n recent years, science departments across the country have played an important role in the preparation of future secondary school science teachers (NRC 2001). Their participation in this enterprise ranges from offering subject-specific teaching methods courses to redesigning courses to model effective teaching practices to developing innovative projects that allow students to integrate the learning of science and pedagogy. These new courses, however, pose additional challenges to the responsible science faculty (ACE 1999). Instructors in these classes must not only create learning environments that engage students in learning science but also must help students think critically about important issues related to learning and teaching.

Ideally, prospective teachers enrolled in these courses should approach science learning from a pedagogical perspective, analyzing common misconceptions and appropriate teaching strategies. Simultaneously, they should approach their teaching practice with a scientific attitude, systematically collecting and analyzing evidence of student understanding to guide their actions (NRC 1996).

At our university, we have developed an innovative teacher preparation program within the College of Science designed to recruit and prepare undergraduate science majors to become secondary level science teachers. The program is the result of the collaborative efforts of different science departments and the College of Education. Students enrolled in the program are required to take seven core science education courses that focus on central topics in the teaching and learning of science. These courses have been designed according to research on teacher preparation and recent calls for reform in science education (NRC 1997; NRC 2001). The strong focus on science education has made the program appealing to an increasing number of high-quality undergraduate science majors who otherwise would not have considered teaching as a career.

The Challenge

One of the pivotal courses in our science teacher preparation program is Curriculum Decisions and Assessment in Science (STCH 420), which focuses on the practical aspects of planning and implementing lessons and assessments in a secondary school science classroom. This course has two main components. Part of the class is taught in the university setting, where we analyze, discuss, reflect on, and gain practice in designing and implementing lesson plans and assessment tools.

As a second component, students are required to work one period a day in a secondary school classroom observing, co-teaching, and teaching the same group of students over an eight-week period in close collaboration with a mentor teacher. During this time, prospective teachers work with their mentors on specific tasks related to curriculum development, lesson planning and delivery, and assessment.

In this course, we create opportunities for prospective teachers to develop a scientific attitude toward teaching. One of the course’s central goals is to help future teachers ground their planning and assessment decisions in the systematic collection and analysis of evidence of student learning. Thus, we constantly encourage students to think critically and logically to establish valid relationships between the collected evidence and their decisions and actions. Attaining this learning outcome has become one of the course’s most challenging tasks.

Despite their scientific background, prospective science teachers in our program approach teaching in an unscientific way. Their actions in the classroom are guided more by their personal beliefs about good teaching practices than by the results of formal investigations about how people learn (Donovan, Bransford, and Pellegrino 2000). They are inclined to make decisions based on what they feel is right, rather than on what educational research indi-
cates is most appropriate for a given context. Most of them do not see the need to uncover real evidence of student understanding, a concept that they find difficult to grasp. Thus, they tend to evaluate the quality of a lesson based on superficial observations of student behavior. Many of our prospective teachers believe that if students are active and having fun, learning is taking place.

Three years ago, we started asking students to complete different research tasks during the eight-week period when they worked in a secondary school classroom. The tasks were designed to help them develop a scientific attitude toward teaching and strengthen their investigative skills. However, our initial attempts failed to focus students’ attention on the systematic gathering and analysis of data as the basis for their judgments and decisions in the classroom.

Prospective teachers needed more guidance and scaffolding to complete the investigations. To our surprise, their work improved when they approached the research tasks from a different stance. The quality and depth of most of their analyses improved substantially when we specifically asked them to assume the role of a journalist investigating the ins and outs of teaching science in their assigned classroom.

The News Reports
Students enrolled in our science education course complete three news reports over their eight weeks of field experience. These reports focus on central issues in planning, assessing, and teaching science lessons. The content and format of each report vary from task to task and are selected to support the development of skills in gathering and analyzing data on teaching and learning. Although the assignments guide students’ investigation, there is ample room for students to select a specific area of interest and to exercise their creativity in completing and presenting their reports. We summarized the central features of each of the research tasks and evaluated their educational strengths.

