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ABSTRACT

A science laboratory skills performance assessment for elementary and secondary school science teachers in California, using a multi-methods approach, is described. Seven domains of teacher performance identified included: pedagogy, content, materials and equipment, management, knowledge of students, climate, and communication. Within each domain, between two and nine elements/categories of performance were identified. For each element, indicators that describe specific teacher knowledge, skills, and behaviors were written for use in assessing performance. Student behaviors that reflect teacher performance in certain areas were included as part of some indicators. Domains, elements, and indicators are the basis of the assessment. The primary data collection method used was observation; other methods used include interviews and questionnaires. Selection and education of observers insures a contingent of experienced, well-trained evaluators. The 2-day training includes review of the evaluation technique; role play; and group review of procedures, guidelines, and videotapes of acceptable and unacceptable performance levels. Trainers assess each trainee on properly conducting a conference, using prompts and recording responses, recording evidence and notes properly for the observation, sorting the information by elements in a reasonable manner, making sound remarks and judgments based on the information, and filling in forms in a clear and complete manner. (TJH)

Assessment of Laboratory Skills of Science Teachers via a Multi-Methods Approach

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Background

In its report, Who Will Teach Our Children? A Strategy for Improving California's Schools, the California Commission on the Teaching Profession (1985) recommended that the State have a credentialing process that includes three assessment components: an assessment of general knowledge prior to entry into a teacher education program, a test in the subject-matter field at the completion of the program, and a series of on-site assessments of new teachers who would be in a "residence" status before being fully credentialed.

Current assessment requirements for teacher credentialing in California include the California Basic Educational Skills Test (CBEST), the NTE Core Battery, and the NTE Specialty Area Tests. These tests have been reviewed by California teachers and teacher educators in recent years in terms of their appropriateness for use in the credentialing process (Wheeler and Elias, 1983; Wheeler, et al., 1988). The reviews were undertaken primarily because of added testing requirements instituted by the California Legislature, the increase in the number of credential candidates taking the NTE examinations in California, the increased demand for new teachers, and the general concern about improving teacher assessment in subject-matter knowledge and teaching ability.

California has relied on a program approval model for candidates attending in-state teacher education institutions (Commission on Teacher Credentialing, 1988). However, it is now generally

accepted that: "...individual assessment provides a better way of evaluating the capabilities of potential teachers than does program approval" (Goertz, Ekstrom, and Coley, 1984, p.iii). The California Teacher Credentialing Law of 1988 calls for "Deregulation of the academic training of teachers by shifting the emphasis from granting credentials on the basis of program approval to granting credentials on the basis of comprehensive assessments of individual candidates" (Section 44279.3,b.5). The pilot testing of existing performance and alternative assessments (Estes, et al., 1990) and the development of prototype assessments under the California New Teache -oject (CNTP) are two steps in making the change from the program approval model to the candidate assessment model.

The 1987-88 review of fifteen NTE Specialty Area Tests by over 400 California educators pointed out some major concerns with these tests. First, there is strong need to augment, or in some cases, replace the multiple-choice tests with some type of performance assessment. Second, several of the multiple-choice tests do not match the California curriculum frameworks as closely as the reviewers felt they should and therefore need to be replaced or supplemented by tests that provide a more comprehensive coverage of the frameworks. (Wheeler, et al., 1988)

The California Legislature, in the California Teacher Credentialing Law of 1988 (Chapter 1355 of the Statutes of 1988), provides support for developing alternative methods for assessing beginning teachers. "...the Commission shall establish procedures to assess the teaching performance of beginning teachers on a regular basis by on-site visits of assessment teams or through the use of uniform exercises in a controlled setting, or both..." (Section 44279.6). As part of this effort, five innovative assessments were pilot-tested in the spring of 1989 at California New Teacher Project sites (Estes, et al., 1990). Funding was also provided for the development of five new prototype

assessments, including this project for development of a procedure for assessing science laboratory teaching performance of elementary and secondary school teachers, for pilot testing in the spring of 1990.

