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AUTHOR	Craven, John A., III
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ABSTRACT

This paper presents debates on the need to examine teacher education programs and discusses the importance and impact of mentoring on the learning outcomes of the science teacher educator (STE). The position is taken that a mentoring program for preservice teacher education should be a part of all advanced graduate programs. A lack of research on the issues related to the structure of science teacher education programs is indicated, and a comparison of the present studies on the distinction between the preparation of science teachers and science teacher educators is given. The standards developed for the preparation of science teachers identify the framework for the "knowledge, skills, experiences, attitudes which are essential for the qualification of a successful teacher." The importance of conceptual change concerning mentoring before science education reform can be meaningful is stressed. (Contains 31 references.) (YDS)

MENTORING FUTURE MENTORS: THE PREPARATION OF SCIENCE TEACHER EDUCATORS

John A Craven III, Queens College/City University of New York

Introduction

Issues regarding the structure of science teacher preparation programs have been in existence for several decades (e.g., Yager et al., 1997; Yager & Bybee, 1991; Yager & Penick, 1990; Bethel, 1984; Mechling et al., 1982;). Yet in existing studies of science teacher education programs, no distinction is acknowledged between the preparation of the science teacher and that of the science teacher educator. For as little that is known about the preservice preparation of science teachers, even less is known about the preservice preparation of science teacher educators (PSTE).

The lack of research in this area may suggest that the proximity of undergraduate, graduate, and advanced graduate programs in science education creates assumptions that affect program design. Conceivably, an overarching assumption is that the needs of the student vary little from one stage to another except for the addition of more course work in research, pedagogy, and (perhaps) science. Yet significant differences in the roles and responsibilities do indeed separate science teachers from science teacher educators. In a critique of the traditional model of teacher education programs, Feinman-Nemser (1990) charges that, largely, methods courses are taught largely by university professors rather than master teachers.

Thus, there is a need to examine the skills and knowledge required for an exemplary teacher educator. Feinman-Nemser's comment highlights the necessity of examining the assumptions that may be made regarding the education of the PSTE. These include that the PSTE:

1. was initially a good science teacher,
2. experienced an exemplary K12 science teacher preparation program,
3. possesses standards- and research-based skills and understandings about science, teaching, and learning, and
4. can teach, model, design curriculum, and create an appropriate classroom environment for preservice teachers.

This paper presents arguments for the need to examine such programs and discusses the importance and impact that exemplary mentoring has on the learning outcomes of the science teacher educator (STE). Second, this paper presents an exemplary mentor model from an STE preparation program and argues that a formal program of mentoring the preservice science teacher educator (PSTE) should be part of all advanced graduate programs. Finally, this paper explores the application of an exemplary mentor model to other dimensions within teacher preparation.

Standards for Science Teacher Educators

The Association for the Education of Teachers in Science (AETS) has recently developed Standards for those involved in the preparation of science teachers. These standards are designed to clearly articulate and define a framework for the "knowledge, skills, experiences, attitudes, and habits of mind essential for the successful science teacher educator" (Lederman et al., 1997). The domains within the standards include Knowledge of Science; Science Pedagogy;

Curriculum, Instruction, and Assessment; Knowledge of Learning and Cognition; Research/Scholarly Activity; and Professional Development Activities. The Standards represent, in part, an outcome from pressures both within and outside the community of science teacher educators to ensure that all students studying to teach science have the opportunity to become well-prepared.

While the standards do help to identify the essential qualifications for the STE, they do not address the ways in which those skills and understandings are achieved. Thus, the question remains, how does the PSTE learn the skills and knowledge necessary for exemplary practice? The answer to this question has profound implications on the design and structure of programs that prepare science teacher educators. For, as Marton (1988) reminds researchers, what is learned (that is, the outcome or the result) and how it is learned (that is, the act or the process) are two inseparable aspects of learning.

