elements focused on during the program. The program supports 13 American K–12 teachers, selected from across the nation, to spend six weeks with a mentor scientist in a nationally recognized science laboratory in the southeastern United States. The Research Experiences for Teachers program features are specifically designed to encourage reflective planning based on teachers' understanding of inquiry, experimental design, the nature of science, process skills and communication. Results of this study include teachers' increase in positive and accurate statements concerning implementing research-based science practices (e.g. inquiry-based learning) and one case study that demonstrates one teacher's Research Experiences for Teachers experience and changes made to her classroom practices after attending the program.

Introduction

One way to enhance teachers' effectiveness is to provide professional development opportunities and encourage teachers' attendance. Professional development, according to Guskey (1986), is an organized effort targeted towards changing teachers' behaviors with an expectation that these changes will improve teachers' instructional practices and, subsequently, students' learning. In this sense, professional development is seen as the catalyst for transforming research-based theory and findings into best teaching practices and increased student achievement. Because of the increased pressures placed on schools to have their teachers and students perform at

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high levels of 'quality' due to the No Child Left Behind Act (2001) (Public Law 107–110, 2002), professional development activities are common in all schools (Fullan, 1993; Jacob & Lefgren, 2004; Brooks, 2006).

Schools seek to implement change through professional development training that may provide teachers with new ideas and strategies. The goal for professional development programs is, generally, an enhancement of more effective teacher practices (Abdal-Haqq, 1998), but may also be a way to ensure all teachers are implementing a new strategy or practice seen as necessary to the school or district.

For professional development to be effective, teachers must be motivated to implement the learned strategies acquired during training. Unfortunately, low motivation and low implementation is common following teachers' professional development (Guskey, 2002). Therefore, for activities such as teachers implementing a professional development training that may take effort and commitment to those activities, intrinsic motivation may be necessary to ensure that those behaviors continue over time (Deci & Ryan, 2000). Research demonstrates that implementing professional development and making changes to classroom practices often takes more time than expected (Fullan, 1993; Guskey, 2002). The more a person takes responsibility and ownership of the changes, the more likely those behaviors will continue so that classroom strategies influence student achievement.

Research on designing effective professional development for teachers of science and mathematics suggests including seven main components to ensure quality (Loucks-Horsley *et al.*, 2003). The Research Experiences for Teachers (RET) program was designed with these components in mind, and by this definition is an effective vehicle for learning by K–12 teachers. The seven components of effective professional development are that it: (1) is driven by a well-defined image of effective classroom learning and teaching; (2) provides opportunities for teachers to build their content and pedagogical content knowledge and examine practice; (3) is research based and engages teachers as adult learners in the learning approaches they will use with their students; (4) provides opportunities for teachers to collaborate with colleagues and other experts to improve their practice; (5) supports teachers to serve in leadership roles; (6) links with other parts of the education system; and (7) has a design based on student learning data and is continuously evaluated and improved (Loucks-Horsley *et al.*, 2003).

In response to the professional development standards set forth by the National Research Council (1996), RET programs provide meaningful, real-world experiences that may impact science teachers' understanding of science and teaching of science (National Research Council, 1996; Kardash, 2000; Seymour *et al.*, 2002). Typically RET programs place teachers in a university or industry laboratory for six to eight weeks during the summer, allowing teachers a look into the real world of scientific research. Immersion in real-world science research is an authentic activity that uses procedural knowledge that may be passed on to students in the classroom (Driscoll, 2005). The national laboratory in which the RET program takes place operates high-field magnets that scientists use for basic research in physics, biology, bioengineering, chemistry, geochemistry and materials science. The educational center facilitates K–20 educational programs, one of which is the National Science Foundation (NSF) supported RET program. RET offers K–12 teachers the opportunity to conduct real-world science research and experience the excitement of the processes of science. Teachers have the opportunity to learn the language of science and reach a sophisticated understanding of how scientists do their work. Teachers are considered scientists and are fully embedded in the culture of the science laboratory.