Science as the Focus of the Assessment

Science was chosen as the focus of this assessment for several reasons. In an era of rapidly developing technology and worldwide competition, the development of future mathematicians, scientists, and engineers remains a national priority. In order to develop top scientists, we need quality science teachers, starting at the elementary school level. The importance of scientific literacy and the need for educational reform to start with children in kindergarten are emphasized throughout the Project 2061 report (American Association for the Advancement of Science, 1989).

A study of the data for sixth graders from the California Assessment Program (CAP) found that higher amounts of time allocated by schools to science instruction were associated with higher CAP performance levels in reading, mathematics, and writing, even for low SES schools (Wheeler, 1986-87). Quality science instruction provides an opportunity for students to improve skills in these three areas as well as to develop more advanced thinking skills (e.g., analysis, comparison, inference, evaluation), which are receiving increased attention of curriculum specialists (Quellmalz, 1985) and policy makers.

As part of their effort to improve the quality of California's teaching force, the Commission on Teacher Credentialing has been reviewing the credentialing requirements. Part of this effort was a review of the NTE Specialty Area Tests. The tests in Biology and General Science and in

Chemistry, Physics, and General Science were reviewed by 34 and 25 California educators, respectively. The reviewers were highly trained and very experienced teachers and teacher trainers from throughout the State of California. Not only did they review a current test, item by item, and the test specifications, but they were also asked to comment on those aspects of the credentialing process for their subject area that needed to be changed. The recurring concern expressed by reviewers of both science tests was the need to assess laboratory demonstration and presentation skills and lab safety. Although some felt aspects of lab safety could be tested on a multiple-choice test, all agreed that laboratory presentation and demonstration skills of credential candidates could only be evaluated through a performance assessment or an observation of the teacher conducting a science laboratory activity (Wheeler, et al., 1988).

The national need for highly trained scientists; the importance of science instruction for developing students' basic skills in reading, mathematics, and writing as well as more advanced thinking skills in these and other areas; and the concerns of many California teachers and teacher educators who reviewed the NTE science tests that laboratory demonstration and presentation skills and lab safety be evaluated as part of the credentialing process led to this project. Having such an assessment for use with new teachers should address all three reasons listed above.

Development of the Assessment

Several sources of information were utilized in developing the materials and procedures for this assessment. These include reviews of the literature on effective science teaching, other teacher performance assessment systems, textbooks on science teaching methodology, California's curriculum guides and framework for science, and California's standards for new teachers.

Most research on effective teaching looks at teacher-centered instruction and few studies focus specifically on science teaching or on student-centered teaching situations such as hands-on science lab activities. White and Tisher (1986), however, in their review of research on science teaching identified conditions that were found to contribute to a science lab. These were student involvement in and control over the activity, and student interaction with the teacher and with other students.

A set of studies of science teachers in Australia, by Tobin and Garnett, found that science teachers identified by other educators as exemplary shared the following characteristics. They exhibited adequate pedagogical knowledge, with the secondary teachers exhibiting much stronger content knowledge than the elementary teachers. The secondary teachers were also able to explain scientific phenomena, demonstrate scientific principles, expand on student learning of given scientific concepts, and probe student understanding to diagnose partial understandings and misunderstandings. The major goal of the instruction of these exemplary teachers was to improve student understanding. They used laboratory activities and concrete models as essential means by which to attain this goal. Each lesson was carefully related to previously learned material and real-world applications. The teacher asked many questions and encouraged the students to ask questions. Students were provided with feedback on their progress. In addition to their instructional skills, these teachers had strong classroom management skills which led to high levels of student engagement. By moving around the room, the teachers monitored student understanding, engagement and behavior (Garnett and Tobin, 1988; Tobin, 1987; Tobin and Garnett, 1988).

In our review of observation assessment materials from nine states, the following aspects of

effective teaching were found to be emphasized. Planning should be carried out so as to achieve selected objectives and take into account the individual differences of students. Instruction should be related to these objectives; appropriate to the content, objectives and students; and motivating. A variety of teaching methods should be employed to promote student engagement. Control of student behavior and consistency are important aspects of management. Evaluation should be used to monitor the effectiveness of and to improve instruction as well as to obtain information about the progress and needs of students. The learning environment should be positive, setting high expectations for students, working to improve learners' self concepts, and encouraging student learning and enthusiasm for learning. Communication should include feedback to students. Organization of time, space, materials, and equipment should provide accessibility and an attractive and orderly environment. The teacher's presentation of content should be accurate and relevant to other topics. The teacher should set good examples of reading, writing, and speaking skills.

