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ABSTRACT

This article aims to: (1) improve novice and experienced science teachers' understanding of contemporary pedagogical research, its value in improving classroom practice, and how to effectively communicate this in an interview; (2) improve administrators' interviewing practices so that exemplary candidates stand out from other candidates; and (3) improve science teacher education programs so that their preservice teachers become exemplary science teachers. Research is cited that explains and describes exemplary science teaching, exemplary science teacher education programs, and identifying exemplary science teachers. Thirteen productive interview questions are provided with sample answers from a solid candidate and a dubious candidate. Also included is a chart of the components of a research-based rationale for teaching science, lists of desirable teacher and student attributes, and a discussion of the implications that these points hold for science teacher education. Contains 54 references. (DDR)

Preparing and Hiring Exemplary Science Teachers

by

Michael P. Clough
Craig A. Berg

PREPARING AND HIRING EXEMPLARY SCIENCE TEACHERS

by Michael P. Clough and Craig A. Berg

For the second consecutive decade, science education in the United States has been identified by science educators to be in crisis (AAAS 1989; Aldridge 1989; APA 1993; Hurd 1990; Penick and Yager 1986; Staver and Small 1990; Yager 1980; Yager and Penick 1987). Since 1980, well over one-hundred articles have been published concerning our citizen's lack of science literacy and the perceived crisis in science education. Yager and Penick (1984), comparing students' perceptions reported during the 1978 National Assessment of Educational Progress (NAEP) with another sample reported in 1983 (Hueftle, Rakow, and Welch 1983), conclude that students see science classes as dull, no fun, and a place they do not wish to be. The 1986 NAEP report indicated that "roughly 33% of seventh and eleventh-graders described their science classes as often or always boring" (Weiss 1993). And the more years students enroll in science courses, the less they like it (Yager and Penick 1986). More condemning is the data indicating that approximately half the surveyed students felt their science knowledge was useless outside of school. Even after almost a decade of reform, the 1990 NAEP data (National Center For Education Statistics 1992) paints a severely depressing picture of science education in America. Hands-on activities and investigations are infrequently used, and the United States has the disconcerting distinction of ranking first in frequency of textbook reading as a means of instruction (Lapointe, Mead, and Phillips 1989).

This ongoing crisis in science education is due to many factors. Acquiring talented, innovative, and energetic science teachers for our nation's schools would certainly help resolve this crisis. Unfortunately, securing such science teachers is not easily accomplished given poor hiring procedures and too many archaic science teacher education programs. This article has three major aims: 1) improve novice and experienced science teachers' understanding of contemporary pedagogical research, its value in improving classroom practice, and how to effectively communicate this in an interview; 2) improve administrators' interviewing practices so that exemplary candidates stand out from other candidates; and 3) improve science teacher education programs so that their preservice teachers become exemplary science teachers.

EXEMPLARY SCIENCE TEACHING AND EXEMPLARY SCIENCE TEACHER EDUCATION PROGRAMS

Despite the general crisis in science education, pockets of undeniable excellence do exist as illustrated by the very popular *Focus on Excellence* monograph series (Bonnstetter, Penick and Yager 1983; Penick, Yager, and Bonnstetter 1986; Penick and Yager 1983; Penick 1983a; 1983b; Penick and Bonnstetter 1983; Penick and Lunetta 1983; Penick and Meinhard-Pellens 1984) and work by Tobin and Fraser (1987; 1989; 1990). Reform suggestions usually revolve around teaching less content, but with more depth, allowing students to make more decisions about *how* to learn, emphasizing design of experiments rather than following recipes, and applying knowledge rather than merely learning as an academic exercise. All reforms have stressed understanding the nature of science, and, without exception, all have sought science literacy including an appreciation of science and the scientific enterprise. The difficulty is in preparing teachers to understand and implement exemplary teaching.

