

# How Elementary Teachers Use What We Teach: The Impact Of PER At The K-5 Level

Danielle Boyd Harlow

*Gevirtz Graduate School of Education, University of California, Santa Barbara, CA 93106-9490  
dharlow@education.ucsb.edu*

**Abstract.** This paper presents an investigation of how a professional development course based on the Physics and Everyday Thinking (PET) curriculum affected the teaching practices of five case study elementary teachers. The findings of this study show that each teacher transferred different content and pedagogical aspects of the course into their science teaching. The range of transfer is explained by considering how each teacher interacted with the learning context (the PET curriculum) and their initial ideas about teaching science.

**Keywords:** Teacher education, science education, physics education research, professional development, inquiry, elementary science, elementary teacher education.

**PACS:** 1.40E-, 1.40eg, 1.40Fk, 1.40G-, 1.40J-, 1.40Jh.

## INTRODUCTION

It is not surprising that elementary school teachers face challenges in their efforts to teach physical science in ways that are consistent with authentic scientific inquiry. Attaining the sort of conceptual understanding necessary to teach through methods of inquiry-based instruction is difficult even for secondary school teachers who ideally major in a science content area [1]. Elementary teachers take only a few science and science methods courses, making these few courses vital to shaping their understanding of science content and the nature of scientific inquiry.

Research on teacher learning indicates that courses in which teachers have the opportunity to learn in the way they are expected to teach may be useful for teachers trying to implement new teaching methods [2]. As a result, several inquiry-based physics curricula have been designed by the PER community with the needs of future and practicing elementary teachers in mind [3]. While there is evidence that these courses result in greater conceptual understanding as measured by written tests, there is less evidence that teachers *use* what they learn in these courses when they teach science to their elementary school students. In fact, we have little understanding of what teachers *do* with the skills and knowledge gained in such courses once they return to their elementary classrooms. Only by understanding what teachers do when they are

teaching, can we really understand how our courses can help elementary teachers.

Research indicates that learners may transfer unexpected or even unintended aspects from a learning situation into a target context and many contemporary scholars of transfer argue that understanding *what* learners transfer is more important than understanding *whether* learners transfer specific knowledge and skills [4][5][6][7]. Using such an understanding of transfer, I aimed to identify what teachers (who are learners in our physics courses) transferred from a physics course for teachers into their teaching practices.

## THE LEARNING CONTEXT

The teachers who participated in this study were enrolled in a 6-week (2.5 hours/week) physics course offered as a professional development course for practicing K-5 teachers. The course was entitled Magnetism and Electricity for Elementary Teachers (MEET) and was adapted from the magnetism and electricity units of the Physics and Everyday Thinking (PET) curriculum [8]. PET differs from other curricula in its content as well as in its focus on elementary students' ideas, the nature of science, and learning about how one learns physics. Through hands-on and computer-based activities and small group and whole class discussions, the teachers develop their understanding of physics.

During the magnetism unit of MEET, the elementary teachers proposed and developed models of magnetism that explained why an iron nail that had been rubbed by a magnet behaved differently than an iron nail that had not been rubbed by a magnet (a nail that has been rubbed by a magnet will itself act like a magnet while a nail that has not been rubbed by a magnet will act like an ordinary piece of non-magnetized ferromagnetic metal). Through the series of activities in this unit, the elementary teachers enrolled in the class not only learned physics content associated with magnetism but also about the evidence-based nature of scientific models. In the subsequent unit, the elementary teachers developed an understanding of current electricity through exploration of simple series and parallel circuits.

## METHODS

This study was designed to answer the question, “What do teachers transfer from MEET to their science teaching and what factors are involved in the transfer?” I studied five teachers in detail through qualitative research methods including video-taped observations and interviews. Data were collected in three stages: 1) Prior to the first day of class, I video taped each teacher teaching two science lessons of his or her choice; 2) During the MEET course, participating teachers’ interactions in small group and whole class discussions and activities were video taped; and 3) After MEET, the teachers were asked to teach two science lessons that aligned with the topics of the course and these lessons were also video taped. Interviews about the teachers’ experiences with science and about the decisions they made while teaching were also conducted pre- and post-MEET.