Over 100 California science educators, who were invited to serve on this Project's Science Assessment Development Committee or to be reviewers of this Project's materials, were asked to describe the purpose of laboratory work in their science classes. Their responses fell into several major areas. A good science lab enables students to understand scientific methods and the nature of research and experimentation. It also provides a structure for learning science content. As reinforcement or an alternate approach, it increases the learning of science content taught by other methods. The science activity serves to increase student interest in and improve student attitudes toward science. By experiencing science, students learn to better understand and appreciate their environment. Another valuable benefit they listed is that laboratory skills and safety are developed through a science lab activity. Additionally, the lab serves to encourage higher-order thinking skills, promote group work and cooperation, and develop skills in other subject areas.

The September 1989 draft of the California Science Framework (Science Curriculum Framework and Criteria Committee, 1989) sets forth the following expectations for science programs in California's public schools:

1. The major themes underlying science, such as stability, patterns of change, evolution, systems and interactions, scale and structure, and energy, are developed and deepened through a thematic approach.
2. The three basic scientific fields of study--physical, earth, and life--are addressed, ideally each year, and the connections among them are developed.
3. The character of science is shown to be open to inquiry and controversy, and free of dogmatism; the curriculum promotes student understanding of how we come to know what we know and how we test and revise our thinking.
4. Science is presented in connection with its applications in technology and its implications for society.
5. Science is presented in connection with students' own experiences and interests, frequently using hands-on experiences that are integral to the instructional sequence.
6. Students are given opportunities to construct the important ideas of science, which are then developed in depth, through inquiry and investigation.
7. Instructional strategies and materials allow several levels and pathways of access so that all students can experience both challenge and success.
8. Printed materials are written in an interesting and engaging narrative style; in particular, vocabulary is used to facilitate understanding rather than as an end in itself.
9. Texts are not the sole source of the curriculum; ordinary materials and laboratory equipment, video and software, and other printed materials, such as reference books,

provide a substantial part of student experience.

10. Assessment programs are aligned with the instructional program in both content and format; student performance and investigation play the same central role in assessment that they do in instruction.

The California Standards of Pedagogical Knowledge and Competence for Beginning Teachers have criteria in the following for new teachers: Student Rapport and Classroom Environment; Curricular and Instructional Planning Skills; Diverse and Appropriate Teaching; Student Motivation, Conduct, and Involvement; Presentation Skills; Student Diagnosis, Achievement, and Evaluation; Cognitive Outcomes of Teaching; Affective Outcomes of Teaching; Capacity to Teach Crossculturally; Readiness for Diverse Responsibilities; and Professional Obligations. (Commission on Teacher Credentialing, 1988)

Expertise is provided to the assessment development staff by a consultant and a committee of ten, all of whom teach science in public elementary or secondary schools in Northern California. They have several years of teaching experience and have worked with student teachers and as mentor teachers. The materials developed for this project were reviewed by over 60 California science educators in January 1990 and tried out by committee members in classrooms and with video tapes. Based on the comments of the reviewers and committee members, the materials were revised for use in the pilot testing, being conducted by Far West Lab in the spring of 1990.

Description of the Assessment

We identified seven Domains of teacher performance to be covered by this assessment. They are:

Pedagogy, Content, Materials/Equipment, Management, Knowledge of Students, Climate, and Communication. Within each Domain, between two and nine Elements, or categories of performance, were identified. The list of Domains and Elements is shown in Table 1.