Model science teacher education programs consistently prepare teachers to implement exemplary teaching (Krajcik and Penick 1989; Penick, Yager, and Berg 1988). These particular programs require considerable coursework and clinical experience (lasting three to four semesters) that reflects and models the healthy body of available pedagogical research. Extensive classroom experiences concurrent with these education courses provide necessary opportunities to become proficient at implementing research-based teaching strategies. However, far too many science teacher preparation programs fail to: 1) require the extensive course and field work necessary to understand and implement exemplary teaching; 2) link education coursework to practicum experiences, and 3) model exemplary teaching. Consequently, practicing teachers often complain about their teacher preparation. Scales (1993) writes that many teachers do not believe their teacher education program sufficiently addressed concrete implications for the creation of curriculum and use of various instructional techniques. The sorry state of many science teacher education programs has prompted Moore (1994), editor of *The American Biology Teacher*, to call for the elimination of the education major! However, while accurately stating that many K-12 science teachers are inadequately trained, Moore did not address the real problem in science teacher education - that far too many programs bear no resemblance to model programs. What are the characteristics of exemplary teachers that science teacher education programs should be promoting, and when properly prepared, how can administrators identify them in an interview?

IDENTIFYING EXEMPLARY SCIENCE TEACHERS

The recognition that poor teacher education programs and hiring practices sometimes result in thousands of students experiencing years of mediocre science teaching necessitates a thorough look at interviewing strategies. Resolving the crisis in science education will be a battle waged on many fronts by many determined individuals. Concerned administrators who make the time to improve their interviewing procedures and expectations for prospective employees will make important contributions, not only for their school and students, but also for science education in general. Science teachers who take the time and effort to understand and effectively implement exemplary teaching need to learn how to make themselves stand out in the interviewing process.

Interviews for teachers typically center around factors such as character, reasons for teaching, personality, prior teaching experience, and discipline. Each of these are extremely important, but missing is an interrogation into what a prospective employee knows about exemplary science teaching, and how the candidate would implement such a program. What follows is a description of an interview that would assess a candidate's ability to implement an exemplary science program (NSTA 1983-87; Bonnstetter, Penick and Yager 1983; Osborne and Freyberg 1985; NSTA 1987; Yager, Hidayat, Penick 1988; Penick 1991; Yager 1990; Berg and Clough 1991a; 1991b; Yager 1991; 1993; NABT 1992a; 1992b). Teachers will find these questions useful in preparing themselves to understand the attributes of exemplary science teachers and programs. After all, teachers make exemplary programs (Penick, Yager, and Bonnstetter 1986)!

Interview questions are carefully phrased so as not to cue a particular response. Each question is followed by a rationale for asking the question, a response indicating an awareness of contemporary research concerning effective science instruction and exemplary science programs, and a response indicating lack of knowledge concerning effective science instruction and exemplary science programs. Although few candidates will fit the extremes provided, the type, thoroughness, and consistency of a candidate's responses indicates a great deal about their pedagogical conceptual framework as well as their ability to reflect on teaching. Reflective teaching deserves wide attention (see the March 1991 issue of *Educational Leadership*) because sustained individual and programmatic improvement comes from the identification of a desired state and continual self-evaluation. Essentially, what schools need are science teachers with an extensive research-based rationale for teaching science (Clough 1992).

PRODUCTIVE INTERVIEW QUESTIONS:

Question 1: How would you define learning?

Rationale: The response will indicate a great deal about the conceptual framework from which a teacher is operating.

Solid candidate: Learning is an *active* process in which learners construct meaning from interactions with their environment. This process can be facilitated, but it cannot simply be given to a student. (Emphasis is placed on the learner and how to best facilitate engagement and construction of accepted meaning.)

Dubious candidate: Learning is acquiring knowledge from various sources. The teacher, textbook, and worksheets are examples of sources of knowledge. (Emphasis is placed on knowledge and how to best stuff it in students' heads.)

Question 2: What can you tell me about student misconception research and its implications for teaching science?

Rationale: The response indicates whether the candidate understands the significance of students' prior ideas about science concepts. For example, awareness of student misconception research should affect both the general strategies for structuring lessons and the specific interactions with students.

Solid candidate: Misconception research suggests that students' prior knowledge can greatly accelerate or retard science learning. Misconceptions are strongly held and very resistant to change. For this reason, teachers must continually assess what students are thinking. This is accomplished by asking questions that require students to express their thinking, asking students to make predictions, and always asking them to explain their reasoning. This ongoing process provides the teacher with an assessment of where students are so that future instructional strategies will be tailored to meet students' needs and instructional goals.

