GEOSCIENCES FOR ELEMENTARY EDUCATORS: A COURSE ASSESSMENT

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Abstract

Geosciences for Elementary Educators engages future elementary teachers in a hands-on investigation of topics aligned with the third and fifth grade Earth/Space Science and Scientific Inquiry benchmarks of the Oregon Content Standards. The course was designed to develop the content background of elementary teachers within the framework of the science described in the content standards, to provide an opportunity for future teachers to explore the content area in relation to what takes place in the classrooms of elementary schools, and to initiate a community of learners focused on teaching science to elementary students. The course focused on four themes: the classroom teacher as an activity and curriculum developer using diverse resources to keep the content current and alive; the classroom teacher as educator dealing with the diverse backgrounds of students in a developmentally appropriate manner; the classroom teacher as reflective practitioner exploring the links among pedagogy, content, and student learning; and, the classroom teacher as citizen staying current with emerging policy issues and debates that impact education. In a course where process is extremely important, participants are assessed on what they can do with content and process knowledge through preparing lesson plans, presenting lessons in a simulated classroom environment, and developing a portfolio and journal. Lesson plans demonstrate participant understanding of inquiry, using models, deductive and inductive approaches, links between communication skills and content knowledge, and effective use of technology, including the Internet. For each topic, the mixture of demonstration, experimentation, inquiry, and lecture models are explored through investigation, discovery, and analysis.

Introduction

The introduction of content standards into the debate over reform in American education changed the framework for preparing future elementary teachers [1-4]. As concepts of standards-based education began to work through state and local reform movements, the alignment of practice in undergraduate programs where students receive their content preparation became the focus of efforts by the National Science Foundation to change practice through the Collaboratives for Excellence in Teacher Preparation (CETP).

The status of the earth and space science content area shifted to one of prominence among the science standards and encouraged efforts among the earth and space science

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community to respond to the needs of teacher preparation through curricular changes in academic programs and the engagement of professional organizations [5-7]. At Portland State University, the changing status of the earth and space science content area within standards-based education, with funding from the Oregon Collaborative for Excellence in the Preparation of Teachers (OCEPT), combined to initiate a course for future elementary teachers within the Department of Geology.

In this paper, we review the design, implementation and modification of *G 355: Geosciences for Elementary Educators*. We also report the results of an assessment of course impact on career development of elementary teachers.

Need for the Course

At Portland State University, successful completion of course work and student teaching leads to recommendation by the Graduate School of Education for an Initial License to the Oregon Teacher Standards and Practices Commission. An additional ten-quarter credits are required for completion of a master's degree and a Continuing Teacher License. Admission to the Graduate Teacher Education Program (GTEP) requires completion of an undergraduate degree and recommendation from an appropriate content-area advisor. The curriculum of the undergraduate degree may be from any of the disciplinary departments or a general studies degree. In addition to undergraduate major requirements, students preparing to be elementary teachers are provided a list of highly recommended courses. Prior to the 1999-2000 academic year, the only science courses included were *General Biology* or three courses offered through the Center for Science Education (*Natural Science Inquiry*, *Integrated Science Concepts*, *Context of Science in Society*). In the 1999-2000 PSU Bulletin, introductory geology courses and labs were added to the list.

In 1999, funding provided through OCEPT allowed development of *G 355: Geosciences for Elementary Educators*. Once developed, sustainable course offerings require adequate enrollment to justify a shift of faculty resources. At the time, these resource needs were balanced against the need to develop the content background of elementary teachers within the framework of the science described in the content standards, to provide an opportunity for future teachers to explore the content area in relation to what takes place in the classrooms of elementary schools, and to initiate a community of learners focused on teaching science to elementary students. Annual enrollment of 25-30 students has met the enrollment requirement.