In a way, AETS has recognized the importance of "how" future science teacher educators best learn the skills and knowledge of an exemplary STE. It has done so through the Outstanding Mentor Award. In establishing the annual award, AETS has explicitly placed high value on, and recognition of, superior mentor models in the preparation of future science teacher educators. The award also implicitly acknowledges that it is through the intense mentor-student relationship that effective and useful conceptual change practices can be applied. These conceptual changes are often necessary before current science education reform efforts can be meaningfully understood (Hurd, 1993; Yager 1991). Consequently, the theoretical framework underlying the mentoring process should also be clearly understood. Furthermore, effective models of mentoring programs that currently exist must be identified and shared within the professional community.

Theoretical Framework for Mentoring

Constructivism has been at the forefront of recent efforts to improve science education (Yager, 1996). Research in learning psychology continues to provide evidence that knowledge is constructed by the learner (Driver et. al., 1994; Glaserfeld, 1989; Pope, 1982). Constructivism, with deep roots in Ausubelian psychology, explains that knowledge is synthesized, modified, and is evolutionary in character (Novack, 1985). But the learner is not isolated in this interaction between perceptions and internal rules - the social construction of knowledge is critical (Driver et al., 1994; Hewson et al., 1992; West & Pines, 1985). As a consequence, much of what we believe to know or understand results from a process of socialization. The impact of the socialization process on individual perspectives and understandings has been well documented (e.g., Erickson, 1991; Sarason, 1981; Bandura, 1977; Lortie, 1975; Kuhn, 1970;). Constructivist theory and socialization theory can be interpreted as being deeply embedded in some pre-professional and professional development models for teachers.

In an overview of the existing paradigms for professional growth, Sparks and Loucks-Horsley (1989) identified five models of staff development. These include: a) individually guided staff development , b) observation/assessment, c) involvement in a development/improvement process, d) training, and e) inquiry.

Of these five, the model of Observation/Assessment draws largely on the power of social constructivist learning theory. Within this model, phases of activities include a pre-observation conference, observation (collection of data), analysis of data, post observation conference, and analysis of the observation/assessment process between teacher and observer (Sparks et al., 1989). Sparks and Loucks-Horsley (1989) describe fundamental assumptions underlying the Observation/Assessment model. These include:

1. that reflection and analysis are critical in the observation/assessment model,
2. that reflection by an individual is enhanced by another's observations,
3. that observation and assessment of classroom teaching can benefit both observer and observee, and
4. when teachers see positive results from their effort to change, they are more apt to continue to engage in improvement.

Variations of the Observation/Assessment model can be found in the Peer Coaching Model (Showers and Joyce, 1996) and Shon's (1987) Coach and Student Model. Galbraith and Anstrom (1995) define the peer coaching model as a confidential process by which expertise is shared, feedback and support is provided, and assistance in developing and refining classroom skills is given. Through companionship, feedback, adaptation, and support, the peer coaching model can promote a self-perpetuating process to improve teaching and professional development (Galbraith and Anstrom, 1995). Another variation of the socialization model for professional development can be found in the writings of Donald Shon.

Shon (1987) argues that settings such as classrooms are terribly more complex than the simple models often presented within pedagogical courses in preservice programs. Thus, the simple application of facts or knowledge is not all that simple. Shon argues further that professional education should focus on improving the teacher's ability for "reflection-in-action". In this model, the practitioner learns by doing and develops the ability for continued learning and problem-solving throughout his or her career. Shon draws, in part, upon the work of John Dewey as he advocates that the student cannot be taught what he needs to know nor can the learner simply be told what to see. Through the student and coach interactions the learner is provided a mechanism for meaning-making in the profession (Shon, 1987). Shon's argument finds support in the works of others. Marton (1988), in describing ways of improving learning (that is, when learning is described as a conceptual change) states,

> It is important that educators provide instructional means by which the students can obtain guidance to help them meet the expectations. "We cannot directly make someone acquire a certain meaning, but we can possibly aid him or her to impose one structure on a phenomena rather than another. One of the ways of doing so is to introduce a cognitive conflict which makes the learner reconsider his or her habitual way of delimiting the phenomena (pg. 78).