Dubious candidate: This candidate will be unfamiliar with the tenets of constructivist psychology, or will not be able to suggest how these tenets would be transferred into the classroom. This candidate will have a difficult time describing the benefits or instructional strategies resulting from a knowledge of misconception research.

Question 3: How will you decide what content, materials, and activities are appropriate for your students?

Rationale: This response will expose a candidate's ability to translate constructivist and developmental psychology into the daily workings of the classroom. Moreover, a candidate should be able to describe what science education professional organizations consider to be essential content.

Solid candidate: Content, materials and activities must be both cognitively and developmentally appropriate for students. Because learning is an active process, the content, materials and activities must be such that students will be engaged both physically <u>and</u> mentally. Activities will typically precede verbal strategies so that <u>both</u> formal and concrete operational learners will have a better chance of grasping the meaning of reading materials and discussions. Science\Technology\Society strategies (Yager 1990) and cooperative learning activities will be commonplace to facilitate meaningfulness, content acquisition and other noble student goals (see figures 1 and 2). Also important are several science education initiatives such as *Science For All Americans* (AAAS 1989) and *Scope, Sequence, and Coordination* (NSTA 1990) which are pushing for less content, and more depth and coherence. Although this candidate understands the need to implement state and district requirements, they do not blindly follow them. Rather, they make research-based decisions to best facilitate deep robust understanding of the fundamental ideas in science, while facilitating the other noble goals of science education.

Dubious candidate: Content will be determined solely by the curriculum and textbook selected. The materials and activities that are fun and best-illustrate the content will be used. Although the candidate may speak of "Hands-on" activities, their definition seems to indicate this means only that students are working with equipment. Moreover, little is said about the other conditions that must accompany activities to facilitate student goals.

Question 4: Describe to me what would be happening in your classroom on a typical day.

Rationale: Can the candidate clearly articulate a desired state of science instruction? Do they know what this would look like in their classroom? If they cannot clearly address this, what are the chances they can implement an exemplary program?

Solid candidate: This candidate expresses a very thorough and clear description of the classroom, activities, and student actions. Students will be active and much discussion will be occurring. This classroom will <u>not</u> be quiet! Students will be seen doing science (predicting, proposing experiments, testing ideas, and making mistakes). This description is congruent with prior responses and those that follow.

Dubious candidate: A general description is provided, but "seeing" this classroom is difficult. Too much emphasis is placed on a quiet environment where students are reading about science, doing worksheets, or listening to the teacher. Experiments, if described, are "cookbook" activities requiring little mental engagement.

Question 5: What are some of your student goals for science instruction, and what is your justification for these goals?

Rationale: Is a candidate's list too narrow, focusing only on content acquisition? How does their list compare to recommendations made by the National Science Teachers Association (NSTA), American Association for the Advancement of Science (AAAS), and other prominent science education organizations?

Solid candidate: A broad list of goals is quickly provided (such as those found in figure 1) indicating that the candidate has given this some previous thought. This candidate readily justifies the list provided.

Dubious candidate: This candidate provides a narrow list of goals (perhaps focussing simply on content acquisition) and seems to have difficulty extending and justifying the list.

Figure 1: Student Goals Consistent With The Desired State of Science Education

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Students will:

- Convey self-confidence and a positive self-image.
- Use critical thinking skills.
- Convey an understanding of the nature(s) of science (i.e. social studies of science).
- Identify and solve problems effectively.
- Use communication and cooperative skills effectively.
- Actively participate in working towards solutions to local, national and global problems.
- Be creative and curious.
- Set goals, make decisions, and self-evaluate.
- Convey a positive attitude about science.
- Access, retrieve and use the existing body of scientific knowledge in the process of investigating phenomena.
- Demonstrate deep robust understanding of science concepts rather than mastery of many insignificant/isolated facts.
- Demonstrate an awareness of the importance of science in many careers.

Question 6: What will you do to facilitate these goals?

Rationale: Answers to questions 5 and 6 can be compare to number 4 for consistency. Also see figure 2 and 3 for features to look for in a response.

Solid candidate: This candidate seizes any goal from question 5 and describes the student actions consistent with that goal. The content, materials, activities, and teacher actions and strategies that would likely facilitate these student actions are described. The candidate may even choose another goal and voluntarily work through that.

