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Competencies of Constructivist Science Teachers

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Introduction

Teachers of science at all grade levels must demonstrate competencies consistent with the achievement of the vision of high quality of science teacher. They should not only demonstrate that they have the necessary knowledge and planning skills to achieve these goals, but also that they are successful in engaging their students in studies of such topics as the relationship of science and technology, nature of science, inquiry in science and science-related issues. Competencies are intended as the foundation for a performance assessment system, through which teacher candidates must satisfactorily demonstrate their knowledge and abilities in the science teacher preparation program. This competencies address the knowledge, skills and dispositions that are deemed important for teachers constructivist courses in the field of science.

Competency 1: Understanding of Science Content

Teachers of science understand and can articulate the knowledge and practices of contemporary science. They can interrelate and interpret important concepts, ideas, and applications in their fields of licensure; and can conduct scientific investigations. To show that they are prepared in content, teachers of science must demonstrate that they:

a. Understand and can successfully convey to students the major concepts, principles, theories, laws, and interrelationships of their fields of licensure and supporting fields.

b. Understand and can successfully convey to students the unifying concepts of science.

c. Understand and can successfully convey to students important personal and technological applications of science in their fields of licensure.

d. Understand research and can successfully design, conduct, report and evaluate investigations in science.

e. Understand and can successfully use mathematics to process and report data, and solve problems, in their field(s) of licensure.

Knowledge within the content discipline is required as the basis for conducting instruction through inquiry and engaging students in effective inquiry.

Competency 2: Nature of Science

Teachers of science engage students effectively in studies of the history, philosophy, and practice of science. They enable students to distinguish science from nonscience, understand the evolution and practice of science as a human endeavor, and critically analyze assertions made in the name of science. To show they are prepared to teach the nature of science, teachers of science must demonstrate that they:

a. Understand the historical and cultural development of science and the evolution of

knowledge in their discipline.

b. Understand the philosophical tenets, assumptions, goals, and values that distinguish science from technology and from other ways of knowing the world.

c. Engage students successfully in studies of the nature of science including, when possible, the critical analysis of false or doubtful assertions made in the name of science.

Students should engage in active investigation and analysis of the conventions of science as reflected in papers and reports in science, across fields, in order to understand similarities and differences in methods and interpretations in science, and to identify strengths and weaknesses of findings.

Competency 3: Inquiry

Teachers of science engage students both in studies of various methods of scientific inquiry and in active learning through scientific inquiry. They encourage students, individually and collaboratively, to observe, ask questions, design inquiries, and collect and interpret data in order to develop concepts and relationships from empirical experiences. To show that they are prepared to teach through inquiry, teachers of science must demonstrate that they:

a. Understand the processes, tenets, and assumptions of multiple methods of inquiry leading to scientific knowledge.

b. Engage students successfully in developmentally appropriate inquiries that require them to develop concepts and relationships from their observations, data, and inferences in a scientific manner.

In science education, inquiry may take a number of forms: discovery learning, in which the teacher sets up the problem and processes but allows the students to make sense of the outcomes on their own, perhaps with assistance in the form of leading questions; guided inquiry, in which the teacher poses the problem and may assist the students in designing the inquiry and making sense of the outcome; and open inquiry, in which the teacher merely provides the context for solving problems that students then identify and solve bridge.

These approaches lie on a continuum without boundaries between them. What is common to all of them is that they require students to solve a genuine (to them) problem by observing and collecting data and constructing inferences from data. More advanced forms of inquiry require students to ask questions that can be addressed by research, design experiments, and evaluate conclusions. Teachers who use inquiry effectively tend to be more indirect, asking more open-ended questions, leading rather than directing, and stimulating more student-to-student discussion. Students who learn through inquiry gain a deeper understanding of the resulting concepts than when the same concepts are presented through lecture or readings. This has led to the principle that less is more: teach less, learn more is typical for constructivist science teacher.