In the variations of the student/mentor models described above, cognitive conflicts can result through a program of exemplary, purposeful approaches to questioning and probing the learner in authentic context (i.e. classrooms).

<u>Mentor Model In Practice</u>

Having explored the theoretical framework of mentor programs, attention is now turned towards an examination of a superior model in practice as acknowledged by the 1997 Outstanding Mentor Award. At the Science Education Center at the University of Iowa, particularly through the sequence of science teaching methods courses, Dr. John Penick has nurtured and developed a mentoring program for future science teacher educators. In that program, the PSTE gain skills and understandings regarding the education of preservice science teachers and the supervision of practicum/student teaching experiences. The model is described as a series of phases including Framework Construction, Framework Evaluation in Context, and Framework Application.

Framework Construction

The exemplary mentor model begins with early and extensive involvement of the PSTE in the science teacher education program. Most often, involvement in the methods and practicum courses does not come by request nor requirement of the instructor. Rather, those motivated PSTEs who explicitly express interest in the program are invited by the professor to sit in on the first of three methods courses offered to preservice science teachers. The PSTE is expected to participate in class discussions, read the required readings for the course, and write a rationale paper (a research-based justification of intended approaches to teaching and learning science) just as the preservice teachers do.

In addition to fulfilling the expectations of the course from the preservice teachers perspective, the PSTE meets with the instructor before, after, and quite often during the class (when students are involved in cooperative exercises, for instance). During those sessions, matters of pedagogy, course design, and the roles of the instructor and students as they relate to the instructor's goals are discussed. Furthermore, the PSTE is questioned about his or her observations and interpretations of the classroom interactions. Responses to these questions reveal the PSTE's skills to assess classroom learning and provide insights into emerging frameworks of understanding.

Through purposeful questioning of the PSTE, the instructor both assesses the perceptions and understandings of the PSTE and provides the cognitive conflicts necessary for the PSTE to move to deeper understandings about pedagogy, curriculum, and approaches to teaching and learning. In the Iowa program, involvement in the methods program lasts as long as the PSTE maintains interest and involvement in the sequence of courses. Naturally, exemplary PSTEs maintain interest and involvement in the program throughout their studies. Following a progression through the courses and sustained involvement, more responsibilities are laid upon the PSTE. These responsibilities include initiating and maintaining focused discussions about science teaching and learning, modeling researched-based approaches and habits of teaching and questioning, and assessment.

Preservice teachers in the methods courses are constantly being assessed with regard to their skills and understandings about the teaching and learning of science, the final evaluation rests largely on an exit interview. In that interview, the students are questioned about their researched-based rationales for teaching science which they write and continue to hone throughout their program. Consistencies and inconsistencies are made apparent to both instructor and student during the interview which typically lasts from one hour to an hour and a half.

Ultimately, the students are asked to evaluate their own efforts and performance as a student in the course. They are asked to consider their ability to integrate relevant research into discussions, their ability to demonstrate effective classroom practices, and to weigh their self-perceived potential against their actual performance. In short, the students are requested to "grade" themselves and to defend that grade using appropriate evidence. Furthermore, the process is as instructional as it is evaluative to both student and instructor. The exit interview is a very difficult one for most students in that most students have never been given the responsibility for assessing themselves as learners.

If it can be said that the process is a difficult one for the student, it can also be said that the process requires special skills and understandings on the part of the interviewer. And, again, these skills and understandings are fostered by the mentor model of the instructor. Initially, the PSTE only sits in on the exit interviews of the students in the course. The PSTE listens to both instructor and student throughout the exchange. He or she makes notes of patterns of interactions and questions, tries to identify the purpose and direction the questioner is leading to, and listens for "gaps" in understandings on the part of the student.