Dubious candidate: This candidate clings to content acquisition and rephrases prior responses. Little is said about other goals of instruction, and what is said, indicates a clear lack of thought how to facilitate such goals.

Figure 2: Components of a research-based rationale for teaching science

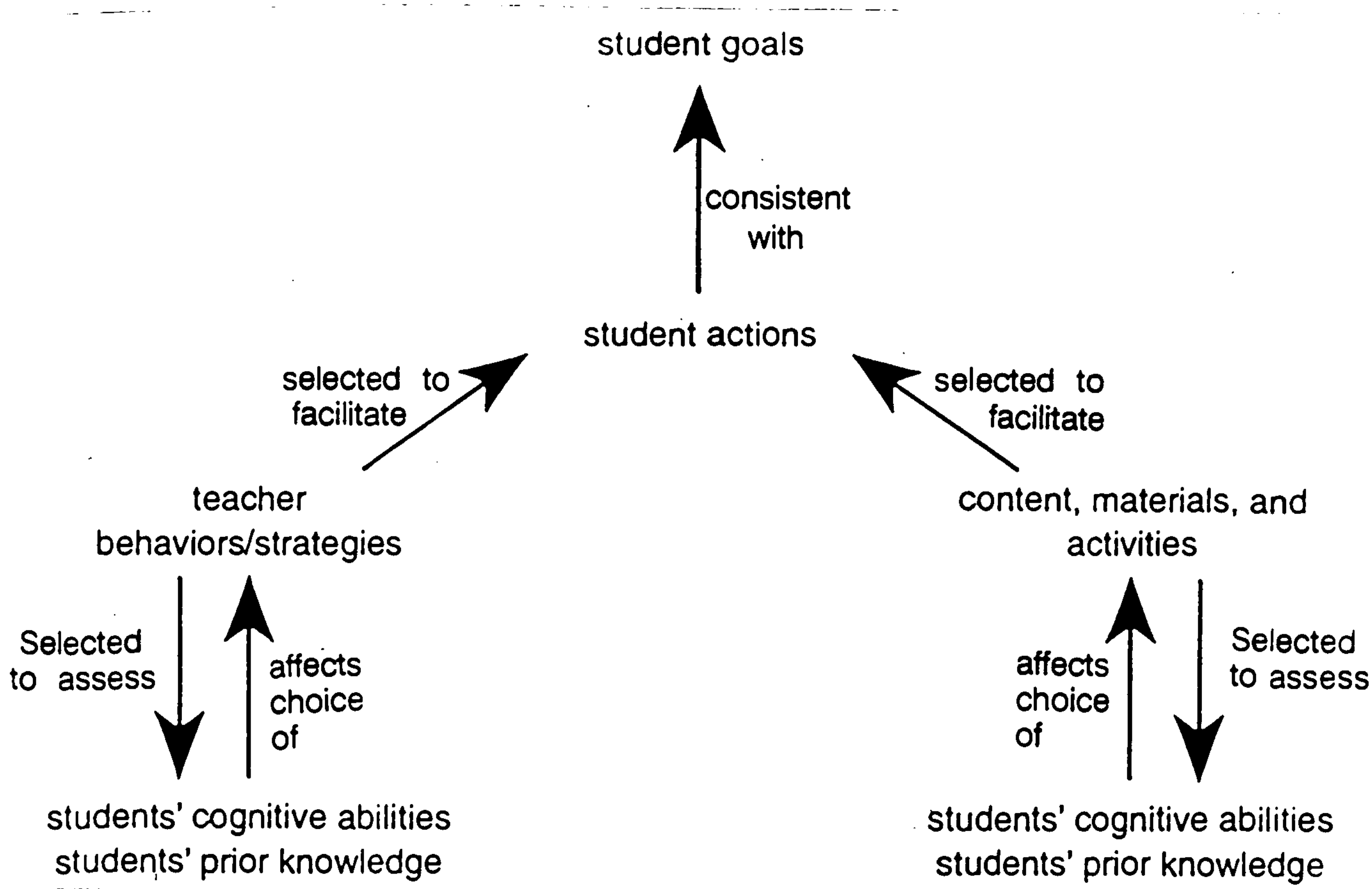

Figure 3 - Student and teacher attributes.