Newspaper Section (evidence of teacher planning). The first assignment is designed to help prospective teachers identify different sources of evidence and practice a variety of methods of data collection in the classroom. The task is focused on the topic of planning for science teaching, and students present their results in a newspaper format (two-page spread). Prospective science teachers collect evidence of teacher planning in the form of written documents (lesson plans, student guides, and lab manuals), interviews (of teachers and students), direct observations (written descriptions, photographs, and videos), and student work (worksheets, homework assignments, and lab reports). They use this evidence to write short newspaper articles that describe the different ways in which planning manifests in the daily activities in the classroom.

The articles should be carefully crafted to present information only in a descriptive way, avoiding any type of evaluative remarks while clearly citing the evidence used. Imposing this restriction focuses students’ attention on the evidence. Otherwise, they easily forget about the collected data and spend most of their time either expressing their personal opinion about what they observed or providing “tips” about teaching. They may include their opinions as part of a required editorial section, written to provide a critical overview of their investigation’s results. The following excerpt from one student’s newspaper illustrates the appropriate type of description:

Begin at the Beginning:
At the beginning of each class, the students are given some “bell work” to do. This usually involves answering a question that pertains to the previous day’s work. A half sheet of paper is handed out to the students, and they write while the teacher takes attendance. Each morning, the instructional plan is written on the left side of the board.

This assignment not only helps prospective teachers identify and gather useful information in a classroom setting but also it makes them recognize the subtle ways in which good planning affects the learning environment. Many of our students think that teaching is easy when they first arrive in the secondary school classroom. Their experienced mentors seem to run the show without much effort. It is only when prospective teachers face the challenge of looking for evidence to support their claims that they start thinking beyond personal beliefs and surface appearances. It is then that they begin to acknowledge the complexities of science teaching.

Feature Article (evidence of student understanding). To complete their second investigation, prospective teachers prepare a feature article on assessing student understanding for a news magazine. The assignment allows students to evaluate teaching based on the careful analysis of documented evidence of student learning, not on unsubstantiated beliefs and opinions. Their work in this case is focused on gathering evidence of student understanding on a given topic, idea, or concept discussed in the secondary school classroom. We require them to base their analysis on two principal data sources—written student work completed in or outside the classroom and individual interviews with the students in their course.

Using an essay format, prospective teachers carefully analyze any piece of evidence they cite or use to justify their claims. In contrast with their first task, this news report is not based on the description of classroom activities but on the critical analysis of those events using student learning to guide their thinking. Figure 1,
an extract from one student’s article, illustrates the nature of this task. In this excerpt, our prospective teacher analyzes his students’ answers to a question designed to explore their opinions about Lamarck’s theory of adaptation.

Students complete this assignment in the middle of the semester and must apply what they have learned thus far in the course to analyze and evaluate their teaching practices. Their feature article should provide an overview of the types of assessments used in the classroom and the ways assessment is used to collect evidence of understanding. They should also suggest how to use the assessment data to make decisions, provide feedback to their students, help students build connections, or create new learning opportunities. They may also propose lesson modifications based on the evidence they have collected.

Many prospective teachers find this assignment challenging because they are just beginning to learn how to analyze student work. They have a tendency to assess the success of a lesson based on how many students complete the work, rather than on evidence of understanding. They easily attribute student mistakes to lack of effort or attention, without any further analysis.

Although some prospective teachers do not have the scientific background that would help them best identify and analyze students’ misconceptions, the task makes them confront some of their strong beliefs about learning and assessment. They realize how difficult it may be to uncover student understanding and assess what students have really learned (Wiske 1998; Wiggins and McTighe 1998). They also become more sensitive to the need to analyze their students’ work to evaluate the educational efficacy of their lessons.

**Free Format (evidence of educational alignment).** The last research task focuses on teaching strategies and instructional models. For this assignment, students collect evidence from the beginning of their field experience. The central goal is to analyze and evaluate the alignment between the teaching strategies used in the classroom and the central ideas, learning objectives, and assessment instruments associated with each lesson. Prospective teachers are free to select the format in which to present their news report, as long as it differs from that of the previous assignments. Initially, we asked students **FIGURE 1**

**Feature Article. Sample of a diagnostic assessment analysis.**

At the beginning of class, before our discussion of natural selection (but after an activity that illustrates Lamarck’s ideas on adaption), I put the following statement and questions on the board:

Lamarck, an 18th century naturalist, developed a theory to explain how living things adapted to their environments. According to his theory, living things could perceive what they needed to survive via special nerves. When these nerves were stimulated, they in turn activated a substance called the \textit{fluida}, which caused the necessary changes to take place. For example, a giraffe might stretch its neck to reach high leaves, and in so doing the nerves in the neck would be stimulated. These nerves would activate the \textit{fluida}, which would cause the giraffe’s neck to grow. The giraffe would then pass on its longer neck to its offspring.