Competency 4: General Skills of Teaching

Teachers of science create a community of constructivist learners who construct meaning from their science experiences and possess a disposition for further exploration and learning. They use, and can justify, a variety of classroom arrangements, groupings, actions, strategies, and methodologies. To show that they are prepared to create a community of constructivist learners, teachers of science must demonstrate that they:

a. Vary their teaching actions, strategies, and methods to promote the development of multiple student skills and levels of understanding.

b. Successfully promote the learning of science by students with different abilities, needs, interests, and backgrounds.

c. Successfully organize and engage students in collaborative learning using different student group learning strategies.

d. Successfully use technological tools, including but not limited to computer technology, to access resources, collect and process data, and facilitate the learning of science.

e. Understand and build effectively upon the prior beliefs, knowledge, experiences, and interests of students.

f. Create and maintain a psychologically and socially safe and supportive learning environment.

Science related instruction should be presented in many ways including, but not limited to, cooperative learning, concept mapping, diagramming, model building, role playing, game-playing, simulating, studying cases, questioning, discussing, solving problems, inquiring, field trips, projects, electronic media, written reporting of investigative techniques and data, and reading.

In general, learning a particular concept should involve multiple interactions with various features of the concept. In turn, concepts must be integrated into a coherent network of concepts from which one can make cogent decisions. Teachers must provide learning opportunities requiring multiple interactions with a concept in different contexts.

Candidates should know how to use appropriate technology including, but not limited to, computers and computer peripherals, both to enhance learning and to relate the use of technology to science. The ability of students to use technological tools is becoming increasingly important for collecting and processing data; and for presenting and disseminating the results. In addition to using technology in the science classroom, teachers should also ensure that students understand the role technology plays in professional science.

Teachers of science should be able to determine and use presently held student knowledge to frame and develop new concepts to be learned. Much of what we know about how people learn

has been encapsulated in the epistemology of constructivism. Learners are actively involved in the knowledge construction process by using their existing knowledge to make sense of new experiences. Pre-existing knowledge influences the way new knowledge is added to the individual's conceptual model, modifying its subsequent meaning. To be effective, teachers must learn how to listen and to probe for various conceptualizations, and then use this knowledge to frame the way the concepts to be learned are taught. Pretesting and preconceptions surveys are excellent ways for candidates to determine the prior conceptual knowledge of their students. Candidates should also be able to show how they used prior conceptions and variations in the knowledge of their students to plan instruction in relation to the target concept.

Competency 5: Curriculum

Teachers of science design, plan and implement an active, coherent, and effective curriculum. They begin with the end in mind and effectively incorporate contemporary practices and resources into their planning and teaching. To show that they are prepared to plan and implement an effective science curriculum, teachers of science must demonstrate that they:

a. Understand the curricular recommendations of the National Science Education Curriculum, and can identify, access, and/or create resources and activities for science education that are consistent with the National Curriculum.

b. Plan and implement internally consistent units of study that address the needs and abilities of students.

Curriculum identifies three major dimensions: the intended curriculum (goals and plans), the implemented curriculum (practices, activities, and institutional arrangements) and the attained curriculum (what students actually achieve through their educational experiences).

Well prepared science teachers can plan, implement and evaluate a high quality science curriculum that includes long-term expectations, learning goals and objectives, plans, activities, materials, and assessments. Candidates should know how to effectively use various resources such as news media, libraries, resource centers and the Internet.

Competency 6: Assessment

Teachers of science construct and use effective assessment strategies to determine the backgrounds and achievements of learners and facilitate their intellectual, social, and personal development. They assess students fairly and equitably, and require that students engage in ongoing self-assessment. To show that they are prepared to use assessment effectively, teachers of science must demonstrate that they:

a. Use multiple assessment tools and strategies to achieve important goals for instruction that are aligned with methods of instruction and the needs of students.

b. Use the results of multiple assessments to guide and modify instruction, the classroom environment, or the assessment process.

c. Use the results of assessments as vehicles for students to analyze their own learning, engaging students in reflective self-analysis of their own work.

