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ABSTRACT

This paper focuses on pre-service teacher education and elaborates on the critical importance of three attributes to the development of professional science teachers: (1) science teachers must be reflective practitioners of their profession; (2) all instructional practice and decisions of science teachers must be backed by a research-based rationale that they are consciously aware of and are able to defend; and (3) science teachers must be able to impact student learning in multiple domains of science. Why the development of each of these attributes should be a critical goal of pre-service science teacher education programs is discussed as well as which strategies in the program could help accomplish each of these goals. (Contains 15 references.) (ASK)

PREPARING "PROFESSIONAL" SCIENCE TEACHERS: CRITICAL GOALS

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The Professional Science Teacher: Need of the Times

Current science education reform efforts such as the National Science Education Standards (National Research Council, 1996) and Science for All Americans (American Association for the Advancement of Science, 1994) promote teaching and learning of science that goes far beyond a simple transmittal of scientific facts, figures, and processes to be learned in a rote manner for their own sakes. They call for science instruction that, among other goals, enhances student understanding of the nature of science, enables them to critically analyze scientific information and apply it to real-life situations, and sets them on a path of life-long learning in science and science related matters. In order to implement such reform, new professional responsibilities must be undertaken by the science teacher. In order to foster the ability to undertake and fulfill these responsibilities (*i. e.,* facilitate the kind of science instruction characterized above), substantial reform of both pre-service and in-service science teacher education must occur. A variety of teacher education "standards" has been developed (Danielson, 1996; National Research Council, 1996) and continues to be developed through efforts such as the CASE (Certification and Accreditation in Science Education) Project to guide the necessary reform of science teacher education. These standards are being designed and implemented to produce "professional" science teachers capable of undertaking the new responsibilities. However, we are faced with the question: What is it that sets the professional teacher apart from a teaching craftsman (one who is capable of merely transmitting scientific knowledge)?

Professional science teachers can be characterized by several attributes related to the teaching and learning of science. The goals of any science teacher education program must include the development of these attributes if the program aims to prepare professional teachers rather than mere teaching craftsmen. Focusing on pre-service science teacher education, this paper elaborates the critical importance of the following three attributes to the development of professional science teachers.

1. Science teachers must be reflective practitioners of their profession.
2. All instructional practice and decisions of science teachers must be based on research-based rationale which they are consciously aware of and are able to defend.
3. Science teachers must be able to impact student learning in multiple domains of science.

In the ensuing pages I turn to a discussion of why the development of each of the following attributes should be a critical goal of pre-service science teacher education programs and what strategies in the program could help accomplish each of these goals.

Critical Goal 1: Reflective Practitioner

Science teachers must be reflective practitioners of their profession. Three questions immediately arise here: 1) What exactly does it mean to be a reflective practitioner? 2) Why is it important for teachers to be reflective? 3) How does one learn to be reflective?

The answer to the first question is far from simple. Reflectivity is construed in a variety of ways and this variety can "disguise a vast number of conceptual variation" (Calderhead, 1989, p. 2). LaBoskey (1993) notes that the definition of reflection is quite complex and that most definitions have built upon a conception of reflectivity originally posited by Dewey (1910). Thus, in order to understand the meaning of reflectivity, it is worth considering Dewey's conception of the term.

According to Dewey (1910), reflection is the "active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends" (p. 6). To the 'careful consideration of belief and form of knowledge' might also be added 'careful consideration of practice or strategies', from the perspective of the teaching profession. The implication here is that reflection involves continued evaluation of one's own practice in the light of what Dewey has called the "ground of belief".

Why is such evaluation (or being reflective) important in the teaching profession? Dewey (1904, 1910) argued that teachers should be encouraged to become thoughtful and alert students of education rather than just proficient craftspeople. This is important because "Unless a teacher is such a student, he may continue to improve in the mechanics of school management, but he cannot grow as a teacher, an inspirer and director of soul-life" (Dewey, 1904, p. 151). Growth as a teacher and inspirer is critical for those who teach science. Scientific knowledge is the product of much exploration, experimentation, and continued analysis of information thus generated. Students need to learn the importance of such analysis and learn how to do it for the purposes of both getting into the scientific enterprise themselves and being able to scrutinize scientific information that impacts their lives. Being able to continually analyze and evaluate also lies at the heart of reflectivity. It is crucial for science teachers to be able to reflect both about the scientific knowledge they expect their students to learn and the ways in which they will help them learn. Unless teachers are reflective, they will not be able to foster reflectivity in their students because students copy their teachers' behavior. In effect, non-reflective teachers will produce students who do not know how to think for themselves.

