

Development Of A Standards-Based Integrated Science Course For Elementary Teachers

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Abstract. With the national mandates that science be an integral component of all levels of education, the importance of having courses for future elementary teachers designed to meet state and national standards is critical. This paper describes how three SIUE faculty, one from biology, chemistry, and physics, initiated, coordinated, and implemented curricular changes to our Foundations of Science course. The goals of this project were 1) to enhance the current content curriculum, 2) to revise current curricular modules and develop new modules to be inquiry-based, 3) to improve and expand upon the use of technology, and 4) to further articulate the interrelatedness of the sciences in the curriculum. Meeting these goals required the complete revision or creation of 25 hands-on inquiry-based modules. Evaluation of the project involved 1) determining the impact of the modules on student learning, 2) gathering student perspectives of the modules, and 3) collecting faculty feedback. This paper outlines the developed modules and presents our initial findings related to the student perspectives of the modules and their impact on student learning.

Keywords: Science Standards, Elementary Teacher Training, Curriculum Development

PACS: 01.40.Di, 01.40.Jp

INTRODUCTION

Currently, all students pursuing a degree and certification for teaching elementary school at Southern Illinois University Edwardsville must complete SCI 341, Foundations of Science. This course impacts about 120 future elementary teachers (plus about 100 other students from various departments) every year, and each of these future teachers will impact hundreds of young students over their careers. With the national mandates that science be an integral component of all levels of education, the importance of having SCI 341 (only one of three college science courses these future teachers are required to complete prior to certification) designed to meet state and national standards is critical.

SCI 341 is a team-taught course with one instructor from biology, chemistry, and physics. The course is designed to be a hands-on activity-based course (little to no lecture) that meets for two hours twice a week. Course objectives include understanding and using the process skills of science, learning basic concepts, and appreciating science as an integrated whole.

The previous curriculum for SCI 341 did address some of the standards; however, the course needed

major curricular changes to address all of the content standards. In addition, incorporating inquiry, technology, and the interrelation of scientific disciplines was lacking. The goal of this project was to rectify these shortcomings and improve our instruction. Meeting this goal required the complete revision or creation of 25 hands-on inquiry-based modules. This paper outlines the developed modules and presents our initial findings related to the student perspectives of the modules and their impact on student learning.

PROJECT OVERVIEW

The project involved three SIUE faculty, one each from biology, chemistry, and physics, who initiated, coordinated, and implemented curricular changes to SCI 341 in conjunction with all faculty who were instructors for this course and with School of Education faculty. Coordinated efforts with School of Education faculty improved the overall quality of our program by minimizing curricular overlap while still providing curricular integration.

The goals of this project were four-fold. First, to enhance the current content curriculum (biology,

chemistry, physics) to include earth, environmental and space sciences. Second, to revise current curricular modules and develop new modules to be inquiry-based in accordance with state and national science standards. Third, to improve and expand the use of technology by incorporating Calculator-Based Laboratory (CBL) into existing and newly developed modules. And fourth, to further articulate the interrelatedness of the sciences.

We enhanced the content curriculum by integrating topics into existing modules and by the development of new modules. Space science topics were incorporated though the physics curriculum while environmental science topics were integrated into the biology curriculum. Earth science topics were not well integrated into the curriculum for multiple reasons; however, our future work will address this need.

We enhanced the level of inquiry by basing each lesson on a modified Karplus learning cycle^{1,2} that allowed students to experience inquiry-based activities in a cooperative learning environment. The modules were specifically designed to teach the science content through inquiry as well as model the learning cycle for the students.

Integrating technology was accomplished by developing multiple modules that utilized Calculator Based Laboratory (CBL) technology, used modern scientific equipment, and addressed how science, technology, and society are interrelated. Teaching technology was also introduced to students by way of SMART technology used for classroom presentations.

We enhanced the integrated nature of the course by specifically designing modules to be interrelated, with references to prior modules where appropriate. In addition, the modules for each discipline were dispersed throughout the semester to alleviate the perception that the course was three separate “mini-courses” with three separate instructors. To emphasize the interdisciplinary nature of science, a portion of each exam would include an interdisciplinary section covering concepts that relate to all the science disciplines.