Process of Course Development

Michael Cummings and Denise Monte developed the original course. Monte, an undergraduate student in the B.A. program in Geology, was anticipating admission to the Graduate Teacher Education Program (GTEP) and a career teaching middle school science. Readings on teaching, learning, and geoscience education and weekly discussions were used to define structure, objectives, geoscience topics, and supporting activities. Cummings offered the course for the first time during Spring 1999. Michael Goodrich adopted the course structure and objectives when he became the instructor of record in 2001. Regular discussion, including discussions to prepare this paper, continues as the course evolves. *Foundations of Earth Science* was selected for the textbook because of its coverage of topics in the earth/space science content area [8].

Guiding Concepts for Course Development

Instead of exploring all the roles an elementary teacher plays in the lives of students, schools, and communities, the course focused on four themes: the classroom teacher as curriculum developer using diverse resources to keep the content current and alive; the classroom teacher as an educator dealing with the diverse backgrounds of students in a developmentally appropriate manner; the classroom teacher as reflective practitioner exploring the links among pedagogy, content, and student learning; and, the classroom teacher as citizen staying current with emerging policy issues and debates that impact education.

Table 1
Topics Selected for Spring 2000 Offering of *G355: Geosciences for Elementary Educators*

Standards-based education and developmentally appropriate practice
- Standards-based education, Common Curriculum Goals, Content Standards, and Grade 3 and 5 Benchmarks
- Developmentally appropriate practice at the elementary level
- Writing lesson plans

Understanding minerals and their uses
- Description of minerals and their identification
- Properties of minerals and their uses

Rocks: the key to interpreting Earth history
- Rock description and classification

The rock cycle and its applications

Processes that change the Earth's surface

Geologic processes at work at the Earth's surface
Geologic hazards associated with surface processes
Field Study to examine processes that change the Earth's surface

Weather and the changing surface of the Earth

Weather patterns in the Pacific Northwest
Basic meteorology

Earthquakes and volcanic hazards

Plate tectonics and plate boundaries
Hazards related to earthquakes and volcanoes
Dealing with hazards

Space science and the solar system

Introduction to the solar system
Activities to explain night and day, the seasons, the changing night sky
Orbits of the planets and moons

The selection of topics to be covered from the earth and space sciences (Table 1) is the responsibility of the instructor guided by the third and fifth grade benchmarks of the Oregon Education Content Standards [4]. However, once the major topic themes are identified, the exploration of the content is a shared responsibility between participants and instructor. During this exploration, the instructor models various active learning methods that are matched to the characteristics of the content and invites participants to examine the methods and evaluate their potential impact on student learning. The course participants explore content by developing classroom activities that are demonstrated through constructing lesson plans, handouts appropriate for use in classrooms, and presentation in a simulated classroom environment. Peer evaluation of classroom presentations encourages reflection on practice and clarity of content presentation. As the course progresses, participants develop skills in constructing and using knowledge with the instructor's guidance and modeling and peer evaluation.

The mixture of demonstration, experimentation, inquiry, and lecture used in the presentation of each topic models teaching geosciences as they are practiced through investigation, discovery, and guided analysis. Within this framework, the study of rocks becomes one where examining, describing (writing and sketching), and comparing are primary activities while naming and interpreting are secondary. During the exploration, all participants are placed on an equal footing where common skills can be used and the prior knowledge that may be held by a few does not dominate the activity. Discussion and reflection on the activity emphasizes the importance of allowing all students to have access to learning without feeling isolated by lack of prior experience or knowledge.

Organization of content knowledge in a useable framework and developing handouts that are appropriate for student use are explored through preparation of lesson plans. Table 1 presents a two-part framework for lesson plans. The first part is prepared from the perspective of the classroom teacher. Each item asks participants to focus on the complex process of developing effective activities aligned with benchmarks and standards. Participants are encouraged to concentrate on the educational objectives of their activities with emphasis on curriculum dimensions (what comes before and what is to follow), development of extensions that are appropriate to a variety of learning styles and levels, and the link between the activity and student inquiry. The second part of the lesson plan is written from the perspective of elementary students. Participants prepare handouts and worksheets for use with their activities and are encouraged to focus on the clarity of presentation, developmental and cultural appropriateness of requested information, effectiveness of the sequence of observations/interpretations, and the correlation between handouts and the fundamental characteristics of the content. For each item on a worksheet or handout, participants are required to justify its use and the educational objectives it addresses.