Hullfish and Smith (1961) have argued that "apart from gaining control of the method of reflection it is impossible to learn any facts at all" (p. 210). They have also argued that if one doesn't learn to think while in school, it is fair to ask how are they to keep on learning. This argument has direct implications for pre-service teacher education programs. If student-teachers do not learn to be reflective while in school, how are they to keep on learning how to teach? Therefore, development of reflectivity in student-teachers must be a prime goal of pre-service science teacher education programs.

How can reflectivity be developed? What strategies in the program would help foster reflectivity? In order to answer these questions, one must consider the characteristics of the process of reflection. Dewey (1910) suggested that reflection is characterized by a three-step process. These include problem definition, means/ends analysis, and generalization. He further suggested that true reflection is carried out with attitudes of open-mindedness, responsibility, and wholeheartedness.

If a program aims to develop reflectivity in student-teachers, it must provide opportunities for student-teachers to identify problems in teaching practices, to analyze the means and ends related to these practices, and to draw generalizations, all with the attitudes of open-mindedness, responsibility, and wholeheartedness. There are two levels at which this could be accomplished. The first level is reflectivity about the strategies and practices employed by the course instructor. The second level is reflectivity about students' own behavior in teaching and all other experiences within the program. Accomplishment at both of these levels presumes that the course instructors themselves are reflective practitioners of their own profession, and that numerous teaching experiences are provided to student-teachers so that reflection about the earlier experience can be used to improve the later experience. Thus, reflective course instructors and multiple teaching experiences built into the program constitute two primary requisites for fostering reflectivity.

For reflecting on the instructor's practices, student-teachers should be asked to identify practices that may appear problematic to them. This could be achieved by student-teachers maintaining journals about every class meeting and then going through the journal entries to identify problems, or by video-recording class meetings and identifying problems through video analysis. Class time should be allowed on a periodic basis for student-teachers to share the problems they have identified and the instructor must then guide student-teachers in a means/end analysis of the problem. At this step, a non-reflective instructor will be of precious little help, if any, since such an instructor would most likely not have a rationale for the actions identified as problematic. When generalizations are drawn, these should be reflected in future practices of the instructor to demonstrate that reflection has resulted in his/her own growth as a professional. If the evidence of growth indicated by incorporation of generalizations into practice is not visible, student-teachers would miss the entire purpose of reflection—evaluation with the intent to change when necessary.

For reflecting on their own teaching experiences, the best strategy might be to video-tape every teaching experience, analyze the video-tapes for problem identification, and then engage in a means/end analysis of the problematic action. Here, the reflective instructor may have to help student-teachers identify problems by asking them questions about why a particular action was undertaken and then guiding them in a means/end analysis of what might be done differently to better achieve the goals student-teachers had in mind. A strategy to guide the means/end analysis would involve the instructor pursuing questions about why the student-teachers did what they did until they begin to see the problematic aspect of the specific action. Then, again through questions, the instructor could lead them to preferred alternative actions in the given situation. If there are any resulting generalizations, student-teachers should be made responsible for incorporating them in their future teaching experiences. This reflective process should be repeated later to evaluate their growth since the previous teaching experience.

The type of reflective activities described above have been identified as reflection on practice or professional reflection (Baird, Fensham, Gunstone & White, 1991). Baird et al. have also identified another kind of reflection—phenomenological reflection—that is reflection on general life experiences as a teacher, learner, or researcher. In a three-year naturalistic case study of both pre-service and in-service science teachers, Baird et al. found that both types of reflection served to improve teachers' knowledge, awareness, and control of themselves and their classroom practice.

