Meeting the Needs of Our Future and In-Service Teachers: The Development and Implementation of a PER-Based Course to Teach Instructional Strategies in Astronomy

Rebecca S. Lindell\textsuperscript{1}, Douglas Franke\textsuperscript{2}, Elizabeth Peak\textsuperscript{1}, Thomas Withee\textsuperscript{1,3} & Thomas Foster\textsuperscript{1}

\textsuperscript{1}Department of Physics, Southern Illinois University Edwardsville, Edwardsville, IL
\textsuperscript{2} Department of Physics, Knox College, Galesburg, IL
\textsuperscript{3} Collinsville High School, Collinsville, IL

Abstract: In the last five years the State of Illinois radically changed its Science certification programs. This change resulted in the creation of a new certification in Earth and Space Science. To meet the requirements of this new program, the SIUE Department of Physics and Office of Science and Mathematics Education created a new course entitled “Instructional Techniques in Astronomy”. Required for all students seeking Earth and Space Science certification, it is also ideal for meeting the needs of in-service teachers, who need additional astronomy courses to become “well-qualified”. This paper reports on this unique course, which combines content and pedagogy along with both teacher-participant and instructor views on the effectiveness of this new course.

Keywords: Teacher Preparation, Astronomy Education, Earth and Space Science Education
PACS: 01.40.Di, 01.40.Jp

INTRODUCTION

Over the last few years, the State of Illinois radically changed its Science certification programs. This change resulted in the creation of a new certification in Earth and Space Science\textsuperscript{1}. To meet the requirements of this new program, the SIUE Department of Physics and Office of Science and Mathematics Education created a new course entitled Phys 434: “Instructional Techniques in Astronomy”. This course was created to address several real needs. First, the Illinois Professional Teaching Standards have raised the bar for what it means to teach astronomy in Illinois. Every K-12 student must have basic astronomy competence.

This course services three separate populations of students. Since SIUE currently does not offer a math-based astronomy course, this course provides Earth and Space Science pre-service teachers the opportunity to refine their skills before they leave SIUE. Second, this course also services Astronomy and Space Science in-service teachers who need to maintain certification or who need additional astronomy courses to become “well-qualified”. Third, the SIUE Department of Physics offers a MS in Physics with a specialization in Physics and Astronomy Education Research. Students in this program will benefit from the additional astronomy content of this course, as well as interactions with teachers.

This unique course combines content and pedagogy to provide these pre-service and in-service teachers a content-based, but accessible, course designed to help improve their teaching.

DIFFERENCES FROM ‘METHODS’ COURSES

At SIUE, there are currently not enough Earth and Space Science pre-service teachers to allow them to complete a separate ‘methods of teaching’ course and these pre-service teachers complete their methods course along with both pre-service chemistry and physics teachers. There is simply not enough time within this course to focus on the unique issues faced by astronomy instructors.

The Instructional Strategies in Astronomy course allows students to not only refresh their knowledge of different instructional pedagogies, they are also
exposed to some of the unique instructional content, including planetarium simulators, telescopes, and outdoor observing activities. In addition they are exposed to the cross-disciplinary field of Astronomy Education Research and how they can incorporate these results into their classrooms.

**COURSE OVERVIEW**

Physics 434, Instructional Techniques in Astronomy, was officially offered for the first time during the Summer 2005 semester. Offered with less than a week’s notice, three teacher-participants, one in-service and two pre-service teachers, immediately enrolled in the course.

The course was offered as a primarily independent study course with a two-hour seminar each week. The goals of the course were three-fold: 1) To foster an appreciation of astronomy and science 2) To enhance student understanding of cognitive science and Astronomy Education Research with regards to its application to astronomy instruction and 3) To encourage development of interpersonal, reasoning and technological skills.

Each week teacher-participants were required to be ready to discuss the assigned readings, as well as completing detailed essays. Table 1 shows the course schedule and associated assignments. In addition teacher-participants were required to complete a final project for the course.

**Final Project: Astronomy Lesson Plan**

Each teacher-participant completed a semester-long project consisting of a 2-4 week lesson plan for coverage of an astronomical topic within a high school honors astronomy course. The lesson plan needed to include each type of instruction that was detailed in class: outdoor observing (both activity and observing session), in-class instruction (formal and informal) and computer instruction. The types of instruction needed to reflect the results of cognitive science and astronomy education research and needed to be inquiry-based or employ active engagement methods where appropriate. In addition, the lesson plan needed to include learning objectives, all assessments (formative and summative), and Illinois state science standards addressed. The final project was worth 30% of the final course grade. An overview of the different projects is detailed in Table 2.

**TABLE 1. Course Schedule/ Assignments**

**Week 1:** Introduction and Orientation, Implications of Cognitive Science and Astronomy Education Research for the Teaching of Astronomy
- **Readings:** Redish's Chapter 2, Slater and Adams, Chapter 3
- **Assignment:** Part I: Teacher-participants compared and contrasted the five footholds for instruction presented in Redish to the six “big ideas” presented in Adams and Slater. Part II: Reflected on how each of these ideas has been observed in teacher-participants’ own learning.

**Week 2:** Introduction to Inquiry-based Instruction I
- **Readings:** Posner, Strike, Hewson and Gertzog; Vossniadou; Nussbaum and Novick
- **Assignment:** Critique of astronomy activities effectiveness at promoting conceptual change.

