This educational project involves prospective science teachers in implementing a natural science course for nonscience majors. Our model creates a space for nonscience majors to experience learner-centered teaching practices while giving prospective teachers an opportunity to apply their science and science education course knowledge and learning.

National and international reports indicate that U.S. secondary school students continue to lag behind students from other countries in their understanding and application of science (NCES 2002). Consequently, the ways in which science teachers are trained have come under intense scrutiny. In particular, results of educational research on teacher education indicate that one of the central challenges in the preparation of prospective science teachers is ensuring that their college coursework is infused with realistic opportunities for them to plan, implement, and assess student-centered lessons that promote meaningful learning (NRC 2001).

To address this central issue in the preparation of future science teachers, we have designed and implemented an educational model that involves prospective secondary school science teachers in all aspects of teaching a natural science course for nonscience majors. The model gives prospective science teachers an opportunity to immediately apply and test their science and science education course knowledge and learning, while creating a space for nonscience majors to experience research-based teaching practices (Donovan, Bransford, and Pellegrino 2002).

The new model: This educational model involves prospective science teachers in implementing a natural science course for nonscience majors. Our model creates a space for nonscience majors to experience learner-centered teaching practices while giving prospective teachers an opportunity to apply their science and science education course knowledge and learning.
course (NATS) for nonscience majors and a science teaching course (STCH) for prospective secondary school science teachers enrolled in the Science Teacher Preparation Program at our university. We expect the model to be easily transferable to the coupling of any standard science teaching methods course and introductory science course at the college level.

We designed the NATS course to introduce freshmen nonscience majors to relevant—and sometimes controversial—topics at the interface of science, technology, and society. The course is structured to engage students in interactive learning activities using the learning cycle as the main instructional model (Lawson 1995). In every session students work in small groups of two to four people on specific hands-on and minds-on activities planned to promote mastery of course content and to develop key thinking and cooperative learning skills.

The focus of the STCH course is to prepare prospective science teachers to develop thoughtful lessons that engage students’ interest while addressing specific learning goals. STCH students are undergraduate science majors typically in their junior and senior year, who have completed at least 18 units of science courses and 3 to 10 units of science education courses. Although the course in its prior offerings had a field component in which students worked for a total of 40 hours in a secondary school classroom, we had little control over the nature of their experience. Thus, not all of the prospective science teachers were exposed to exemplary models of learner-centered teaching practices and many did not develop the teaching knowledge and skills defined in the course learning objectives.

As part of the reformed STCH course, instructors meet with the prospective teachers for 75 minutes twice a week to co-plan and co-assess the daily activities of the NATS class. Prospective teachers also attend every session of the NATS class where they play two major roles:

1. On a daily basis, individual prospective teachers monitor, support, and assess the work of a small group of NATS students (two to four students). In this capacity, the future teachers interact directly with students by stimulating discussions, asking guiding questions, and providing explanations and formative feedback during the various class activities. The prospective teachers also collect the daily work of their assigned students, evaluate their performance using a rubric collectively designed in the STCH class, and provide written feedback to each student on a daily basis.
2. Prospective teachers also assume the primary teaching responsibilities for the NATS class following a pre-defined rotation schedule. Working in small groups of two or three people, they design and implement the lesson plans for three or four sessions of the NATS class during the semester. For each of these lessons they meet several times with the main class instructors to identify the central concepts of a lesson, define the learning objectives, and discuss appropriate instructional activities and assessment tools. The leading teachers are also responsible for presenting a written lesson plan to their classmates prior to the NATS class in which the plan will be implemented. The STCH sessions and the leading teachers are thus used to reflect on and discuss relevant learning and teaching issues using the actual lesson plans as the central object of analysis.