In order to develop reflectivity in pre-service teachers, time must frequently be allocated during regular class meetings to apply the process of reflectivity as described in previous paragraphs. It must be actively undertaken during class meetings. This will help student-teachers learn the process of reflection and develop a reflective attitude. Moreover, personal reflections beyond those undertaken during class must be assigned as homework tasks in order to help develop the habit of reflection and improve the quality of reflection. This can be achieved by asking them to identify and analyze problems or issues other than those considered during class, and reporting back on their analysis either in written form or verbally during a future class meeting. The in-class exercises and homework assignments would, hopefully, foster the attitude of reflection and equip student-teachers with techniques of reflection to the extent that they can go out to be reflective practitioners of their profession. After all, if they don't learn to be reflective while in school, how will they keep on growing after they become teachers, and in turn how will they help their students to grow?

Critical Goal 2: Research-Based Rationales to Guide Practice

All instructional practice and decisions of science teachers must be based on research-based rationales which they are consciously aware of and are able to articulate precisely and defend. Why are research-based rationales important for teachers? At least two lines of argument can be presented in response to this question.

First, being aware of current research and continually aligning practice with research findings is what makes a teacher professional and distinguishes him/her from a mere craftsperson. A professional teacher possesses specialized knowledge not only of the subject s/he teaches but also of the enterprise of teaching. The professional teacher, rather than the craftsperson type teacher, is capable of growing as a teacher by virtue of keeping up with research findings and applying them reflectively to his/her practice. A professional teacher is in touch both with changes in specific subject matter and advances in pedagogical research. Such a teacher is more desirable than the craftsperson type teacher because the professional teacher will continue growing as a teacher. Such a professional teacher would have continually improved impact on student learning. Compared to the craftsperson type teachers, science teachers whose actions are guided by research-based rationales exhibit professionalism and will be more successful in having a positive impact on student learning.

Second, teachers' work in most schools is guided by prescribed curriculum guidelines and restrictions imposed by institutional structure. In such an environment, trying something different or innovative in one's classroom may be extremely difficult and may invite criticism, opposition, and conflict. Though the teacher's action may be entirely appropriate and congruent with research findings, unless the teacher has a research-based rationale by which to defend his/her actions, s/he may not be able to convince the critics of the value and appropriateness of his/her actions (Clough, 1992). Thus, without the rationale, even a fully competent teacher may never be able to act professionally in the classroom by way of applying current research findings to his/her own teaching practice and will, therefore, not be able to impact student learning to the maximum extent.

Penick (1985) has suggested that a rationale for science teaching must include "carefully formulated goals and a well-justified set of behaviors to obtain those goals. These behaviors are based on which is currently known about how children learn, the effects of teachers and students, and the nature of science." Having such a rationale constitutes, according to Penick, one of the traits which make one a "formal operational teacher"—a teacher who is at the highest level of the continuum of teaching skills, aptitudes, and knowledge.

In order to prepare science teachers who have rationales which they are able to defend, the entire science teacher education program must be designed around the rationales, including teaching and learning goals. Right at the beginning of the program students should be asked to identify goals that they would like to have for their students in science classes. A consensus list of goals to be worked on throughout the program should be generated. In generating goals and merging them to produce a consensus list, the course instructor may need to help focus the thinking of student-teachers by asking questions such as why is this goal important, how is different from some of the other goals, and how feasible would be the measurement of the achievement of the specific goal. The next step would be to locate research literature in support of the goals agreed upon by the class. Here again, the instructor and student-teachers must be equally involved. They should all do literature searches and each student should be charged to identify at least two pieces of literature in support of each goal. This literature should comprise part of the readings for the course.

During the rest of the program, the research literature identified by the entire class should be discussed and arguments analyzed in terms of research support and their appropriateness for the goal. This should happen on a regular basis. These discussions may lead to refinement of goals and/or addition or deletion of particular pieces of research literature to build stronger bases for the stated goals. After students have gained some confidence in relating arguments to the goals and identifying behaviors that match the goals, they should periodically be asked to analyze the instructor's goals on the basis of his/her behavior in class. They should also be engaged in analyzing video-tapes of their own and their colleagues' teaching experiences to examine the extent to which their behaviors matched their goals. This analysis should be used by students to modify their behavior and align it more closely to their goals during future teaching experiences. Again, to achieve this goal, the program must provide multiple teaching experiences. Analysis of teaching behaviors in the context of specific goals will also provide a meaningful setting for the development of reflectivity.