This qualitative study examines one professional development program and how this experience affects teachers' thoughts about planning and science teaching practices specific to the elements focused on during the program (Loucks-Horsley *et al.*, 2003). The program supports 13 American K–12 teachers, selected from across the nation, to spend six weeks with a mentor scientist in a nationally recognized science laboratory in the southeastern United States. The RET program features are specifically designed to encourage reflective planning based on teachers' understanding of inquiry, experimental design, the nature of science, process skills and communication.

Results from a previous study (Dixon & Wilke, 2007) lead to several research questions that we explore in the present study. Specific research questions addressed in this study are: How does an RET program affect teachers' expectations and values about science instruction? How does an RET program influence teachers' practice as it relates to inquiry, experimental design, nature of science, process skills and communication?

Theoretical framework

Expectancy-value theory is based on the notion that a person's motivation to perform a behavior is the product of expectations about his or her own ability to perform the task (i.e. meet a goal) and the value of that goal to the person (Eccles *et al.*, 1982). Expectancy-value suggests that the product of these two forces equals the individual's motivation to achieve that goal. If one or the other force was zero, then the motivation to achieve that goal would also be zero. For example, if a teacher had high expectations concerning her ability to implement changes to her classroom practices based on a professional development training, but did not value those changes or strategies, her motivation to implement the strategies would be zero, despite the fact that she had the expectation to perform the goal. Wigfield and Eccles (2000) researched the concept further to explain that a person's choice of tasks or goals, persistence on those tasks and performance on those tasks can be explained by determining the individual's expectancy and value concerning the task or goal. Other theorists in this area (Atkinson, 1964; Eccles *et al.*, 1982) 'argue that individuals' choice, persistence, and performance can be explained by their beliefs about how well they will do on the activity and the extent to which they value the activity' (Wigfield & Eccles, 2000, p. 68).

Teachers participating in the RET program choose to apply. This choice may be linked to the teachers' intrinsic motivation to learn and acquire new science teaching skills (Deci & Ryan, 1985), to wanting to attend a program in a new area of the country or to earning a stipend. What teachers believe about their abilities and teaching practices may also influence their expectancies of making change (West & Anderson, 1976).

The RET program provides many opportunities for participating teachers to experience life in a research laboratory as modeled by their mentor scientists. Teachers are left open to develop their own beliefs about the aspects of real-world science that may be important to incorporate into their own classrooms. Although formal and informal discussions helped the teachers sift through their experiences, each teacher constructed his or her belief about what is necessary for an effective science classroom.

Program features

This RET program focused on five elements of quality science teaching: inquiry, nature of science, experimental design, process skills and communication. These five elements were chosen based on past research of the RET program (Dixon & Wilke, 2007) and are considered key aspects of effective science teaching set forth by the National Science Educational Standards (National Research Council, 1996). All five elements of the RET program were researched and commonly defined by both researchers involved in the data collection and analysis. These five elements were used as the basis for a weekly colloquium discussion led by a staff member. At the end of each week, an expert was called upon to discuss the topic with participants from a research perspective. Participants were left to extract the elements and relate them to their own students, school and curriculum so the RET experience was as valuable to each participant as possible. Working definitions for each element based on science literature and the National Science Education Standards are as follows.

- *Inquiry*: a set of processes that scientists use to ask questions about the natural world. Students can pose such questions as well and then find ways to investigate the phenomena they are curious about, interested in or motivated to study. Inquiry-based activities are ones in which students develop a deep understanding of science concepts by making sense of it in their own way. Inquiry activities that are developed by teachers lead students through the process by allowing them to discover how science relates to other subjects and to students' own lives.
- *Nature of science*: the meaning of science, assumptions, values, conceptual inventions, method, consensus-making and the characteristics of knowledge produced—and, considering this, how students and teachers think about science and scientists. Understanding the nature of science indicates a view of the world as understandable, that ideas about the world are subject to change and that the study of science is an intellectual and social endeavor (Project 2061) done by men and women.
- *Experimental design*: a set of actions and observations, performed in the context of solving a particular problem or question, to support or falsify a hypothesis or research concerning phenomena. The experiment is a cornerstone in the empirical approach to acquiring deeper knowledge about the physical world. Measurements are made objectively and all conditions can be kept controlled across experimental trials.
- *Process skills*: measuring, observing, classifying, recording information, communicating, predicting and drawing conclusions/inferring. They are specific, observable

skills that are used to 'do science'. These skills are used by students and scientists as they observe the natural world.