Participants are assessed on what they can do with content and process knowledge through preparing lesson plans, conducting classroom activities, and developing a portfolio and journal. Lesson plans demonstrate participant understanding of inquiry using models, deductive and inductive approaches, links between communication skills and content knowledge, and effective use of technology including the Internet. Conducting classroom activities demonstrates participant understanding of the use of problem solving approaches and the scientific method, classroom management, developmentally appropriate presentation techniques, understanding of cognitive and ethical development of elementary students, and the importance of sharing classroom materials. Participant-generated lesson plans and plans shared with peers form the nucleus of a professional portfolio.

Experience in elementary classrooms varies among participants. To provide a shared experience and to spark discussions based on classroom practice, participants are required to visit an elementary classroom and to share their observations with all participants. Participants are provided with a crib sheet to help them focus on classroom management techniques, student responses to teacher prompts, and approaches used by teachers to engage all students in the learning process. The shared experience encourages students to reflect on their own vision of practice and the nature of the learning environment.

Public schools operate in a complex web of cultural, financial, and political influences. Often participants have not explored the impact of these factors on their career opportunities and professional practices. During the course, participants collect news items and discuss the impact of current events on practices in public schools. Near the end of the course, they prepare a synopsis of current events and a reflection.

The Course in Practice

We have adjusted the structure of the course based on assessment of participant background, career goals, response to assignments, and student learning. The adjustments include changes in classroom management, construction and grading of assignments, and participant potential.

In a course where process is extremely important, content is tested and used in a simulated classroom environment. To provide participants with an opportunity to present science lessons, engage other participants in the manipulation of materials, receive feedback from their peers, and practice their skills requires scheduling large blocks of time when, in fact, class time is limited to two, 2-hour class periods. The problem becomes greater as class size increases; current enrollment is between 20 and 25 participants. This classroom management issue has been addressed by allowing each participant the opportunity to make two presentations during the ten-week term. Prior to the first presentation, participants develop a scoring guide. This activity allows them to explore their own understanding of the components of a well-designed classroom activity and encourages reflection on their own practice. The first presentation is short and covers a narrowly focused subject. Participants are expected to incorporate feedback received from the first presentation into the second, a presentation of an entire lesson plan. Although these time saving devices help, this is an unresolved problem.

The task of developing lesson plans and work sheets for use in an elementary classroom is foreign to participants. However, constructing the bridge between content and pedagogy requires that participants engage in this process. Our philosophy is that one learns by doing. Successive lesson plans should demonstrate increasing sophistication not only in the pedagogy used in the lesson plan, but in the richness of content knowledge. Although this progression of improvement should be evident, it becomes confused after students discover a wealth of classroom activities and lesson plans on the Internet. We encourage students to explore different websites to find resources. However, simply downloading an activity is not acceptable. Internet resources raise the basic question: Does the improvement in the quality of lesson plans during the term reflect an increase in content and process knowledge or increased skill at finding Internet resources? The question faced by instructors is how to evaluate lesson plans when the creative concept, design, and student work sheets may come directly from a website. Three approaches have been developed in areas of content evaluation, lesson plan format, and student worksheet requirements.

Many excellent websites present lesson plans that are developmentally appropriate, contain accurate and appropriate content, and have proven track records with classroom teachers. However, there are other sites that present lesson plans with factual and conceptual errors. Conceptual errors often arise from inappropriate use of analogs to illustrate physical processes in the geosciences. To help participants evaluate websites, lesson plans judged by participants to be appropriate are examined in class. The exercise helps participants evaluate the authorship of the website, the critical review it has received, and their responsibility as teachers to critically review material before introducing it into the classroom. Participants soon recognize the conflict between their own lack of content knowledge and the need to critically evaluate website content.