Constructivist science teachers must feel confident in using authentic assessment it to measure achievement of science. Assessment is not a punitive action; rather it should be a process of learning by teacher and student. Good assessment strategies help students learn about their strengths and weaknesses. Poor assessments result only in a sense of failure or incompetence for sincere students. Reflective teachers help their students identify and celebrate their achievements.

Central to the process of assessment is the concept of alignment: the consistency between goals, actions and assessments. New teachers must learn how to design instruction and assessments that are consistent with multiple goals, not just those aimed at content acquisition. In a climate of positive assessment, learners and their teachers look for evidence to document growth. Diagnostic, formative and summative assessment strategies are woven throughout instruction as a natural part of the classroom activities. Portfolios are often used to collect evidence of growth and change.

Multiple assessment methods including videotapes, demonstrations, practicum observations, discussions, reports, simulations, exhibitions and many other outcomes are useful alternatives to the traditional written test. Peer assessment in cooperative learning groups is especially useful for demonstrating skills using laboratory equipment, and for evaluating process skills such as the creation and interpretation of graphs. Computer-based testing can help students diagnose their own abilities while placing fewer demands on teacher time.

Authentic assessment has also become an important part of science education. It is assessment that mirrors and measures students' performances in 'real-life' tasks and situations. It is also important that teachers be able to involve students in self-analysis. Too often assessment is something done to students. It takes little effort for candidates to include items that require student reflection on tests, projects, or activities they have completed. Conferencing with students using data from their assessments may also be a way of involving students in self assessment as long as the students themselves are doing the assessing.

Competency 7: Safety and Welfare

Teachers of science organize safe and effective learning environments that promote the success of students and the welfare of all living things. They require and promote knowledge and respect for safety, and oversee the welfare of all living things used in the classroom or found in the field. To show that they are prepared, teachers of science must demonstrate that they:

a. Understand the legal and ethical responsibilities of science teachers for the welfare of their students, the proper treatment of animals, and the maintenance and disposal of materials.

b. Know and practice safe and proper techniques for the preparation, storage, dispensing,

supervision, and disposal of all materials used in science instruction.

c. Know and follow emergency procedures, maintain safety equipment, and ensure safety procedures appropriate for the activities and the abilities of students.

d. Treat all living organisms used in the classroom or found in the field in a safe, humane, and ethical manner and respect legal restrictions on their collection, keeping, and use.

Safety and liability are especially of concern to science teachers, given the variety of environments in which they may teach and the materials they may use. Candidates must know how to check and use safety equipment properly and the hazards of improperly shielded equipment, and must be able to avoid risks from fire hazards and biological contaminants. It is also important that candidates actually behave in a safe manner, model ethical and safe behavior, and ensure that students behave safely at all times. They must give proper safety instruction and causations, and must label materials and equipment in such a way as to maintain safety.

Competency 8: Professional Growth

Teachers of science strive continuously to grow and change, personally and professionally, to meet the construstivist needs of their students, school, community, and profession. They have a desire and disposition for growth and betterment. To show their disposition for growth, teachers of science must demonstrate that they:

a. Engage actively and continuously in opportunities for professional learning and leadership that reach beyond minimum job requirements.

b. Reflect constantly upon their teaching and identify ways and means through which they may grow professionally.

c. Use information from students, supervisors, colleagues and others to improve their teaching and facilitate their professional growth.

d. Interact effectively with colleagues, parents, and students; mentor new colleagues; and foster positive relationships with the community.

Teaching becomes a profession when teachers practice with a common knowledge base and apply their knowledge to effective practice Professional teachers must be capable of profound reflection on practice, competent to enter into dialogue of the practice they know and the theory or literature they read; and able to observe, document, and analyze their own practice and experience, and take that analysis into their practice.