- *Communicating about science*: how scientists do their work and communicate about scientific discovery and research, describing how scientists work in the real world.

Methodology

Participants

Thirteen teachers from around the country were selected to take part in a six-week professional development program with a mentor scientist. The participants included 10 female teachers and three male teachers. The participants ranged from first-grade to 12th-grade teachers, and teaching experience ranged from two years to 39 years, with a mean of 11 years of experience. Eight of the 13 participating teachers hold Master's degrees. Various ethnic and cultural backgrounds were represented by the participants, and the student populations they represent range from Title I schools with 80% free and reduced lunch to affluent private schools. The teachers were selected based on their application, their desire for participation, their potential for science education leadership at their school and a videotaped lesson.

All teachers who were accepted into the program and indicated their commitment to participate consented to participate in the research study. Twelve participants drove from various cities or states and one teacher was local. The non-local teachers were housed in an apartment complex near the laboratory for easy access to the facility. Participants were paid a stipend that was not connected to the research study so honesty and openness from all participants was anticipated.

Procedure

The following qualitative data were collected from the 13 participating teachers.

- Written lesson plans (submitted pre-program).
- Videotaped lessons (submitted pre-program).
- Pre-program interviews.
- Post-program interviews.
- Revisited lesson plans.
- Follow-up telephone interviews or personal interviews.
- Classroom observations.

Participating teachers were asked to submit a 'typical' science lesson plan along with their application before beginning the RET program. The lesson plans were analyzed based on a mastery lesson plan design used by both researchers participating in the investigation of the study. Videotapes of a typical science lesson were submitted by each participant before beginning the RET program. The videotapes were analyzed using the five previously identified elements as context. Identical protocol for each videotape was used by both researchers to ensure validity.

Post-program observations were conducted on five out of the 13 participants. Those five participants were chosen based on their proximity and availability to be observed by the researchers. For each observation, two researchers watched and wrote field notes. The field notes were typed as written accounts and were again coded and analyzed by both researchers. Following each observation, an interview was held with the teacher to clarify observations and provide researchers with an opportunity to ask more questions. In addition to these observations, telephone interviews were conducted with as many teachers as possible.

Written lesson plans and videotapes of lessons were compared with the modification of those plans and observations that indicated changes in the classroom post-program. The participants were asked whether they would modify the submitted lesson plan after the RET experience. Many teachers, particularly experienced teachers, do not write out their lesson plans in full. Therefore, more insight into teachers' changes to thoughts about planning and their changes to instruction were provided by the interviews and observations.

Data analysis

All 13 participants were interviewed at the start of the program (within the first week) and at the conclusion of the program (within the last week). The data were analyzed in two ways. First, all 13 participants' responses to interviews were transcribed and coded through the framework of changes to thoughts about planning and changes to instruction specific to the five elements of the RET program. Both researchers coded and analyzed the transcribed interviews separately and then met to ensure consistency. Consistent use of identical interview promoted inter-rater reliability within the coding of the data.

Quantifiable data from pre and post interviews were recoded in organized charts and one case study was conducted. We elected to conduct one case study after analysis of the data indicated that a closer look at how participants were changing their ideas about planning and instruction might yield interesting results. The case study focused on a teacher demonstrating specific attitudinal and practice changes in science teaching. The case-study participant is an experienced teacher with over 13 years of teaching. The case-study participant was a first-time attendee during the summer of 2006. The case-study participant demonstrated changes in her thinking about science lesson planning and changes to science instruction based on the elements of the RET program.

Findings

Data were organized into charts, by element, to address the research questions: How does an RET program affect teachers' expectations and values about science instruction? How does an RET program influence teachers' practice as it relates to inquiry, experimental design, nature of science, process skills and communication?