Evaluation of the project was threefold. First, exams were analyzed to evaluate the students’ mastery of the content giving us some indication of the impact of the modules on student learning. These exams were analyzed using Primary Trait Analysis³. Second, questionnaires were developed and administered via WebCT to gather the students’ perceptions of each module. Third, questionnaires were developed to collect faculty feedback about the modules. Evaluation was an ongoing process with iterative improvements made with each semester.

SCIENCE 341 CURRICULA

Activities Modules

The SCI 341 curriculum is taught through a series of modules developed around a modified Karplus learning cycle. Table 1 lists the modules by title separated by discipline. Each module was designed for one two-hour class period except for Ecology (which requires three periods).

TABLE 1. Lesson Title by Discipline

Biology	Chemistry	Physics
Cells	Acids & Bases	Conservation of Energy
Characteristics of Life	Changes of State	Exploring Basic Circuits
Classification/Taxonomy	Classification of Matter	Exploring Magnets
Ecology (Field Biology)	Energy and Matter	Linear Motion
Genetics	Measurement and Excel	Lunar Phases
Microscopes	Nature of Science	Seasons
	Properties of Matter	Understanding Waves
	Science, Technology, and Society	
	Structure of Matter	

Science Project

Each student in SCI 341 was required to design and implement a science project in five stages. First, the student would submit three project ideas and worked with his/her mentor instructor to refine the project’s focus. Second, the student would submit a three-page literature review discussing the science involved with his/her project. Third, the student would submit a list of materials and a detailed procedure. Fourth, the student would submit a draft of their full project containing abstract, safety information, purpose, hypothesis, literature review, materials, method, results including tables and graphs, conclusion, and possible future work. Stage five was identical to stage four; however, this was their final project paper that was graded by all faculty who taught the course. The criteria and expectations for each stage were clearly written in our “Guidelines for Science Project – Science 341” handout given to students the first day of class.

Scoring of each stage was done by rubrics. To encourage students throughout the project, the rubrics allowed for returnable points: points that could be earned back if the mentor's feedback was taken and appropriate changes were made to their project. Since most students had little to no experience writing scientific papers, the returnable points allowed students to submit draft papers, learn what they had done well and what they needed to improve upon, and actually make the changes without seriously impacting their overall grade in the course.

EVALUATION

Impact on Student Learning

Student learning was examined by using Primary Trait Analysis (PTA) based on student scores on exam questions (characterized by topics). We judged the instruction to be successful if the PTA were above 70%, moderately successful if above 60%, and not successful if below 60%. Table 2 summarizes the results with topics that were unsuccessful in italics.

Student Perspectives

Evaluation of the student perspective of the course was achieved by two methods: surveys probing student perspectives of each module and end-of-semester course evaluations. Students received points towards their overall grade by completing a ten-question survey about each module. Surveys were taken via WebCT (web-based course management system) and students had one week after completion of the module to take the survey. Surveys included six scaled response statements and four free response questions (see Table 3). To date, only average response values and frequency distributions have been examined for general trends and anomalous patterns. Typical patterns were seen in frequency distributions of scaled response items: high frequency of response around the mean with few to no outlying responses. No bimodal or flat distributions were observed. Average values are summarized in Table 3.

Thorough qualitative data analysis of free response questions was not completed at time of publication; however, initial findings indicated that qualitative data supported findings from scaled response data.

Table 2. Primary Trait Analysis Results

Topic	Section 1	Section 2	Section 3	Average
Cells	70.76%	81.36%	73.75%	75.29%
Characteristics of Life	78.70%	84.85%	75.69%	79.75%
Classification	76.09%	89.06%	84.38%	83.17%
Ecology ⁴	52.09%	73.53%	72.71%	66.11%
Genetics	80.80%	78.96%	74.05%	77.94%
Microscopes	96.74%	79.80%	79.86%	85.47%
Atomic Structure	67.75%	66.48%	67.97%	67.40%
<i>Acid and Bases</i>	<i>52.90%</i>	<i>47.50%</i>	<i>46.21%</i>	<i>48.87%</i>
<i>Changes of State</i>	<i>52.80%</i>	<i>63.91%</i>	<i>52.60%</i>	<i>56.43%</i>
Density	75.00%	76.25%	76.14%	75.80%
Graph Interpretation	67.70%	67.53%	83.33%	72.86%
Heat of Reaction	51.45%	67.42%	62.50%	60.46%
Intrinsic vs. extrinsic	65.22%	75.00%	67.05%	69.09%
Multiple Proportions	69.57%	67.50%	59.09%	65.39%
Physical/ chemical changes	94.93%	78.33%	83.33%	85.53%
Circuits	63.26%	55.45%	65.42%	61.38%
<i>Energy</i>	<i>43.77%</i>	<i>42.73%</i>	<i>57.22%</i>	<i>47.91%</i>
Linear Motion	88.04%	75.18%	75.78%	79.67%
<i>Lunar Phases</i>	<i>54.97%</i>	<i>66.54%</i>	<i>53.25%</i>	<i>58.25%</i>
Magnets	70.47%	62.71%	66.67%	66.62%
<i>Seasons</i>	<i>41.67%</i>	<i>54.39%</i>	<i>57.58%</i>	<i>51.21%</i>
Wave Motion	68.12%	64.38%	56.52%	63.00%
Interdisciplinary 1	73.91%	73.64%	67.50%	71.68%
Interdisciplinary 2	89.28%	72.33%	74.93%	78.85%
Interdisciplinary 3	63.91%	78.01%	63.91%	68.61%