Prospective teachers involved in this project are also expected to continuously reflect on their experiences in the NATS classroom. They are asked to complete weekly entries in an on-line journal where they analyze relevant learning and teaching issues in working with NATS students, and evaluate the lessons implemented during the week. STCH participants also help design and evaluate the main research projects used to assess the NATS students throughout the semester. These assessments and their accompanying evaluation rubric are created collaboratively by the prospective teachers in the STCH class. Once completed, each individual assignment is evaluated independently by two different prospective teachers and later compared in a STCH session to resolve any grading discrepancies. All final instructional and assessment decisions are reviewed and approved by the course instructors who have the ultimate say.

The evaluation of the performance of the prospective teachers involved in the project is done by the main instructors on a weekly basis through constant supervision and analysis of their work. Their grade in the STCH course is based on their attendance and active participation in all of the STCH and NATS class activities (20%); their efforts to provide quality support and continuous formative feedback to their students (20%); the quality of their lesson plans and implementations (20%); their ability to reflect critically on relevant teaching and learning issues (30%); and on the self-assessment of their growth as science teachers as reflected in a personal portfolio where they showcase and reflect on the work they did during the entire semester (10%; see the evaluation rubric in Table 1).

The model’s rationale
Although field experiences should provide prospective teachers with the opportunity to practice instructional decision making, research indicates that initial student teaching experiences tend to focus on routine tasks and motivational concerns rather than on student understanding (Kagan 1992). Moreover, even though prospective teachers learn a variety of instructional models and strategies in teaching methods courses, the transfer of this knowledge to actual classroom practice is strongly linked to whether they have opportunities to experience and reflect on realistic classroom situations (Korthagen and Kessels 1999). The research literature emphasizes the need to transform teacher preparation into a reflective enterprise where prospective teachers make personal connections to what they learn about teaching (Calderhead 1989).
Our new educational model creates such an opportunity for prospective science teachers to practice research-based teaching models in a real college classroom during an entire semester. Although the college and secondary school environments are certainly different, many of the problems associated with teaching science to non-science majors in a university setting are similar to those faced by secondary school teachers (competing course goals, breath-versus-depth curricular dilemmas, basic student misconceptions). The model also offers the advantage of immersing prospective teachers in a community of practice with shared goals, responsibilities, and experiences (Roth and Tobin 2002).

Student teachers rarely have the opportunity to work side by side with an experienced teacher—they normally observe someone else teaching or teach alone. Likewise, they rarely have opportunities to watch their peers actually teach and, in turn, to be observed and critiqued by their classmates. In our approach, prospective teachers and experienced instructors are continuously involved in shared teaching experiences, including planning, enacting, and reflection on curriculum.

The model also offers several important advantages for prospective teachers including increased support, opportunities for ongoing conversation about teaching, and experience in collaborative work to improve practice. The model also benefits the general education students. According to the research literature, co-teaching or team teaching has a positive impact on student learning and improves evaluation and feedback of students’ performance (Anderson and Specke 1998; Murphy, Beggs, and Greenwood 2004).

Implementation
The two main courses associated with our project, NATS and STCH, were designed during the spring and fall of 2005, and implemented for the first time at our university in the spring of 2006. During this first implementation, a total of 56 non-science majors enrolled in the NATS class and 14 prospective science teachers participated in the STCH course. Thus, NATS students were divided into 14 collaborative learning teams with 3 to 4 students each and one assigned team teacher (STCH participant) to support their work. The composition of the teams was changed at the beginning of each of the four major units in the NATS course. This rotation allowed prospective teachers to interact with different types of NATS students, while giving these students the opportunity to experience different instructional styles and to interact with a great number of their peers with different backgrounds and study habits.

The main co-instructors for the STCH and NATS courses, a chemistry professor with expertise in science-teacher preparation and an experienced high school science teacher, planned and implemented the first unit of the NATS course, while prospective teachers monitored and provided support to the student groups. This gave prospective teachers four full weeks to get used to their role of guiding and supervising student team work, while observing, discussing and reflecting on the teaching practices of the main course instructors. During the last three units of the NATS course, in addition to their student team work, the prospective teachers took turns working in small groups to carry out the lessons, including planning and implementing the class activities, in close collaboration with the main instructors.