The observations and interviews resulted in a total of 60 hours of video data, 40 of which were relevant to the questions under investigation. These 40 hours were transcribed and these transcripts of observations were

the main source of data because they represented what the teacher actually *did* with his or her students and therefore represented science to his or her elementary students. In particular, to identify what teachers transferred from MEET to their teaching practices, I looked for evidence that the teachers used ideas and content learned in MEET to shape how they taught.

Teachers draw on their understanding of science content and of the nature of scientific inquiry when transforming an activity to be appropriate for a particular class of students and when responding to unexpected science ideas expressed by their students during science lessons. Such improvisational uses allows one to see how teachers *used* ideas rather than just that they recalled ideas. Thus, only teachers’ use of ideas learned in MEET to solve new problems in the context of teaching science to elementary school students counted as transfer in this study. From observed instances of improvisation in the context of teaching science, I identified the requisite knowledge of the teacher to make the decisions and then examined pre-measures to identify whether evidence existed that this knowledge was part of his or her pre-MEET teaching repertoire. Only knowledge used in post observations that was not present in pre-measures was considered transferred.

## THE TEACHERS

Five of the ten teachers enrolled in MEET participated in this study. The five case study teachers ranged in teaching experience from a first year teacher to a teacher who had been teaching for 29 years. Their frequency of teaching science also varied greatly. One teacher rarely had the opportunity to teach science while another teacher taught science twice a day.

As shown in table 1, based on the criteria used to identify transfer, three teachers exhibited evidence that they transferred aspects of MEET into their teaching practices and two showed little evidence of transfer.

**Table 1: Transfer claims and evidence by teacher**

Teacher	Transfer Claim	Evidence
Ms. Carter 12 <sup>th</sup> yr teacher	Physics content, model based reasoning, pedagogical strategies	Recognized testable student models and proposed ways of testing, asked students to predict based on models and support with evidence, self report/observations of changes in teaching strategies.
Ms. Bailey 3 <sup>rd</sup> yr teacher	Used content to teach consistent with prior idea of inquiry	Observations of post science lessons followed format described in pre-interviews. Used MEET activity to fit her stated inquiry goals.
Ms. Allen 1 <sup>st</sup> yr teacher	Transferred physics content and idea that students can create science ideas	Self-reports of how science content helped implement science lessons, recognition that an activity done in MEET would address problem students came up with in post-MEET lesson.
Mr. Dugan 13 <sup>th</sup> yr teacher	Little or no evidence of transfer	Taught topics he was familiar with prior to MEET. Followed provided lesson plans closely.
Ms. Evans 29 <sup>th</sup> yr teacher	Little or no evidence of transfer	Taught topics she was familiar with prior to MEET. Used activities as she had in the past.

Next, I briefly describe the three teachers for whom I observed transfer and what he or she transferred from MEET into her post-MEET teaching.

*Ms. Carter:* Prior to MEET, Ms. Carter (a 12<sup>th</sup> year teacher) was apprehensive about teaching and learning physical science. Her teaching, while hands-on, often represented science as vocabulary and fact-based. After MEET, Ms. Carter's teaching appeared very different. During her observed teaching about magnetism after MEET, Ms. Carter's students proposed models to explain why iron nails which had been rubbed by a magnet act like a magnet, while ordinary (unrubbed) nails do not. They then tested and revised these models. While both the models presented by the students and the experiments done to test and revise the models of magnetism differed from those proposed by the elementary teachers in MEET, the tests were appropriate for the models presented and thus Ms. Carter's teaching showed that she used her new knowledge about magnetism and about the nature of scientific models as well as pedagogical practices modeled in MEET to guide her students in developing knowledge of magnetism [9].