Finally, an important assignment, which will motivate students throughout the program to think in terms of goals and rationale to defend them, is development of a rationale paper. In this paper, students will identify goals (not necessarily the ones generated by the class as a whole) which they individually think are important, provide research support for why they think each goal is important, and describe sets of teacher and student behaviors that would help accomplish each goal. Writing such a rationale paper would help students think carefully about each goal, find out the extent to which the goals are supported by educational research or current reform agenda, and identify sets of behavior justified by research to achieve the stated goals. The entire exercise will also help them see the bigger picture of the teaching profession, particularly science teaching, and provide a backdrop against which to reflectively assess their practice in order to grow as a professional.

It is preferable to start working on the rationale paper early in the program and treat it as an ongoing assignment throughout the program, revising and modifying the rationale as new knowledge about teaching science is gained, rather than treating it as an end of semester or end of program assignment. Revising the rationale paper at different stages during the program would help students refine their goals, become familiar with appropriate research in support of the goals, and be prepared to apply appropriate strategies in their own teaching practice when they enter the 'real-world' of teaching as professionals.

Critical Goal 3: Impacting Student Learning in Multiple Domains of Science

Science teachers must be able to impact student learning in multiple domains of science. Two questions can be raised in connection with this goal. First, what is meant by multiple domains of science? Second, why is learning in multiple domains important?

Domains of science imply aspects or components which should be included in good science instruction (Yager & Brunkhorst, 1987). Most often science instruction serves just as a mean to transmit currently accepted scientific knowledge from teachers to students and, sometimes, also to help students develop scientific processes and skills. This kind of science instruction usually focuses only on two domains of science—the information domain and the process domain—and presents a severely restricted view of science. A careful examination of the scientific enterprise reveals that science is more than just information and processes. It involves imagining and creating, feeling and valuing, using and applying, and forming a world view. These aspects form the other domains of science namely, creativity, attitudes, applications, and the world view of science (Yager & McCormack, 1989).

Why is learning in multiple domains of science important? If science involves more than just information and processes, students need to learn about the other domains in order to develop a holistic understanding of science and to develop attributes which would enable them to do science themselves. Science education which focuses only on information and processes provides an incomplete picture of science and is deficient in developing attributes which would help students become involved in doing science. Considering the importance of multiple domains of science in science education, science educators have been advocating approaches to science instruction (including assessment) which would enhance student ability in all of these domains (Harms, 1981; Yager, 1987; Yager & Brunkhorst, 1987; Yager & McCormack, 1989). Furthermore, several current science education reform efforts such as Project 2061 (American Association for the Advancement of Science, 1994) and the National Science Education Standards (National Research Council, 1996) strongly advocate science education which incorporates instruction in multiple domains. For instance, the National Science Education Standards identify the 'nature of science' as a separate area of science content standards. They also identify 'science in personal and social perspectives' as an area of science content standards, which directly relates to the application domain. Instruction in multiple domains of science is not only important for students to become better scientists but also for them to understand and deal with the impact of science on our everyday lives. In other words, education in multiple domains of science is far more desirable than education in scientific facts and processes alone.

How can teachers be prepared to impact student learning in multiple domains of science? A teacher education program designed to meet this goal must deal with two aspects. First, the program needs to help students see that science has multiple domains. Most of the discipline-specific science education that students receive in college focuses on information and process domains. Thus, they bring a narrow-minded perspective of science to the teacher education program and would enter the 'real-world' of teaching with the same perspective unless the teacher education program does something to change that perspective.

One of the best ways to change this narrow-minded perspective is to get student-teachers involved in science activities in which they are required to ask new questions, explore resources to find answers, generate and test hypotheses, and share and discuss their findings both in terms of their experience with the activity and how they could apply the process in science classrooms. Designing cartesian divers for different sets of conditions; clay boats that would hold increasingly more weight than their own without sinking; candle suffocation experiments; and activities with batteries, bulbs, and wires are just a few examples of a number of activities that could be used for this purpose. Such activities would help student-teachers see that science involves more than just memorizing facts or developing specific skills such as the use of a microscope. They would help student-teachers see the creative aspect of science, the importance of applying to new situations what one already knows, and develop a better understanding of the nature of science as they take each activity to greater level of complexity or use them to answer new questions related to the concepts they are designed to explore. Of course, only one or two experiences with these activities will not suffice. The program must be infused with multiple opportunities for engaging in such activities throughout the duration of the program.