Students should:

- Actively construct knowledge from what they observe and experience during science activities;
- Ask questions, test ideas, interpret data, gather information, challenge ideas, physically and mentally manipulate materials;
- Work with things before reading about them;
- Actively *do* science;
- Identify and solve problems;
- Make decisions concerning their science study and activities
- Not view classroom walls as a boundary;
- View science as having connections to their daily lives;
- Develop communication skills;
- Convey an understanding of the nature of science; and
- Use scientific knowledge.

Teachers should:

- Start with the students' prior knowledge and cognitive development;
- Use instructional practices that indicate the above differences play a central role in pedagogical decisions;
- Expect different students to achieve differently;
- Expect learning to occur over a period of time as opposed to a daily dose of information;
- Provide a hands-on/minds-on science experience;
- Avoid textbook or lecture centered instruction;
- Facilitate many student goals, recognizing that the single goal of content acquisition is, by itself, and empty goal;
- Remain extremely flexible in their time, schedules, and curriculum expectations;
- Require considerable student self-assessment;
- Ask questions, expecting to hear new and often unpredicted answers;
- Recognize that learning occurs through student activity;
- View science content as something more than knowledge that simply exists for student mastery;
- Expect students to question knowledge, teachers, and authority in a respectful manner;
- Focus on problems, questions, and unknowns;
- Not view classrooms as boundaries;
- Frequently focus on societal issues involving science;
- Not force closure.

Question 7: How do you assess your students' progress?

Rationale: What is a candidate's awareness of authentic assessment? How does the response to this question compare to responses to questions 1, 5 and 6?

Solid candidate: Ongoing assessment strategies are recognized as being an integral part of instruction. Attentively monitoring students' verbal and written explanations and reasoning is essential. Both formative and summative assessment are best achieved by observing what students can do with knowledge. For this reason, authentic assessment plays a large role in this candidate's class. Knowledge that can only be regurgitated is dead knowledge. Recitation does not provide a clear picture of understanding.

Dubious candidate: This candidate stresses summative assessment while seemingly ignoring the ongoing assessment that research supports as necessary for effective teaching. Moreover, assessment seems to center on recall of information rather that the use of knowledge.

Question 8: What is teaching? How would you define it?

Rationale: How does this response compare with those beforehand, especially number 1.

Solid candidate: Teaching is a purposeful endeavor in which an environment is set up to facilitate all the student goals listed earlier. Because learning is an active process of constructing meaning, teaching becomes the process of implementing strategies that require students to be engaged physically and mentally in the subject matter.

Dubious candidate: Teaching is the presentation of material in an interesting and orderly fashion. Emphasis here is placed on equating teaching with telling.

Question 9: Approximately how may hours per week will you put into teaching? How will these hours be spent?

Rationale: Does the candidate have a realistic picture of the effort needed to produce and maintain an exemplary program?

Solid candidate: This candidate will stress that the development and maintenance of an exemplary science program necessitates putting in "far more than minimal time," both in and out of school (Bonnstetter, Penick and Yager 1983). The candidate's description of an exemplary science program will make this clear.

Dubious candidate: This candidate will emphasize the time spent grading papers outside of class, but may not visualize the time required to produce and maintain a program consistent with the desired state of science education.

Question 10: What is the value of educational research? How do you use this in your teaching? Provide an example.

Rationale: Many science teachers have misgivings about education research. Few realize how extensive the science of pedagogy has recently become. A large and growing body of research concerning effective teaching does exist, and much of this research is well-established and unambiguous in its implications for classroom practice.

Solid candidate: Exemplary science teaching is undeniably an art, but this candidate recognizes that its articulation is based on a firm foundation of empirical evidence derived from classroom practice. Exemplary teachers draw from a deep knowledge base to make well-founded pedagogical decisions. Education research is valuable for establishing a desired state of science instruction. For example, the National Science Teachers Association has published several monographs on exemplary science programs (NSTA 1983-87) and exemplary science teachers (Bonnstetter, Penick, and Yager 1983). These provide a beginning point to develop an exemplary program here at other schools. This candidate will make clear that their research-based rationale (Clough 1992) provides evidence for most everything done in teaching.

