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Science Teacher Education: Assumptions, Standards, and Methodology of Science Instruction

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Science Teacher Education: Assumptions, Standards, and Methodology of Science Instruction

A review of Malloy College's teacher education program in New York suggests that future science teachers should be more childlike as they develop their own teaching styles.

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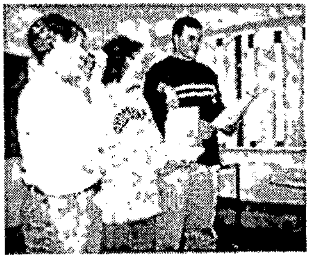

George Nelson, Director of Project 2061 of the American Association for the Advancement of Science (AAAS), suggests that the majority of our nation is not science literate: "In general knowledge of science and mathematics, U.S. 12th graders were among the lowest-scoring students from the 41 nations that participated in the Third International Mathematics and Science Study (TIMSS)" (Nelson, 1999, p. 14). This alarming statistic reflects the great demand for science teachers across the nation, especially in urban areas such as New York City. In New York state, elementary teachers seeking certification are commonly required to take only six credits in science. At the same time, the increasing need to improve the quality and equity of science education is reflected in key documents such as the *Benchmarks for Science Literacy* (AAAS, 1993), the *National Science Education Standards* (NSES) (National Research Council, 1996), and the *New York State Learning Standards for Mathematics, Science, and Technology* (New York

State Education Department, 1996), as presented in Figure 1.

Figure 1.

New York State Learning Standards for Mathematics, Science, and Technology

Standard 1: Analysis, Inquiry, and Design

> Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Standard 2: Information Systems

> Students will access, generate, process, and transfer information using appropriate technologies.

Standard 3: Mathematics

> Students will understand mathematics and become mathematically confident by communicating and reasoning mathematically, by applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, data analysis, probability, and trigonometry.

Standard 4: Science

> Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Standard 5: Technology

> Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.

Standard 6: Interconnectedness: Common Themes

Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning.

Standard 7: Interdisciplinary Problem Solving

Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.

This need to improve science education led us to closely examine our own teacher education program at Molloy College. The skills we hope to equip our teacher candidates with are largely informed by the following five assumptions upon which the NSES (1996) are based:

1. The vision of science education described by the *Standards* requires changes throughout the entire system.
2. What students learn is greatly influenced by how they are taught.
3. The actions of teachers are deeply influenced by their perceptions of science as an enterprise and as a subject to be taught and learned.
4. Student understanding is actively constructed through individual and social processes.
5. Actions of teachers are deeply influenced by their understanding of and relationships with students.

These NSES assumptions became the cornerstones for our review of the implementation of science standards, challenges for teacher candidates, and candidate learning activities, as shown in Figure 2.

Figure 2.

	1	2	3	4	5
UNDERLYING	The vision of	What	The actions	Student	Actions of

ASSUMPTIONS OF NSES	science education described by the *Standards* requires changes throughout the entire system.	students learn is greatly influenced by how they are taught.	of teachers are deeply influenced by their perceptions of science as an enterprise and as a subject to be taught and learned.	understanding is actively constructed through individual and social processes.	teachers are deeply influenced by their understanding of and relationships with students.
CHALLENGE FOR TEACHER CANDIDATES	Providing extensive opportunities for teacher candidates to attain the knowledge and skills to be teachers of excellence as well as develop their own vision for science literacy.	Recognizing the way in which teacher candidates approach the teaching of science often requires a conceptual change.	Teacher candidates must have opportunities to explore their own beliefs about science and the connections to teaching and learning.	Offering opportunities in which teacher candidates and student learners can satisfy their own questions and achieve understanding of the natural world, as well as in a community of learners. Then connecting this understanding to real-life science.	Achieving an understanding, on the part of teacher candidates, that student learner backgrounds, experiences and views of science affect science literacy.

IMPLEMENTATION OF THE ASSUMPTIONS	1. Mastery experiences are provided that promote academic learning in science subject matter. 2. Holistic, interdisciplinary practical and theoretical frameworks are presented. 3. Visions and philosophies for science literacy are shared.	1. Teacher candidates analyze their own science experiences through an autobiography approach (Koch, 1990). 2. A plethora of hands-on opportunities is provided which guide the teacher candidates to experience varied science pedagogical approaches.	Teacher candidates conduct and participate in peer lessons, examining best practices for teaching and learning. Conduct → teaching participate → learning	Each lesson, activity, and discussion must be related to an illustration of that scientific principle in a real life situation.	Teacher candidates learn about developmental levels, as well as issues of diversity.
CANDIDATE ACTIVITIES	1. Research activities, use of technology and interdisciplinary plans are modeled. 2. Conversations, philosophies, and visions for science literacy are shared.	1. Science sharing sessions. 2. Peer lessons. 3. Hands-on inquiry. 4. Field experiences and ideas from partner schools are shared.	1. Peer lessons. 2. Critique of the lesson. 3. Video tape of peer lesson and written reflection.	1. The critique and sharing of journal articles related to science and children, which focus on key issues such as gender, disability, culture or	1. Development of projects that foster sustained science relationships between teachers and students, for instance, journals and conferences. 2. Lesson

				academic ability. 2. Use of the cooperative learning model to construct science literacy. 3. Concept Application of science principles (Discovery model) in all science plans.	plans that include differentiated instruction, legitimate adaptations, and assessments. 3. A range of lessons is developed that are no cost/low cost, use ordinary household materials with prepackaged science labs.