The format for lesson plans requires participants to respond to items that are rarely addressed on websites. We have identified four items that encourage modification from website lesson plans. The first requires participants to cast the lesson plan in a framework of educational objectives. The second requires consideration of the lesson plan within an earth and space science curriculum. The third explores extensions of the activity to address the learning needs of all students in the classroom. The fourth evaluates the potential of the lesson plan to prompt student inquiry.

The lesson plans must include examples of the written materials that will be given to students and examples of the products students are expected to produce. In the case of worksheets or data sheets, each item of any handout must be annotated to indicate why the item is included, how the item fits into the overall structure of the lesson plan, and the justification for the item in the context of learning objectives and curriculum development.

In addition to these process adjustments, issues related to background preparation and the nature of the earth/space sciences have arisen. How do we develop problem-solving experiences where participants may lack deep experience in this approach? Engaging participants in the analysis of examples of problem solving from everyday life experience is a start, but drawing participants into a deeper understanding of the problem-solving process in the context of the earth/space content requires the depth of content knowledge and problem-solving skills to grow at the same time. The first step lies in clearly distinguishing between observation and description, synthesis and interpretation, and evaluation. The second step engages participants in reflecting upon the process that takes place as they explore a topic. What do I need to know to talk intelligently about this subject? What models can I use to demonstrate the basic concepts of this subject? How do I construct classroom activities that engage students in the problem solving dimensions of this subject? At what point does this activity lead seamlessly into student inquiry? How do I recognize when this point has been reached in my classroom?

Participant understanding of standards-based education may be shallow. The standards and benchmarks are addressed by many earth/space science topics. Although participants are able to list the standards they feel their activities address in the lesson plans, their understanding of the physical linking of content to standards may be weak. One approach to strengthening this link is to engage participants in exploring the course textbook in relation to the standards. Constructing an outline that links textbook topics to specific standards and discussing how the topic specifically addresses the standard helps participants build the necessary content-standards links.

Course Impact

Institutionalizing courses specifically designed for the preparation of future teachers in science and mathematics is a goal of OCEPT. Through the support of OCEPT, *G 355: Geosciences for Elementary Educators* was developed in 1999 and subsequently became a regular offering of the Department of Geology. The course not only meets the enrollment requirements for the Department, but is perceived to be a significant benefit to future elementary teachers. In order to assess the benefit of this course for the development of elementary teachers, a survey was developed, approved by the Portland State University Human Subjects Research Review Committee, and administered as paper and web-based instruments to participants in the four offerings of this course. One of the objectives of the survey was to examine changes in attitude with stage of career development. Some participants are completing undergraduate requirements. Some are currently in GTEP. Others are practicing teachers. The survey asked participants about their backgrounds and current status (Table 2), to rank their experiences in the course using a Likert Scale, to numerically rank the value of different components of the class, and to provide open-ended comments (Table 3).

Table 2
Background Questions

1. I heard about *Geosciences for Elementary Educators* from: PSU course catalog Faculty member Friend or classmate Other source (please write in:_____)
2. My ethnicity is: African-American Caucasian (Non-Hispanic) Hispanic/Latino Asian/Pacific Islander Native American/Alaskan Native Other (Please write in:_____) Decline to respond
3. My current status is: Undergraduate Student Post-Baccalaureate Graduate student enrolled in Graduate Teacher Education Program Teacher Other (Please write in: ____)

Table 3

Survey Questions Using Likert Scale, Median (5-point ordinal scale where 5 is highest, 1 is lowest) and Number of Responses

Questions	Median	N
4. This course was a valuable asset in preparing me for a career in education:	5.0	32
5. This course has strengthened my ability to effectively teach science:	5.0	32
6. This course increased my knowledge in geoscience:	4.5	32
7. This course provided me with the skills necessary to construct effective lesson plans for teaching science in elementary school:	5.0	32
8. I would recommend this class to an aspiring elementary educator:	5.0	32
9. Please rank the value of the following components for this class between 1 to 5. Please leave blank if not applicable (Note: 5 = very		

useful, 1 = not useful)		
Preparing lessons	5.0	32
Conducting classroom activities	5.0	32
Scientific Method – problem solving	4.0	32
Using models	5.0	32
Understanding cognitive development	3.0	32
Classroom visitation	4.0	26
Current events in education	3.5	30
Field trip	4.0	19
Other (please write in:______)		
10: If you have further comments, please feel free to write them below:		