<table>
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<tr>
<th>TABLE 1 Teaching portfolio rubric.</th>
<th>Needs improvement 1–5</th>
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<td><strong>Planning</strong>&lt;br&gt;The teacher plans are based upon central ideas in the discipline, clear learning objectives, and knowledge of how people learn.</td>
<td>Planning artifacts demonstrate minimal relationships between central ideas, learning objectives, and instructional activities.</td>
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<td><strong>Instruction</strong>&lt;br&gt;The teacher implements a variety of instructional strategies to foster student learning.</td>
<td>Artifacts exhibit few instructional strategies. Artifacts present little evidence of instructional focus on student learning, motivating and engaging students, and promoting critical thinking.</td>
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<td><strong>Assessment</strong>&lt;br&gt;The teacher understands and uses different assessment strategies to collect evidence of and evaluate student understanding.</td>
<td>Evidence shows few strategies used to assess student understanding and few instances of appropriate formative feedback.</td>
</tr>
<tr>
<td><strong>Reflection</strong>&lt;br&gt;The teacher is a reflective practitioner who evaluates the effects of his or her decisions and actions on students and on student learning.</td>
<td>Reflections exhibit superficial level of self-evaluation. Reflections do not address how the evidence represents learning and growth as a teacher.</td>
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A 35–40 points  B 31–34 points  C 27–30 points  D 23–26 points  E < 23 points
Class activities and interactions between instructors, prospective teachers, and non-science majors were observed, monitored, and assessed using a variety of methods: Observation of planning sessions in the STCH course; observation, audio and videotaping of teaching sessions and student team work in the NATS class; weekly entries in an online reflective journal by each prospective teacher and evaluation surveys by the NATS students. These tools were used to assess the performance of our prospective teachers, provide them with formative feedback throughout the course, and adjust our plans to better support both NATS and STCH students’ learning.

Outcomes
The observation and videotape of student team work in the NATS class allowed us to detect early in the semester that many of our prospective teachers struggled to pose good guiding questions during small group activities. Some of them also dominated the conversation and discussions in their groups, or established one-on-one conversations instead of involving all of the students in the discussions. Other prospective teachers repeated a cycle of posing a closed question, eliciting an individual response, and providing limited feedback; thus restricting the quantity and quality of student contributions.

We used the videotapes in the STCH class to initiate discussions about these various issues, motivate reflection about effective teaching and assessment strategies, and design appropriate interventions. Analysis of the videotapes taken at different points during the semester reveal significant improvements in several areas: the average number of questions posed by prospective teachers in a given group decreased but their quality increased; in particular, they became more adept at eliciting students’ prior knowledge, challenging their ideas, and asking probing questions that better revealed student understanding. Additionally, the amount of time that prospective teachers spent providing one-on-one explanations decreased, while student participation in the small groups increased.

The observation of planning sessions involving main instructors and prospective teachers, and the analysis of the written lessons plans and their implementation, indicate that lesson planning skills also improved during the semester. Although basic models of lesson planning were discussed and modeled by the main instructors during the first unit of the NATS class, the analysis of the initial lesson plans developed by prospective teachers revealed their limited views on planning. Initially, prospective teachers approached planning as a two-step process. First, they selected lesson content and sequence as they reviewed the background materials related to the lesson topics. Once lesson content was established, prospective teachers then searched for instructional activities to “illustrate” or “demonstrate” the selected topics. However, often they selected activities based on their potential to catch students’ interest and ensure student engagement rather than on a formal evaluation of their educational value. Most prospective teachers used the internet as the primary source of both content and activities when building their first lesson plans.