Importantly, the instructor/interviewer models effective questioning strategies for the PSTE and assesses the preservice teacher at the same time. There is a debriefing following the conclusion of the exit interview when the student has left the room. The mentor questions the PSTE regarding his or her observations and inferences. The PSTE is probed for insights into understandings about the teaching and learning of science held by themselves as well as the student who was just interviewed. Equally important, the PSTE perceptions of patterns of questioning and the resulting responses are probed. The PSTE is asked to identify types of questions that are particularly fruitful in eliciting a student's understandings and/or misconceptions.

Framework Evaluation in Context

Integral to all science teacher preparation programs are field experiences that connect to either methods courses or application courses within the program. The practicum experiences can be viewed by both the instructor and student alike as some of the most important preservice experiences. In that students can often verbally describe behavior without actually performing it (Bandura, 1965), the practicum portion of the teacher preparation program provides invaluable insights into the propensity of the students to incorporate their understandings into practice. Also, observing and abstracting meaning from the complex environment called the classroom requires special cognitive skills on the part of the supervisor. And, again, these can be achieved through the mentoring process.

In the Iowa program, an intense integration of technology and instruction provides a superior vehicle for the mentoring model to take place in the K12 classroom setting. First, the preservice teachers from the methods class are divided into teams of three. The task of each team is to construct an appropriate science learning experience for middle school students. This learning experience is to take place for three consecutive days. Cooperatively, the team determines a set of goals, designs the curriculum, gathers the materials, teaches the class, and assesses the outcomes. All of the teams visit a cooperating teacher's classroom to teach their lesson - one team in a class followed by the next team in the next class until all teams and/or classes have been taught. Throughout the teaching experience, the practicum students are wired with wireless microphones, recorded, and videotaped. At the end of the three day teaching experience, the students first analyze their own videotapes and then the class analyzes the tapes together on campus.

The technology of the wireless microphone and videocamera allows the instructor to select any of the three team teachers at any given moment to listen in on the interactions between student teacher and learner. The wireless microphone provides access to audio interactions that otherwise are unobservable. The methods instructor listens in on the teacher-student interactions through a set of headphones that receives a signal through the an amplifier. As the teachers teach, the instructor, tethered by a long line connecting headphones to camera, takes notes regarding pedagogy, curriculum, and content of the lesson. As in previously described phases of the mentor model within the Iowa program, the PSTE accompanies the instructor to the field to also observe and supervise the practicum students.

In that observation is theory laden (e.g., Kuhn, 1970), the PSTE will not typically be able to observe what the experienced instructor observes in the complex setting of the classroom. Yet, again, through interacting with the PSTE, the instructor can help try the PSTE construct a theoretical framework that is compatible with the instructor's. As this is being accomplished, both the PSTE and the instructor are able to "see" the same thing in the classroom. To foster the development of an adequate framework, the PSTE is also tethered to a set of headphones which enable him or her to listen in on the teacher student interactions. Similar to the instructor, the PSTE takes notes about the pedagogy, curriculum, and content of the lesson.

There are frequent interactions between the instructor and PSTE. Notes are compared and the PSTE is questioned about his or her observations. The instructor will ask the PSTE to provide elaboration and pedagogical implications of the observations and assessments he or she is making. Furthermore, the PSTE is probed about his or her interpretations of the classroom interactions, student roles, and teacher roles both real and hypothetical.

What the preservice science teacher educator reports he or she observes while supervising student teachers, while watching the science teacher educator teach preservice teachers, and selfreflective feedback on their own models of teaching and supervision all provide the STE with evidence of the soundness of the PSTE's theoretical framework. Importantly, inconsistencies - which translate into weaknesses - in the theoretical framework then can be made apparent. At that point the STE, through purposeful questioning, can provide sufficient cognitive dissonance sufficient enough for the PSTE to become aware of his or her own inconsistencies. Through this Deweyan constructivist approach (Prawat and Floden, 1994), a conceptual change from inadequate ways of viewing the classroom, learning, and teaching of science to more adequate or useful (also theory-based, integrated) ways is fostered.