Five elements of the RET program

The five elements of the program were not mentioned specifically in the pre interview so as not to bias the participants into giving answers that might be considered socially desirable responses. However, throughout the pre-program interview, many of the participating teachers mentioned some or all of the five elements that matched, conflicted with or could not be determined to match our working definitions.

Colloquia focused on five science teaching elements: inquiry, experimental design, nature of science, process skills and communication. In post-program interviews, teachers mentioned changes in their planning and instruction based on some or all of these discussions. Additional themes emerged from observations and interviews once the participants returned to their classrooms in the fall. The time between the program and classroom implementation may demonstrate the significant changes made by these science teachers based on their experience at RET. Oftentimes professional development programs produce initial *claims* of change by participants, but follow-up research shows little change to classroom practice (Guskey, 2002).

Results of the teachers' responses to pre-interview and post-interview questions are displayed in Table 1. The numbers indicate the number of comments made on a particular topic. As evidenced by this table, the positive matches (comments matching the working definition) were greater in the post-program interview than in the

Table 1. Teachers' comments regarding the five elements of the program

	Pre-program interview	Post-program interview
Inquiry		
Positive	18	29
Negative	7	0
Neutral	2	5
Experimental Design:		
Positive	5	10
Negative	6	9
Neutral	8	4
Nature of Science:		
Positive	3	11
Negative	0	2
Neutral	3	5
Process Skills:		
Positive	2	8
Negative	0	1
Neutral	0	1
Communication:		
Positive	5	15
Negative	2	1
Neutral	2	2

pre-program interview. There were also fewer negative matches (comments conflicting with working definitions) in the post-program interview.

There was an increase in the number of positive comments about all five program elements during the post interview. These results indicate that some understanding of each of the five elements was gained during the RET program. Not unexpectedly, some neutral comments existed in the post-program interview.

During a pre-program interview participants were asked about school, local and district mandates that affect lesson planning. Many of the participants mentioned very strict or somewhat strict mandates on lesson planning and curriculum elements during their pre-program interview. Some even mentioned being mandated on the timeline of teaching elements: 'We have to teach certain content at certain times—it's all mapped out when we teach rocks and when we teach magnets …'. However, many of the participating teachers mentioned a desire to make changes to their science lesson plans as a result of participating in the RET program in spite of strict mandates within the school (see Table 2). Results also suggest that teachers may include subtle changes to their teaching *before* making radical changes to their lesson plans.

Teacher change is not only related to professional development opportunities, but also to the policies that exist at the district and school level (Fullan & Hargreaves, 1992). With ongoing and increasing pressure to meet national, state and district mandates with regard to student achievement, demonstrating quality teaching and professional development, teachers may feel stifled. Teachers may attend a professional development program that presents innovative and creative ideas, but feel that they have no opportunity to veer from the set curriculum

The expectations (Wigfield & Eccles, 2000) of teachers during the pre-program interview reflect this reality. Consequently teachers did not have high expectations that participating in the program would result in significant changes to their instruction. By the end of the program the participants valued certain elements of the content acquired during the RET program enough to make statements indicating a desire to change their teaching practices.

Table 2. Teachers' comments concerning their mandates of planning and plans for changes to instruction

	Pre-program interview	Post-program interview
Mandates		
limited (strict)	18	10
Somewhat limited (general guidelines)	13	
Not limited (little policy)	5	
Will make changes to plans		
Many changes		24
Some		19
Little		2

Case study

The pre-program and post-program interviews with all 13 participants left us with more questions about the degree to which changes would be made by the teachers. If numerous pre-program interview comments (n = 18) demonstrated that the participants felt limited by district and/or school mandates, how would changes to teaching practice occur? Are there other barriers to making changes to classroom practice?

Eighteen pre-program and 29 post-program comments were made by participants indicating a positive alignment with thoughts about inquiry and our research-based definition. During post-program interviews, participants mentioned a desire to make significant changes regarding inquiry as a strategy. It appeared that, despite perceived strict limitations to planning and teaching, many of the participants intended to make changes to classroom practice anyway, particularly their teaching of inquiry.