3. If you were Lamarck, what kinds of evidence would you look for to support your theory?
4. Do you see any problems with this theory’s ability to explain the diversity of life on Earth?

Students were told they would not be graded on the answers to the two diagnostic assessment questions. For this reason they may have felt freer to express themselves, and their answers were quite revealing. The following student answers lend insight into their problems and misconceptions:

“If I were Lamarck I would look at the giraffe’s neck and do tests on the giraffe to see if this were true.”

“The only thing that I see as a problem in this theory is that there is no way he could test all types of animals.”

Students had wildly different ideas about evidence with respect to Lamarck’s theory. Although some mentioned a cause-and-effect relationship or some kind of correlation between observations and theory, few suggested looking for physical evidence. In fact, only two students proposed looking for the \textit{fluida}, even though it was specifically mentioned in the statement written in the board.
to develop a video clip, but the quality of their work was greatly influenced by the nature of the technological resources available. Other possibilities include posters, radio shows, websites, or slide shows.

The successful completion of this investigation requires students not only to analyze data collected over a longer period of time but also to use it to evaluate the extent to which planning, assessment, and instructional decisions are congruent. Assessing this type of educational alignment demands that prospective students cross-examine their evidence while recognizing the fundamental interrelationships among the different components of a lesson or unit.

Prospective teachers who struggle with this task tend to compartmentalize their knowledge about science and teaching into isolated units. Others overemphasize instructional issues while downplaying planning and assessment problems. Overall, this assignment is an excellent tool to assess prospective teachers’ ability to recognize the effect of multiple variables on science teaching.

Other Benefits
Each news report is critiqued in the science education classroom using a peer-evaluation format. Evaluation rubrics designed collectively by us and our students guide the process (Luft 1999). Working in small groups, prospective teachers analyze each other’s work, share ideas and experiences, and explain the reasoning behind their decisions and actions. During a group discussion, they identify common themes and unanswered questions that they share with the rest of the class.

This peer-evaluation format allows students to receive constructive feedback from more than one person in a less threatening or intimidating way than if it were given by the instructors alone. Also, the group process allows prospective teachers to learn from their peers’ successes and failures. In general, teachers are not used to having their work viewed by peers, and this evaluation format is in part designed to show prospective science teachers the benefits of such collaboration.

The news reports tend to be writing-intensive tasks. Many of the science majors enrolled in our course are not skilled in the type of analytical writing that is required and, thus, find these assignments daunting (Jerde and Taper 2004). However, by the end of the semester their writing skills show a vast improvement; most students are better able to communicate and support their ideas, examine claims and supporting evidence, and sustain a focused and coherent discussion. After working eight weeks in a secondary school classroom trying to find evidence of teacher planning and student learning, most students recognize the importance of writing as a way to make their thinking visible both to them and to others who may want to analyze it.

The format of the investigations also allows prospective teachers to exercise their creativity. We encourage them to simulate a real news report by spending some time thinking about basic design elements. Citing common slogans from the local news, we invite them to write a report that is “clear, accurate, and to the point,” or “live, local, and late-breaking.” Many students develop remarkably well-designed reports that reflect both their sense of humor and creativity. However, one potential drawback of these types of exercises is that some students focus too much on the design elements to the detriment of the critical analysis.

An evidence-based approach to teaching is central not only to our course but also is a key thread that runs through our entire science teacher preparation program. A core component of the program is guiding prospective teachers in systematically collecting and analyzing evidence of student learning. We put particular emphasis on the analysis of student work as the basis for evaluating the efficacy of their lessons and deciding the appropriate course of action. The goal is to prepare reflective science teachers who continuously search for evidence of student understanding as a way to make well-grounded decisions to improve their practice.

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References