Discussions following the activities are extremely important. One cannot simply hope that doing these activities would suddenly enlighten the participants regarding multiple domains of science. They need to be engaged in discussions that would require them to reflect upon the experience and how it relates to the real-world of science. These discussions should focus on identification of various domains of science through questions (raised both by the instructor and students themselves) which would serve to analyze the activities in terms of the domains. As appropriate and possible, student-teachers should be asked to relate their experiences of these activities to professional scientific research to identify the domains in professional science. The discussions should also consider strategies regarding the use of these activities (and others like them, which the student-teachers will design or locate from available resources) in ways that would help their students see the multiple domains of science which they can learn and practice in their own lives.

Apart from making them aware of the multiple domains of science, the teacher education program must also prepare student-teachers to assess student learning in multiple domains of science. This can be accomplished by asking student-teachers to develop rubrics for assessing growth in each domain within the context of the activities they participate in. Prior to the development of rubrics, the instructor would have to help student-teachers get an understanding of what rubrics are all about and what kind of items might be appropriate for inclusion in the rubrics for each domain. This understanding can be developed by the instructor providing specific research information and leading students in discussions of this information. Whenever students engage in an activity meant for broadening their perspective of science, they should be asked to design rubrics for assessing growth in multiple domains of science through that particular activity. This would help them practice how to assess student growth in multiple domains of science. Then, during the teaching experiences, they must be required to design assessment items or activities for each domain during every unit of instruction they undertake. Required assessment in multiple domains will ensure that they get into the habit of providing science experiences to their students which enhance learning in multiple domains of science and then assessing this learning.

Compared to the craftsperson type teacher, professional science teachers who teach science to impact student learning in multiple domains, whose instructional strategies are based upon research-based rationales, and who are reflective about their practice would do a better job of implementing the quality of science education promoted by current national reform efforts. Professional teachers of this sort are a critical need of our times.

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References

American Association for the Advancement of Science. (1994). *Science for All Americans.* New York, Oxford: Oxford University Press.

Baird, J. R., Fensham, P. J., Gunstone, R. F. & White, R. T. (1991). The importance of reflection in improving science teaching and learning. *Journal of Research in Science Teaching,* 28(2), 163-182.

Calderhead, J. (1989). Reflective teaching and teacher education. *Teaching and Teacher Education,* 5(1).

Clough, M. P. (1992). Research is required reading. *The Science Teacher,* 59(7), 37-39.

Danielson, C. (1996). *Enhancing professional practice: A framework for teaching.* Alexandria, VA: Association for Supervision and Curriculum Development (ASCD).

Dewey, J. (1904). The relation of theory to practice in education. In C. A. McMurry (Ed.), *The relation of theory to practice in the education of teachers* (Third yearbook of the National Society for the Scientific Study of Education, Part I). Chicago: University of Chicago Press.

Dewey, J. (1910). *How we think.* Boston: D. C. Heath and Company.

Harms, N. C. (1981). Project Synthesis: Summary and implications for teachers. In N. C. Harms & R. E. Yager (Eds.), *What Research Says To The Science Teacher,* Vol. 3, (pp. 113-127). Washington, DC: National Science Teachers Association.

Hullfish, H. G., & Smith, P. G. (1961). *Reflective thinking: The method of education.* New York: Dodd, Mead and Company.

LaBoskey, V. K. (1993). Why reflection in teacher education? *Teacher Education Quarterly,* Winter 1993, 9-12.

National Research Council. (1996). *National science education standards.* Washington, DC: National Academy Press.

Penick, J. E. (1985). *The formal operational teacher.* An unpublished paper.

Yager, R. E. (1987). Assess all five domains of science. *The Science Teacher,* 54(7), 33-37.

Yager, R. E. & Brunkhorst, B. J. (1987). The Iowa STS project: Student growth in a variety of domains. In K. Riquarts (Ed.), *Science and Technology Education and the Quality of Life,* Vol. II (pp. 641-648). Keil, Federal Republic of Germany.

Yager, R. E. & McCormack, A. J. (1989). Assessing teaching/learning successes in multiple domains of science and science education. *Science Education,* 73(1), 45-58.

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