To address these deficiencies, we intervened early in the semester not only by asking the prospective teachers to critically analyze the different lesson plans, but also by providing a more structured lesson plan template that

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<th>Proficient 6–8</th>
<th>Exemplary 9–10</th>
<th>Score</th>
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<td>Planning artifacts demonstrate satisfactory relationships between central ideas, learning objectives, and instructional activities.</td>
<td>Planning artifacts demonstrate clear and rich relationships between central ideas, learning objectives, and instructional activities.</td>
<td></td>
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<tr>
<td>Artifacts exhibit some instructional strategies.</td>
<td>Artifacts exhibit a variety of instructional strategies.</td>
<td></td>
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<tr>
<td>Artifacts present sufficient evidence of instructional focus on student learning, motivating and engaging students, and promoting critical thinking.</td>
<td>Artifacts present clear and rich evidence of instructional focus on student learning, motivating and engaging students, and promoting critical thinking.</td>
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<tr>
<td>Evidence shows several strategies used to assess student understanding and clear instances of appropriate formative feedback.</td>
<td>Evidence shows a variety of strategies used to assess student understanding and many instances of appropriate formative feedback.</td>
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<td>Reflections exhibit satisfactory level of self-evaluation. Reflections satisfactorily address how the evidence represents learning and growth as a teacher.</td>
<td>Reflections exhibit in-depth level of self-evaluation. Reflections show real insight on how the evidence represents learning and growth as a teacher.</td>
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required students to articulate their understanding goals and their assessment strategies prior to the identification of instructional activities. Comparison of different lesson plans developed throughout the semester showed that prospective teachers improved in several areas: their learning objectives became clearer, with a stronger focus on meaningful understanding; there was a better alignment between learning objectives, instructional activities, and assessment strategies; and prospective teachers used a larger variety of instructional resources in planning their lesson. Many prospective teachers also developed a more realistic understanding of the amount of effort that is needed to develop a lesson plan that engages students’ thinking in meaningful ways.

The analysis of the online journals, including prospective teachers’ weekly reflections about learning and teaching issues in the NATS classroom, indicate that many prospective science teachers initially used “student engagement” as the basic evaluation criterion when judging the effectiveness of their lessons and activities. Activities that allowed students to engage in extended dialogue or perform hands-on activities were highly valued and deemed most effective. Many prospective teachers also based their initial judgments about a lesson’s success on their personal evaluation of their performance in front of the classroom. From their perspective, they were successful if they were prepared for the class, had all necessary resources in place, and felt comfortable in front of the students.

To better guide prospective teachers’ thinking about assessment and evaluation of a lesson, we asked STCH participants to look for evidence of student understanding during the class activities and use it as the main focus of their reflections. Although the prospective teachers continued to be understandably concerned with their own performance, many of them demonstrated significant improvements in this area. For example, the number of references to individual students’ problems increased during the semester; this was accompanied by a deeper analysis of the possible origin of those difficulties and suggestions to address them. In their portfolios, many prospective teachers recognized that their ability to “listen” to what the students were saying had improved throughout the semester.

Analysis of the assessment and evaluation practices of our prospective students revealed that some of them had difficulties applying consistent criteria in the evaluation of student work. At the beginning of the semester, some of the NATS students complained of inconsistent grading. This issue was quickly addressed by having the STCH participants collectively develop a common evaluation rubric for each assignment. Additionally, each student project was evaluated and graded independently by two of the prospective teachers. Subsequently, the NATS students readily accepted the evaluations of the prospective teachers and any grading discrepancies were resolved by the main course instructors.

Our analysis of the changes in beliefs and practices of the STCH participants from the beginning to the end of the semester indicate that constant reflection, co-planning and co-teaching, and frequent reflective feedback have a positive impact on prospective teachers’ pedagogical decisions and practices. As described in previous paragraphs, the proposed model not only offers prospective teachers an opportunity to develop and apply their pedagogical knowledge in a real setting, but also allows science teacher educators to closely monitor and assess their progress.

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References

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