To investigate these questions, additional interviews and observations were collected in fall 2006 from five of the original 13 participating teachers. The following case study was chosen to illustrate how change in practice occurred and how RET influenced a teacher's planning and teaching of science in the elementary classroom.

Martha (pseudonym) is a second-grade teacher in a middle-class socioeconomic status school in the southeastern United States. Martha attended RET for one year during summer 2006. Martha obtained her Master's Degree and is certified to teach all elementary grades, including early childhood, and has taught the first and second grades for 13 years. Martha became interested in the RET program through a colleague who had attended the year before and recommended the program as a venue for learning about more effective science teaching. Martha demonstrated a great deal of reflection and, as the RET progressed, identified a need for making changes to her science teaching. The descriptions of Martha's practice are grounded in the five elements: inquiry, nature of science, experimental design, processes of science and communication in science.

Inquiry. Martha mentioned inquiry as a way to question her students and help them think about science in new ways. She wanted to change the way that she led her students, and wanted to give them a chance to think through ideas and concepts for themselves. During observations, Martha put this strategy into practice, something she has not done in the past. When asked about her questioning techniques Martha stated:

> That is something I have started doing a lot more this year. I think I did last year, but I never really focused on it. It was something that we just do I think as a teacher. But, this year, having had that experience [the RET], it is something that I just do a lot more of now, a lot more questioning, and having them question and think! Asking them, 'do you have a question for me?' And even when we do the KWL, and asking them, you know what are some things that you think about and want to find out? So, now I write them, I document them. And they are like, 'yeah, I have to find out'.

During observation, Martha was reading her students a book about the rainforest and asked the students 'What will you see if they chop the trees down?' The students responded '[We'll be left with] just the desert. [There will be] no plants or anything that has water and no light and [it will be] really hot. [If the trees are gone then] no one can live there'. Martha went on to ask students: 'What else does the child need from the tree?' The students responded: '[We need] oxygen [and] food'. One student went on to pant loudly as if unable to breathe, and exclaimed 'There are no trees in this room!'

Nature of science. Martha mentioned a desire to include nature of science in her classroom by having her students take on the role of scientists. Students are encouraged to research and investigate answers to their questions. For example:

> … this week we have been working on research and reference, so we will be using the computer a lot and we have been using the encyclopedias. We have been using other books and using all of those, all that is tied in … Because if we go back to the lesson on rainforest, I know my kids could do an awesome job. They'll think about what they learned, because it isn't just about what we read and what we studied, but this has become real. This is now a part of what they know. Not just what they read and studied to do the test. But is now a part of what they know. So, I think it is more effective for them.

Experimental design. In her post-program interview, Martha mentioned that she felt she did 'all activities' before and not any experiments. She mentioned a desire to change that practice with her students, and to help them take a more active approach to learning science. When asked whether she has made this change, Martha mentioned that she is trying to incorporate more experiments but feels that because of the group she has she is still a little bit apprehensive. Martha indicated it is 'not as easy I would have hoped it would have been, but I am doing them a lot more'.

Process skills. Martha was observed using many of the six process skills discussed during the RET program. She used the vocabulary to help students investigate answers to their questions. During observation, a student was describing a picture in the book as '… baby birds'. To which Martha replied 'Great observation'.

Martha used process skills vocabulary to point out the use of each skill by her students as discussed and focused on during the RET program.

Communication. Martha encouraged her students to share their journals, to write and to draw their ideas about the science concepts they were learning. Martha mentioned the importance of the students communicating with each other in this way.

Martha had high expectations of her ability to make changes to her teaching practices. Although not all of the elements produced significant changes in the classroom immediately after attending the program, Martha did make changes in certain areas. She valued inquiry and high-level questioning as important elements to promote student learning. Martha also valued including more experiments in her instruction as a way to promote inquiry.