*Ms. Bailey:* In interviews prior to MEET, Ms. Bailey indicated that she believed that science should be about children asking questions and investigating these questions to find out the answer. After MEET, Ms. Bailey adapted a MEET activity to meet these goals. Like Ms. Carter, Ms. Bailey asked her students to draw models which would explain why a magnet is different from a non-magnet. However, rather than have her students test and revise these models, she used it as an exploration activity to inspire students to ask questions. Her students then shared their questions and listed steps they might take to answer them.

*Ms. Allen:* As a first year teacher, Ms. Allen was looking for strong guidance in how to teach physical science. She used many of the accompanying K-5 lessons that accompany PET/MEET and learned from implementing these activities that her students were capable of creating science knowledge. When her students came across a puzzling situation (two of three light bulbs not lighting in a large series circuit), she identified a MEET activity which she believed would help her students figure out their problem. In order to connect her students' question to the activity, she had to draw on her new understanding of circuits.

The other two teachers, Mr. Dugan and Ms. Evans did not show evidence of transfer.

*Mr. Dugan:* Mr. Dugan was a strong science teacher prior to MEET. He routinely tested new science kits developed by his school district and had much science experience to draw on. After MEET, he taught two science lessons about topics in magnetism that he understood prior to MEET and followed lesson

plans with little deviation. Therefore, the data collected provide little evidence for transfer.

*Ms. Evans:* Like Mr. Dugan, Ms. Evans was a science teaching expert and taught her lessons after MEET on topics she was previously comfortable with and used lesson plans she had in the past. Thus there is little evidence of transfer.

These claims and the evidence to support these claims are summarized in table 1.

## FINDINGS

As described in the previous section, the five participating teachers can be divided into two groups: those for which there is evidence of transfer and those for whom there is not. Considering first the teachers who show evidence of transfer, clearly there are significant differences in the ways that the three teachers used what they learned in MEET to teach elementary school science. However, it is also important to note that there are also some interesting commonalities. In all three cases, the teacher expressed dissatisfaction with some aspect of her science teaching prior to beginning MEET and was seeking something from the course. Ms. Carter was dissatisfied with her ability to teach physical science in general and expressed conflicting views about how to best teach science. Ms. Bailey was confident in her ability to teach science and had strong ideas about how to teach through inquiry, but felt that she lacked the content knowledge to implement such teaching in physical science topics. Ms. Allen, a new teacher, expressed concern about her science teaching because of a lack of experience and lack of guidance in the science curriculum used at her school. Each of these teachers began MEET with ideas about what they hoped to gain from the course. Furthermore, each of these teachers subsequently identified aspects of MEET that were useful in addressing their perceived deficiencies and transferred these aspects. Thus, each of these teachers learned physics (and inquiry) *mindful of their future use of this knowledge* and transferred *only what they sought*.

Mr. Dugan and Ms. Evans, the two teachers for whom there is little evidence of transfer, differed from the other three teachers in important ways. Both of these teachers were familiar and comfortable teaching inquiry-based science and both were considered expert science teachers by other teachers in their districts prior to enrolling in MEET. Furthermore, neither Mr. Dugan nor Ms. Evans had expressed dissatisfaction in their science teaching. They enrolled in MEET for other reasons (e.g., at the request of the district science coordinator and to earn professional development credits). Both Mr. Dugan and Ms. Evans expressed

how much they enjoyed the course and how much they learned about the more advanced topics in the course, but neither attempted to *use* anything new from the course in their teaching of these topics to their elementary students.

The comparison of the similarities and differences across and between the two groups leads to three major findings: 1) All teachers who transferred were dissatisfied with their own science teaching in some way and the teachers who were not dissatisfied did not show evidence of transfer, 2) teachers who transferred, transferred different things from MEET into their elementary teaching practices, and 3) teachers transferred what they came in desiring to know.