TABLE 1

List of Domains and Elements

California New Teacher Project's
Science Laboratory Assessment

A. PEDAGOGY
- A1. Planning
- A2. Sequence
- A3. Prelab
- A4. Directions
- A5. Explanation/Presentation
- A6. Monitoring/Adjusting
- A7. Feedback
- A8. Questioning
- A9. Closure

B. CONTENT
- B1. Accurate
- B2. Integrated
- B3. Related to Objectives

C. MATERIALS/EQUIPMENT
- C1. Teacher Use
- C2. Safe Setup
- C3. Safe Practices
- C4. Availability

D. MANAGEMENT
- D1. Grouping
- D2. Other Personnel
- D3. Routines and Transitions
- D4. Student Engagement
- D5. Timing
- D6. Student Behavior
- D7. Lab Cleanup

E. KNOWLEDGE OF STUDENTS
- E1. Diversity
- E2. Student Characteristics

F. CLIMATE
- F1. Interactions with Students
- F2. Interactions among Students
- F3. Attitudes
- F4. Inquiry

G. COMMUNICATION
- G1. Speaking
- G2. Writing
- G3. Listening
- G4. Strength of Presence

For each Element, Indicators were written that describe specific teacher knowledge, skills, and behaviors for use in assessing performance. Student behaviors, which could reflect teacher

performance in certai ..eas, are included as part of some Indicators. The Domains, Elements, and Indicators are the heart of the assessment. They are the areas in which the observers will collect information for use in making judgments about performance for each of the seven Domains and across all Domains.

Several approaches can be used to collect information on teacher performance. These include: observations, semi-structured interviews, written responses (such as essays or open-ended test questions), structured simulations, and portfolios. Observations were chosen as the primary approach tor collecting information because they are a form of live performance testing and have high face validity for those concerned with ensuring that we have credentialing assessment requirements that are concerned with protecting students from teachers who lack minimal competencies and skills. However, this assessment included two additional approaches--a questionnaire and interviews--to increase the array of information for use in making judgments.

There are a variety of techniques that have been used to collect data and information when using classroom observations. These include checklists, rating scales, coding of behaviors and events, frequency counting, and scripting. For this assessment, we chose guided-note taking. This is similar to scripting in that the observer write out statements of behaviors and events as tney occur. However, the observer also writes notes about what is seen in the classroom setting, and writes these statements and notes in designated areas on the note-taking form during the observation. This approach ensures that evidence and notes are recorded for all Domains prior to the observer leaving the setting of the laboratory activity and also helps the observer sort the evidence and notes related to each Domain for making judgments about performance levels.

The observer uses four assessment components to collect information: (a) the Pre-Observation Questionnaire completed by the teacher, (b) the Pre-Observation Conference with the teacher, (c) the Observation of the teacher implementing a science laboratory activity, and (d) the Post-Observation Conference with the teacher. Three types of information related to the Domains, Elements, and Indicators are collected. They include evidence, notes, and teacher responses. Evidence consists of descriptions and verbal statements of behaviors or events (e.g., Teacher says "..."; Students pick partners for...; Teacher checks worksheet of...). Notes include additional information noted by the observer that will aid in clarifying evidence and making judgments about the teacher's performance in each Domain (e.g., Teacher could be clearly heard in back of room; Two bottles of chemicals were not labeled). The teacher responses are the answers given by the teacher being assessed to the questions listed in the Pre-Observation Questionnaire and asked during the two conferences.

Definition of the Science Laboratory Activity

The focus of the assessment is a science laboratory activity. This is a student-centered, hands-on, inquiry-oriented activity which involves gathering data in a manner appropriate to the topic/concept being investigated and which can be conducted inside or outside the regular classroom or laboratory. A science laboratory activity requires an active role for students. Students are involved in conducting an experiment, in an investigation to gather information, or in collecting and analyzing data and coming to a conclusion or a better understanding of science. A lab activity enhances student learning by allowing students to directly observe and interpret natural or prepared phenomena. If it includes such steps or tasks as the showing of a video tape or film strip, a teacher demonstration, the students learning how to use equipment, a pencil-and-paper problem

solving session, data calculations, or the writing of lab reports, they must be in support of hands-on activities and be only a part of total lab activity.

In order to obtain enough evidence during the observation period, the teachers have been instructed to plan a lab activity lasting a minimum amount of time. The times are 30 minutes for grades K-3, 40 minutes for grades 4-8, and 45 minutes for grades 9-12. These include those prelab and postlab activities which involve students.