Dubious candidate: This candidate may indicate that research is not particularly useful in the "real world of teaching". He or she suggests that their prior teaching experience contradicts most of the research they have been exposed to. Providing examples of where research is useful in teaching may be difficult.

Question 11: What professional education organizations do you belong to? How active are you in these organizations? How do these help improve your teaching? What is something from a recent journal that you have found useful in your classroom?

Rationale: The response assesses a candidate's commitment to professional development, continued learning, and research-based teaching.

Solid candidate: This candidate most assuredly belongs to two or more science education and general education organizations and reads their journals. The National Science Teachers Association (NSTA) and National Association of Biology Teachers (NABT) are two examples of such organizations. This candidate has attended a state, regional, or national science teacher conference and may have made several presentations. Although the candidate would greatly appreciate full funding for attendance at these professional meetings, he\she is willing to take on some of the burden for their professional development. While commitment to professional development may be demonstrated in other ways, the key here is the depth of professional involvement. Extensive professional involvement has been identified by Bonnstetter, Penick and Yager (1983) as a characteristic of exemplary science teachers.

Dubious candidate: This candidate may belong to a professional teacher organization, but does not come across as being committed to professional development. He\she may be able to cite an activity pulled from a journal, but doesn't see professional organizations as essential to professional growth. This candidate would only attend a state, regional, or national convention if full funding was provided.

Question 12: How do you evaluate or assess your teaching? How will you know if you are a successful teacher?

Rationale: Sustained individual and programmatic improvement comes from the identification of a desired state and continual self-evaluation.

Solid candidate: Audio and videotaping are immensely valuable in determining how the actual state of instruction matches the desired state. This candidate analyzes videotapes for student actions, teacher actions and strategies, teacher/student interactions, time-on-task, and students attitudes towards science. Although interested in student rapport and summative student evaluations, emphasis on daily self-evaluation indicates this teacher is a reflective practitioner. Personal evaluation is seen as an opportunity to clearly articulate teaching as a profession.

Dubious candidate: This candidate stresses student rapport and summative test scores, failing to consider daily self-evaluation. A short list of assessment items is provided, and an uncomfortable feeling with personal evaluation is recognized.

Question 13: What are two teaching behaviors you need to improve? How do you plan on improving these behaviors and how will this improve your teaching?

Rationale: Is the candidate a reflective teacher?

Solid candidate: Regardless of the candidate's ability, thorough and consistent self-evaluation empowers him or her to readily identify needed improvement, a rationale for the improvement, and a plan of action.

Dubious candidate: Behaviors, although identified, are not clearly articulated. No rationale for improvement is provided and the candidate has to pause and speculate on what they might do to improve. The response indicates a non-reflective practitioner.

IMPLICATIONS FOR SCIENCE TEACHER EDUCATION:

Administrators adhering to our call for more interrogative interviewing strategies may find that few science teachers are clearly well prepared. Quite frankly, most preservice science teacher education programs do not effectively prepare science teachers to implement research-based exemplary science instruction. Goodlad (1990), as well as others (Goodlad *et al.* 1990; Darling-Hammond 1990; Darling-Hammond and Goodwin 1993; Zeichner 1986), have made strong cases for improving preservice teacher education programs in general. The recent activity of the Association for the Education of Teachers in Science (AETS 1993) is an acknowledgment that reforming science teacher education is imperative if we are to resolve the crisis in science education.

However, effective teachers can be consistently produced by quality preservice science teacher education programs such as the highly regarded one at the University of Iowa (Krajcik and Penick 1989; Penick, Yager, and Berg 1988; Yager, Lunetta and Penick 1980; Tamir 1976). Although this program requires considerable commitment from the science education faculty and the university, other preservice science teacher education programs would be more likely to implement the extensive training required to produce exemplary science teachers if pressure were placed on them to do so. If administrators become aware of the characteristics of exemplary science teachers and programs, and make preservice science teacher education programs aware of these expectations, all sides will win. Goodlad's (1990) vision of the teaching profession and teacher education will only become a reality with pressure from many sources, including the K-12 schools. Administrators will improve their chances of acquiring the best science teachers for their students, and help push for reform in preservice science teacher education, by carefully considering their interviewing procedures for prospective science teachers.

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