**Week 3:** Introduction to the Learning Cycle
- **Readings:** Fuller, Chapter 4
- **Assignment:** Opinion Essay reflecting on if active-engagement methods were sufficient for promoting conceptual change.

**Week 4:** Student Difficulties with Astronomy
- **Readings:** Bailey (2003)
- **Assignment:** Rewriting essay critiqued in previous lesson, so that it met the requirements for conceptual change.

**Week 5:** Instructional Strategies for In-class Instruction
- **Readings:** Redish, Chapter 6 & 7, Slater and Adams, Chapter 5 & 6, Green's Chapter 1 & 2
- **Assignment:** Based on the class readings and discussion, teacher-participants discussed implementing the various active-learning lecture techniques into lectures on one of the following topics: Kepler’s Laws, Spectroscopy or Gravity.

**Week 6:** Instructional Strategies for Multimedia Instruction
- **Readings:** Skim LoPresto and explore Sky Gazer CD-Rom
- **Assignment:** Teacher-participants chose one multi-media activity discussed in class, either a Sky Gazer or CLEA activity, and critiqued its strengths and weaknesses at teaching the concept.

**Week 7:** Instructional Strategies for Laboratory Instruction
- **Readings:** Various Astronomy Lab Manuals to choose best outdoor/ indoor laboratory activities.
- **Assignment:** Teacher-participants chose one laboratory activity from “Physics by Inquiry” and another laboratory activity that purports to teach the same concept from one of the laboratory books passed out last week in class and critiqued the effectiveness of the laboratory activities.

**Week 8:** Instructional Strategies for Outdoor Observing: Learning Constellations and Using a telescope
- **Readings:** Constellation Mythologies
- **Assignment:** To Finish Final Project
Impact on Future Teaching Career

“Well I must say that this course has influenced my future by definitely cementing my decision in wanting to teach. It also opened my eyes to how much work and preparation goes into setting up a lesson plan and how to teach to conceptual change.”

“This course has influenced my future teaching career by demonstrating how to understand education research. Through this course, I now feel confident in reading education research and understanding how the research influences my teaching. In general, this course has taught me how to include many forms of instruction, other than inquiry, [that] can promote interactive engagement. Furthermore, this course has taught me how to find and adapt many resources for science education. By taking this course, I now feel 150% confident walking into my astronomy course this fall. I have developed several lesson plans that are ready to implement and have gained the knowledge and skills to develop additional materials. Furthermore, this course has helped me learn how to continue to improve my teaching.”

“I have learned that teachers have to take the time to prepare a great lesson. There is a lot of time devoted to making a lesson inquiry based, and promoting conceptual change. If as a teacher, I am aware of the amount of time a lesson plan might take I am better prepared to devote that time, and help the class learn.”

Strengths of the Course

“This course offered a very complete assessment towards teaching for conceptual change. Starting with the whole understanding of cognitive models and ending up with how to prepare a lesson plan to promote such change in understanding.”

“The strength of this course is that it requires you to examine why we use the various methods that we use, not just how to use them. Also, this course teaches how to integrate these various methods into a consistent form of instruction. Furthermore, I would recommend this course to any science educator. Although it is geared toward secondary astronomy education, the lessons learned are applicable to physics, chemistry, biology, earth and general science for all ages.”

“This course did a great job of focusing on teaching. I have learned a lot about teaching from this class. In this class I learned about inquiry based teaching and how to promote conceptual change.”
Weaknesses of the Course

All of the weaknesses reported by the teacher-participants concerned the drawbacks associated with any summer course: the increased pace of the course and the increased workload associated with squeezing a 16 week course into 8 weeks. In addition, teacher-participants noted the open nature of any course with a large independent study component.

INSTRUCTOR PERSPECTIVE

One of the more interesting things to come out of this course were the different perspectives that the in-service and pre-service teacher participants brought to the class discussion. While the in-service teacher had been teaching for a year and felt confident in his ability to design inquiry-based lessons, both of the pre-service teachers had not completed their methods course, which is where they typically would first encounter the idea of teaching science using inquiry methods. Although they had completed inquiry-based courses in the past, both pre-service teachers struggled with what we mean by inquiry-based instruction. By revealing the cognitive psychology reasons behind teaching for conceptual change, all three students increased their understanding of the reasons behind teaching for conceptual change. In addition the experienced perspective that the in-service teacher-participant brought to the course was invaluable in helping the pre-service teacher participants master the content presented in the course.

Overall, this course was considered a success. It accomplished the goals stated in the course overview. In addition, it challenged the teacher-participants to master new knowledge and concepts, as well as reinforced content they had had in other courses.

ACKNOWLEDGMENTS

The authors would like to thank the SIUE Department of Physics and the College of Arts and Sciences for finding the funds to offer this course this summer, as well as for providing funds for travel to the 2005 PERC.

REFERENCES

1 Please See The Illinois State Board of Education website, http://www.isbe.state.il.us/certification/html/becoming_teacher.htm, for more information on Earth and Space Science Certification.
2 The course was taught by T. Foster during the spring semester 2005 as an independent study course and not as an official course.
3 The short notice was due to the need for the course by the in-service teacher, who needed it to become certified in Astronomy by the end of the Summer.