Emerging themes

Other themes emerged during the coding of the observation and interview data. During interview and observation, Martha mentioned changes to her lesson planning as well as the barriers she has faced while trying to implement changes to her teaching of science. Since Martha teaches all subject areas in her elementary class, she was asked whether she plans differently for science. Martha stated:

> … usually yes. Because we try to touch different areas, with math or language arts or reading…but just bringing in a lot of hands on things for them also. So, I found that since I have been back [from RET], we have been doing a lot more questioning instead of just telling.

Martha also mentioned her desire to do more 'hands-on' learning with her students so her science classroom becomes more student-centered.

Barriers to making changes. Martha recognizes the difficulties involved in changing how she delivers science instruction and identified her primary barrier as her own colleagues. Martha thought there was the possibility of other teachers seeing her as a threat and making them 'look bad'. Even recognizing this as a possible outcome, Martha persevered and stated that she '[doesn't] blame them'.

Martha mentioned that the colloquium on inquiry helped her to realize that inquiry was something that had previously been missing in her science teaching, stating:

> I think when we did that colloquium on inquiry it was like 'wow!' this is the part that is missing, the part that we don't do. Because we do an experiment we think we are doing science. But are we really doing science, are we really doing what we should be doing in science?

Martha mentioned expectancies concerning her lesson planning, and barriers to making changes, which she plans differently for science than for her other subject areas, and that she is confident in her ability to make changes to her science planning, despite the barriers that she has felt from other teachers and staff members who are questioning her motives. Martha places a high level of value on modifying the science curriculum mandated by her school to make science the most effective and worthwhile for her students, despite resistance from her peers. Martha has evaluated additional elements, such as inquiry and experimental design, and feels that these elements have enough value to require significant changes to science lesson plans.

Discussion

Research indicates that a teacher's beliefs about teaching and learning and his or her practices are not always aligned. A teacher may acquire new teaching strategies and change beliefs about teaching, but it may take years to integrate these into the classroom (Fullan, 1993; Chance & Chance, 2001). Teachers tend to make changes in the classroom gradually. Radical changes to teaching practices rarely occur, even after an effective professional development program or teacher training (Guskey, 2002). Our results suggest that changes to teachers' practices are often subtle, and changes may be easier to implement than it appeared at the end of the program and may even be less disruptive to the *status quo* than originally perceived. These changes may be seen as threatening to colleagues, but may provide the teacher with greater ability to teach science in more effective ways. Anecdotal evidence indicates that RET 'graduates' often face this unanticipated balancing act when they return to their classroom.

The participants in this study discussed changes to their beliefs, but some changes to practice were seen in observations to be more subtle in the classroom than as mentioned in interviews. However, even small and subtle changes to practice demonstrate that the teacher is considering change and may make additional changes in the coming years. Not only may changes to teachers' practice be slow and subtle, but policy and mandates from districts and schools may make change difficult or even impossible (Fullan & Hargreaves, 1992; Hargreaves, 1996; Wirt & Kirst, 2001). When policy, research and teachers' practice do not align, changes in teachers' practice become difficult as teachers try to implement the 'right way' to teach versus what is 'expected'. Teachers may attend a professional development program, and gain insights and knowledge, to return to their classroom and implement new ideas along with their renewed excitement for their content area. However, if the teacher feels that the changes are not appreciated and/or not supported by peers or administration, there may be little motivation to put the changes to thinking and planning into practice.

Regardless of the barriers that teachers faced, the case study in this paper demonstrated that some teachers can overcome the obstacles if they value the changes to practice enough to implement the change. The use of expectancy-value theory as a framework for this study assisted in understanding some of these changes observed by the participants. If the participants believed they had the ability to make changes in their classroom and valued a particular element, some changes were seen in their teaching practices.

The RET coordinators and researchers focused on five elements of science teaching and expected that participating teachers would understand these elements in new ways. In addition, we expected participating RET teachers to implement new science teaching strategies that align with these concepts. Although changes to lesson plans did not reveal changes to teachers' planning, observations and interviews revealed that the participating teachers *were* making changes to their science teaching after their RET experience.

Further research in this area could include a more in-depth investigation of barriers to making changes. Also, investigating other emerging themes, such as the difference between conducting an activity versus an experiment, and changes to lesson planning as a result of a professional development program could be studied in the future.

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