The scoring of the survey results produces ordinal data that is subject to non-parametric analysis. *SPSS* (version 10) was used in this study. The differences in scoring among populations were analyzed using the Kruskal-Wallis test. The Kruskal-Wallis test examines the relation among k-independent variables and is deemed appropriate for comparing the responses to the survey questions. A 95% confidence level was assumed because the population size is small (n=81).

Eighty-one students completed *G 355* during four years. Table 4 contains data on the population eligible for the survey. The percent response is calculated for the total number of participants (n=81) and the number of participants presumed to have received the survey (n=71).

Table 4
Data on Participation in the Survey and the Number of Responses

Number completing course	Restricted addresses or deceased	Returned as not deliverable	Number of responses	Percent response
81	3	7	33	41%/46%

Participants were asked to provide information on how they discovered the course, their ethnicity, and current status. Many respondents (51%) indicated that they had discovered the course in the "PSU course catalog." We can think of no compelling reason why students would browse through the University course schedule to find a course listed in the Department of Geology that deals with teaching geosciences to elementary students. Therefore, we believe the available options did not adequately address the item of interest.

The ethnicity of respondents is summarized in Figure 1. Nine percent of the respondents identified themselves as members of underrepresented populations in science and mathematics (Table 2). At Portland State University, 16.4% of the student population (Fall 2001) is comprised of these groups.

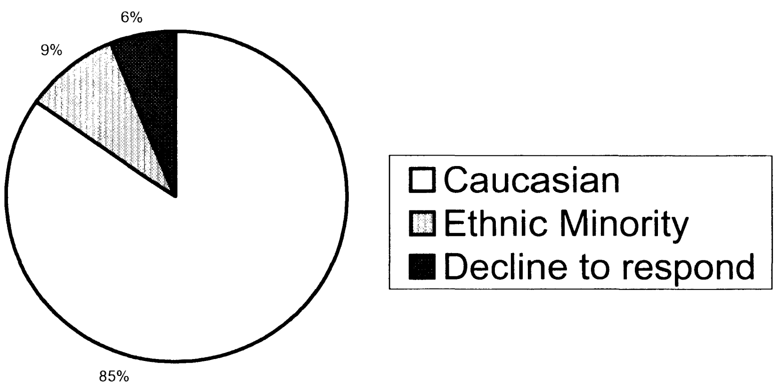

Figure 1. Ethnicity of respondents.

For purposes of analysis, the respondents were placed in five groups depending upon their response to the question on "My current status.." (Figure 2). Thirty percent of the respondents identified themselves as undergraduates at the time they completed the survey. The largest group self-identified as post-baccalaureate students (40%). These students have completed their baccalaureate degree, but may have been part of the applicant pool for admission into a graduate teacher education program at the time the survey was administered. The bulk of survey responses were received at PSU before the pool of students admitted into the spring cohort in the GTEP at PSU was announced. One respondent in this group had applied for GTEP. Two respondents (6%) self-identified as members of a current GTEP cohort. Six respondents (18%) are teachers and one respondent (3%) currently is not in school.