During our exploration of the techniques and tools used to incorporate the NSES assumptions into our teacher education program, themes among the teacher candidate activities emerged. We discovered the most effective techniques employed a practical, hands-on approach to curriculum selection, evaluation, development, and lesson planning. Furthermore, in several activities, preservice teachers engaged in peer review or group interaction and frequently modeled student learning. For instance, in one activity, teacher candidates present personal science autobiographies through both an oral and written history. J. Koch (1996), the creator of this activity, explains the significance of such an exercise: "For methods courses, to meet the needs of elementary teachers, they must explore the experiences and attitudes that students bring to these courses. The science autobiography is a personal writing activity that encourages students to consider their own interactions with the study of science" (p. 42). Students are able to share their favorite science topics, describe their school years in relation to science success, and highlight areas in which they would like to expand their science knowledge. The future teachers made the following comments after completing the activity:

> "I look back and think about some special grade school teachers, but most were straight textbook teachers."
>
> "Science has always been something that has been able to capture my attention."
>
> "I had some problems with science due to its connection to math, but I did have a dream to be a meteorologist when I was a child."
>
> "Mrs. B wrapped a tape measure around the trunk of the tree, and that visual of the tape measure around the tree is what I think about today when asked a question about circumference."
>
> "Since my teacher was never excited about science, that feeling was received by the children."

The science autobiography is used as a tool for reflection and helps teacher candidates realize that in order to meet the new standards, change may be necessary. Understanding their own perceptions, or perhaps their own science biases, is the key to fostering change in their approaches to teaching science in the future.

Another group activity, and a favorite among the preservice teachers, is the science-sharing session. Students pretend they are sharing a key scientific principle with other faculty members at a grade conference. The scientific principle is demonstrated and then elicited from their peers. The idea of exchanging scientific ideas, building on the science ideas of others, and stating the correct scientific concept is both fun and rewarding. It also mirrors the sharing and discussion of children during an inquiry process. Teacher candidates are given the opportunity to share their scientific principle, underscoring the NSES assumption "that what students learn is greatly influenced by how they are taught" (NRC, 1996, p. 28).

The traditional peer lesson is used as a teaching tool in this teacher preparation program as well. The teacher candidates implement their lessons in front of their peers, videotape them, and follow up with a written reflection of their teaching style and effectiveness in meeting their objectives. Through these peer lessons, connections between content areas and the hands-on use of teaching and learning materials are created.

In addition to the peer workshop sessions, preservice teachers participate in concept-development activities, which also allow candidates to walk in the shoes of their future students. The teacher candidates are asked to articulate their perceptions of science, including how they understand time and what a "scientist" is to them. These activities encourage our teacher candidates to examine their own scientific knowledge, beliefs, and attitudes, as well as help them deconstruct these preconceptions, develop alternative conceptions, and understand how these beliefs impact their content knowledge, teaching skills, and dispositions. Moreover, by answering such questions about themselves, teachers realize their students will also be entering the classroom with their own set of preconceived ideas about science. In turn, we hope this realization will serve as a reminder for preservice teachers to approach students as individuals and to avoid making assumptions about what their students know about science.

Lessons Learned in the Process

After this review of our teacher education program, we aligned the *National Science Education Standards* and the *New York State Learning Standards for Mathematics, Science, and Technology* with education course objectives, teacher candidate learning activities, and assessment procedures. We also spoke with the teacher candidates at length, noting their past and current experiences in science education. Two major weaknesses in the program became evident in the benchmark graph, as Standards 1 and 2 were less articulated in the course outline.

First, although the teaching of science became an active process and candidates worked hard to create inquiry-based activities, they failed to pose new questions or seek new answers. We recognized that both student learners and future teachers are indeed influenced by how they are taught. Even when the teacher candidates used the Discovery Model to effectively teach science, they had the "answers" in mind and had difficulty seeking new knowledge.

In an effort to enhance candidates' understanding of investigation and the framework for scientific inquiry, we organized future teachers into small groups in which they would be active learners generating new questions. Furthermore, we incorporated a written reflective component into the assessment process. By using this hands-on approach, we hope to refine future teachers' personal understanding of scientific literacy.

Secondly, a triangulation among the underlying assumptions, the methodology and pedagogy of science instruction, and the applied practice was not always apparent. We found that the vision of effective science education was not reflected in all preservice candidates' teaching experiences. Candidates reported that unless they were placed in a grade where a state science assessment was used, science was often seen as a curriculum "extra." The teaching of an inquiry-based model often did not match the philosophy of the programs in which the candidates did their field work.

Noting the challenges that face teacher candidates as they seek new knowledge for themselves and their students, and providing experiences that allow them to practice their new understandings of science education, helped us to focus on program shortcomings and make changes for the future. In planning for subsequent semesters, the sharing of visions and philosophies will take a greater role as we strive for scientific literacy.

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