TABLE 3. Scaled Response Statement Averages by Discipline

Fall 2004	Learned Content	Learned Methods	Learned Technology	Level of Inquiry	Amount of Content	Level of Content	Ave. n
Biology Ave.	3.9	3.8	3.4	3.7	3.1	3.0	67.5
Chemistry Ave.	4.0	4.1	3.8	4.0	3.2	2.8	69.1
Physics Ave.	3.7	3.6	3.3	3.7	3.0	2.6	69.7
Overall Ave.	3.9	3.8	3.5	3.8	3.1	2.8	68.8

Spring 2005	Learned Content	Learned Methods	Learned Technology	Level of Inquiry	Amount of Content	Level of Content	Ave. n
Biology Ave.	4.0	4.0	3.4	3.8	3.2	3.0	57.6
Chemistry Ave.	4.0	4.1	3.6	4.0	3.3	2.7	59.4
Physics Ave.	4.0	3.9	3.5	4.1	3.2	2.5	57.2
Overall Ave.	4.0	4.0	3.5	4.0	3.2	2.7	58.1

Statement/Question

Learned Content	"This lesson helped me learn about science content."
Learned Methods	"This lesson helped me learn about science techniques and/or methods."
Learned Technology	"This lesson helped me learn about how to use technology."
Level of Inquiry	"This lesson encouraged me to think for myself."
First four statements ranked as 1 = Strongly disagree to 5 = Strongly agree.	
Amount of Content	"How much did you learn during this lesson."
Amount of Content ranked 1=Nothing, 2=Very little, 3=Some, 4=A lot.	
Level of Content	"The level of content presented in this lesson was..."
Level of Content ranked 1=way over my head, 2=high, but learnable, 3=average and learnable, 4=low.	

CONCLUSIONS AND FUTURE WORK

Overall, our project has been successful in designing a curriculum to address the national standards; however, improvements are still needed. Student perceptions of the course indicated that activities helped them learn the science content, science techniques and methods, and how to use technology. Students indicated that the activities helped them think for themselves about a level and amount of content that was appropriate for their background. Exam data indicated instruction was successful for 80% of the topics.

Future work will address how to improve our success rate for instruction, improve our coverage of earth and space science, and incorporation of more technology into the curriculum. Development of a two-semester sequence of instruction is underway. The new sequence will place physics and chemistry in one semester with student projects addressing technological design. Biology and geoscience will be covered during the other semester with student projects addressing the design, implementation, and analysis of a science project as currently implemented in SCI 341. All activities will be examined for possible incorporation of technology. Further examination of data regarding differences in instruction, including instructors, may give insights as to how to improve the success rate of instruction. Our future plans also include examining the faculty's perspectives on the course. Each area of analysis will guide our modifications to the curriculum to improve science instruction for our future elementary teachers which, in turn, should improve science instruction for many elementary students.

ACKNOWLEDGMENTS

We would like to thank all the instructors of SCI 341 for the willingness to implement and provide feedback for the project: Elaine AbuSharbain, Tom Foster, Chris Glosser, Larry Miller, Leo Racich, and Kim Shaw. Funding was made available for this project through an Excellence in Undergraduate Education Grant (Number 05-19). SCI 341 is taught through the Office of Science and Mathematics Education at Southern Illinois University Edwardsville.

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