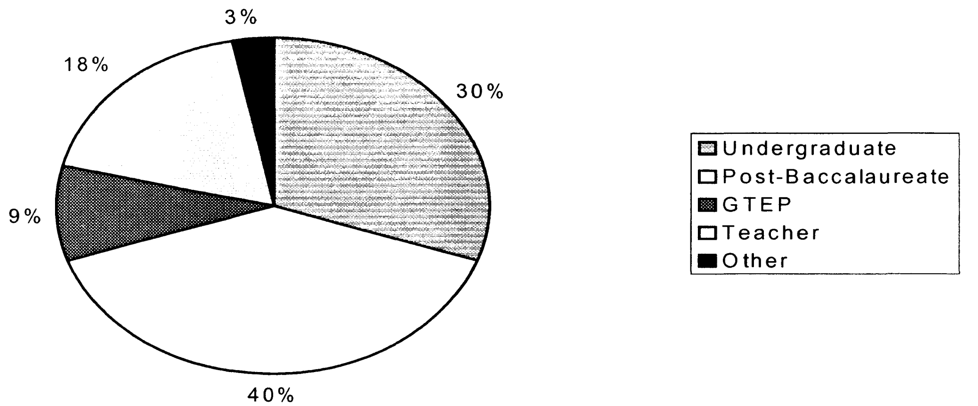

Figure 2. Participant status at the time of the survey.

From the perspective of the course instructors, questions 4 -7 examine elements of course design and objectives. The median of responses indicates participants "agree" or "strongly agree" that the course was effective in career preparation in these areas (Table 3). A median response of "strongly agree" to question #8, recommending the course to their peers, suggests respondents value the career preparation provided by the course.

On question #9, participants were asked to rank the value of course components. The first five items on the list were present each year the course was offered. Classroom visitation, review of current events in education, and a field trip were not included every year the course was offered. The results for these three items are viewed as inconclusive because of the inconsistent results produced when data are disaggregated relative to participant status. The median responses for the first five items on the list may be interpreted in at least three ways. Participants valued the benefit of preparing lesson plans, conducting classroom activities, and using models more than understanding cognitive development and the scientific method/problem solving. A second interpretation suggests that the current instructional design does not tie the importance of understanding cognitive development and problem solving into the classroom experience as effectively as the first three items. The third interpretation suggests that participants did not recognize the components of the course that addressed cognitive development and problem solving as clearly as they did the concrete actions associated with developing lesson plans, conducting classroom activities, and using models.

The survey results explore changing attitudes among participants who completed the course in different years and who are currently in different stages of career development. For this analysis, the responses were examined for three populations, undergraduates, post-baccalaureate/current GTEP students, and teachers. At the 95% confidence level, the responses from these three groups are not significantly different except for question #7 ($p = 0.015$), "This course provided me with the skills necessary to construct effective lesson plans for teaching science in elementary school." For this question there is a significant decline in the ordinal values from undergraduate to post-baccalaureate-GTEP students to teachers. The pattern is believed to reflect the practical experiences of respondents. For the undergraduate students, developing lesson plans is a new experience. Therefore, these students have few reference points to judge what is an effective lesson plan. Teachers, on the other hand, have classroom experience whereby they can judge what constitutes an effective lesson plan. They are likely to judge their skill level at the time they completed the course as inadequate to construct effective plans. However, for question #9 where respondents are asked to rank the value of preparing lessons as a course component, the responses are not significantly different among the three groups. Developing lesson plans as practiced in this course is an effective method to engage participants in the process of thinking about their future teaching practices, but the plans they developed apparently do not hold up under the scrutiny of practice.

Survey results indicate participants found the course valuable in their preparation as elementary teachers. This attitude is summarized by one of the respondents. "This class helped me as a new teacher know how to probe and inspire learning and the thought processes for learning to happen."

Conclusions

Survey results indicate a high degree of satisfaction with the content and practices used in *G 355: Geosciences for Elementary Educators* to engage future elementary teachers. There is no significant difference in responses from course participants over the four years the course has been offered with the exception of lesson planning.

The survey results suggest that *Geosciences for Elementary Educators* is an effective element in the continuum of career development that starts by linking content and pedagogy in a disciplinary context and which is enhanced through the GTEP experience and refined through classroom practice.

Preparing lesson plans, conducting classroom activities, and using models are highly valued by respondents as components of the class. However, instructors need to carefully examine their approach to issues related to cognitive development and the use of the scientific method/problem solving to clearly engage participants in these important aspects of student learning. ■

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