Selection and Training of Observers

Observers for the pilot testing the Science Laboratory Assessment have been carefully selected. All have had several years experience as a teacher in California public schools, are knowledgeable about at least one area of science (earth, life, or physical), and have worked with student teachers, as a teacher trainer, or as a mentor teacher. Prior to conducting any assessments, the observers participated in a training program. The training covered the following: background on performance assessment of new teachers in California and the purpose of conducting the assessments; a thorough understanding of the Domains, Elements, and Indicators; familiarity with the assessment components and materials; an understanding of the procedures and awareness of the guidelines for conducting each component; a discussion of simulated responses, evidence, and notes; practice in conducting conferences through role playing, and in doing observations and collecting evidence using video tapes; an understanding of the process for combining the evidence, notes, and responses and using them to make judgments about performance; and a knowledge of the procedures to be followed throughout the assessment process.

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The training for the spring 1990 pilot testing lasted three days. On the first day, the trainees worked on their own, reading the Observer's Handbook, and thoroughly familiarizing themselves with the Domains, Elements, and Indicators, and with the assessment materials, forms, and procedures.

The trainees then met as a group for two days. The trainers reviewed the areas covered on the first day and answered questions the trainees had. Then trainees were provided with a set of simulated responses, evidence, and notes, and discuss the format and the nature of the information collected, its relevance to the Domains and Elements, and the judgments and summary remarks made based on the information.

Next trainees were paired to role play the conducting of a conference. Trainers monitored this activity and assisted them in developing prompts, accurately recording responses, and following the guidelines and procedures in the Observer's Handbook for conducting conferences. Each trainee played the roles of observer and of teacher being assessed.

When trainees completed the activities related to the conferences, they reviewed, as a group, the procedures and guidelines for doing the observation of the science laboratory activity. They then reviewed segments of video tapes and related documents (e.g., questionnaire, conference notes) for different grade levels. They concentrated on collecting evidence and notes for two to three Domains at a time (Pedagogy and Content; Materials/Equipment and Management; Knowledge of Students, Climate, and Communication). The video tape segments included examples of both acceptable and unacceptable performance levels. At the end of each segment, the trainees share

the information they had collected and discussed how they would judge that teacher's performance level, based on the video tape and related documents.

Trainees were then provided with a Questionnaire, and responses to the Pre-Observation Conference, corresponding to a video tape for a full science lab activity. They reviewed the responses to these documents and then observed the video tape activity in its entirety, taking notes for all seven Domains. When they finished viewing this video tape, they were given the responses for the Post-Observation Conference. The trainees linked the evidence, notes, and responses to each Element; entered the information on the Document Sorting Form; and made judgments about performance at the Domain level (2 if minimally acceptable for credentialing or better, 1 if not acceptable, and X if cannot judge because of lack of evidence). They identified those Domains and Elements for which they lacked sufficient information and discussed ways they might obtain it (e.g., examples of "Other Questions" for the Post-Observation Conference). The trainees shared and discussed their evidence, remarks, and judgments until it was clear that they could record evidence properly, develop suitable remarks, and make reasonable Domain judgments. They repeated this process for a video tape of an activity at another grade level. The trainers reviewed each trainee's completed forms for these video tapes. Trainers assessed each trainee on properly conducting a conference, asking prompts and recording responses; recording evidence and notes properly for the observation; sorting the information by Elements in a reasonable manner; making sound remarks and reasonable judgments based on the information for the Document Sorting Form; and filling in the forms in a clear and complete manner.

Summary

Performance assessments extend our ability to measure the complexities of teaching. Although they are far more costly to administer than the currently prevalent multiple-choice tests, they have many more potential benefits. Multiple-choice tests allow us to sample a wide array of knowledge and skills. Performance assessments permit in-depth assessment, can cover the ability to apply knowledge and skills, and seem to better reflect authentic teaching behaviors. They can be used not only for assessing prospective teachers for credentialing and certification; they can also be used in pre-service training, self-assessment, staff development, and teacher evaluation and recognition.

This assessment, and many others, are still in an early stage of development. However, this is an exciting time for exploring alternatives to traditional forms of assessments. Hopefully this move will help attract the strongest candidates to the teaching profession and will improve the preparation, support, development, and retention of teachers in all subject areas.

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