## DISCUSSION AND IMPLICATIONS

The finding that the teachers who transferred were dissatisfied with their teaching is interesting because it would follow that, to facilitate the use of the science ideas that we teach and methods we use to teach science, it may be useful to help practicing teachers recognize dissatisfaction in their own teaching prior to courses like MEET and to provide tools to help them evaluate their own teaching. When teaching physics, we recognize the importance of eliciting and using students' ideas about science. For example, in MEET, the elementary teachers proposed initial models for magnetism and revised their models because evidence which challenged their model was collected. Perhaps challenging teachers' assumptions about how well their model for teaching children works would create an opportunity for them to consider changes that would enhance their teaching.

Even more provocative is the finding that the teachers knew precisely what they thought they needed and took exactly the part of MEET that fit their predetermined need. One implication of this is that *target-minded learning* (knowing what one seeks from a learning context) may increase the likelihood of transfer. Target-minded learning may facilitate transfer because teacher education courses afford the opportunity to learn so many different things. The teacher who is focused on what she needs is more likely to find it.

A further implication of this study is that it may be useful to explicitly connect physics instruction to teachers' current classroom contexts. This aligns with research in the professional development literature that suggests situating professional development in teachers' classrooms [10]. Requiring teachers to try out new ideas or to practice what they have learned about content or inquiry may help them identify how salient aspects of the course can be directly used in

their teaching practices. This sort of direct application of physics and understanding of authentic scientific inquiry is challenging as the physics instructor must not only have a strong understanding of physics and the nature of science but also of the pedagogical challenges that face elementary teachers. This suggests a need for greater collaboration among education and content specialists to support the teaching of content courses for teachers.

Contemporary theories of transfer claim that much more than we expect may be transferred from a learning situation and that transfer is context-dependent [4]. Understanding what teachers actually do in the context of teaching science in their elementary classroom is vital to understanding what teachers take away from our courses and how they use it in their teaching.

Current reform initiatives [11][12] challenge teachers to create learning environments in which students are active participants in science. Such teaching methods place greater intellectual demands on teachers. New and experienced teachers will need help adopting inquiry-based instructional methods. The findings of this study suggest that by teaching teachers through inquiry, we can help them to use these strategies in their own instruction. However, in the case of such a complex learning environment, we need to help teachers identify the pedagogical and content aspects of the physics instruction that are relevant to their particular teaching situation so that they can identify how what they are learning will help them reform their teaching practices.

## REFERENCES

1. S. Wilson, L.S. Shulman, A. & A. Reichart, *Exploring Teachers' Thinking*, 194-124, (1987).
2. Grossman, Smagorinsky, & Valencia, *Amer. Journal of Education*, **108**, 1-25 (1999).
3. some examples include Goldberg, F., Robinson, S., Otero, V., *Physics for Elementary Teachers*, 2007; L. McDermott, *Physics by Inquiry*, 1996; and AAPT, *Powerful Ideas in Physical Science*, 1996.
4. J. Mestre, *Transfer of Learning: Issues and Agenda*, NSF Report, 2003.
5. J. Lobato, *Educational Researcher*, **31** (1), 17-20 (2003).
6. K. Beach, *Rev. of Research in Educ.*, **24**, 101-140 (1999).
7. see also many of the articles found in J. Mestre, *Transfer of Learning from a Multidisciplinary Perspective*, 2005.
8. Goldberg, F., Robinson, S., Otero, V., *Physics and Everyday Thinking*, 2007. Note that the early version of PET was called *Physics for Elementary Teachers*.
9. D. Harlow & V. Otero, *PERC Proceedings* (2006). Note that in this earlier work, her pseudonym was Ms. Doty.
10. See, for example, R. Putnam & H. Borko, *Educational Researcher*, **29**, 4-15, 2000.
11. AAAS, *Benchmarks for Scientific Literacy*, 1990.
12. NRC, *National Science Education Standards*, 1996.