The technology also allows the PSTE to listen in on the exchange between the preservice teacher and instructor throughout the field experience. The instructor will, under appropriate conditions, provide feedback to the practicum student during and after the lesson. From the practicum student's perspective, the field experience is a particularly vulnerable and intimidating time. They often believe themselves to be under the scrutiny of the middle school students, the instructor and PSTE, as well as the host teacher. Yet on-site feedback provides unique opportunities to provide assessment and instruction to the student that otherwise might be dismissed or forgotten. And, due to the emotionally charged nature of the practicum experience, special skills and understandings, apart from purely pedagogical and curricular, are needed by the instructor. The PSTE has the opportunity to develop these skills and understandings through a process of observation, doing, and feedback from the instructor.

Framework Application

Nearing completion of the PSTE program and after multiple and continuous semesters of involvement in the methods sequence and supervised field experiences, the PSTE is considered a full co-instructor for the methods course. Responsibility for planning, instruction, and assessment is placed equally across the co-instructors. At the same time, the dialogue between the mentor and the pre-professional continues to provide instructional means for strengthening theoretical frameworks.

Conclusion

This paper has discussed ways in which the pre-professional science teacher educator gains the skills and understandings regarding science teaching and learning that are consistent with those of an expert science teacher educator. An obvious question that may be raised, of course, is how would one know that the mentor is an "expert" in the field of science education? Recall, however, that exemplary science teacher educators can be identified by their ability to provide evidence of their practice in accordance to the Standards for Science Teacher Educators. Earlier in this discussion, the Standards were defined as an articulation of the "knowledge, skills, experiences, attitudes, and habits of mind essential for the successful science teacher educator".

Furthermore, this paper discussed how the incorporation of technology in the mentor model, in particular the supervision of classroom practica, can greatly enhance the effectiveness of the mentoring process. Lauren Resnick (1992), in describing ways of cultivating the dispositions to higher order thinking, states that,

> ...interactions in the social situation can provide occasions for modeling effective thinking strategies. Furthermore, skilled thinkers can demonstrate desirable ways of attacking problems, analyzing texts, and constructing arguments (pg. 137).

It has been described in this paper how the incorporation of video camera, wireless microphones, and receivers allows the pre-professional to "listen" in on the thoughts and watch the problem-solving actions of an expert in a contextualized setting.

Implications for Other Dimensions Within Teacher Preparation Programs

Arguments for the mentor model have implications beyond those for the professional development of preservice science teacher educators. Findings from two major studies of teacher preparation programs (Yager et al., 1997 and Goodlad et. al., 1990) report that a high degree of incoherence exists across program features. Given that at some larger teacher preparation institutions more than forty field supervisors are responsible for evaluating the field experiences of the preservice teachers, it is not surprising to understand that a high degree of incoherence exists across the feedback provided to the students. Lacking congruent theoretical frameworks, forty different field supervisors will make very different sets of observations and provide very different kinds of feedback. Yet it is vitally important that the feedback and instruction the practicum student receives from a supervisor remains consistent with the philosophy and approaches exhibited in the on-campus methods courses. It is equally important that the person supervising the practicum student places appropriate attention to those things that the student thus far has been inculcated to value. Applications of the mentor model between methods instructor and field supervisors may be extremely useful in a) fostering similar theoretical frameworks regarding the teaching and learning of science and b) coordinating congruent and coherent approaches to supervising student teachers and practicum experiences.

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John Craven/Assistant Professor/Ph.D.

Organization/Address: **203 Delaney Hall**
Queens College/CUNY
Flushing, NY 11367-1597

Telephone: 718-997-5344
Fax: 718-997-5325

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