CAN SCIENCE METHODS REALLY BE TAUGHT ON-LINE?

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Abstract

In this paper, the process in which both project-based curriculum strategies and *Blackboard* web-based technology were utilized to develop on-line methods courses to prepare science teachers is described. A discussion of the curriculum design process includes a rationale for using project-based instruction in methods courses, along with a rationale for using *Blackboard*, a web-based technology, as the environment for the course. The course's potential for creating highly qualified science teachers as defined by the No Child Left Behind legislation of 2001 and the National Science Teacher Association's *Standards for Science Teacher Preparation* will be explored [1].

Purpose of Science Methods

Science is everywhere around us. Turning on our lights at night, baking a cake, throwing a basketball while expecting someone to catch it, and taking care of our bodies are just a few examples of how we use concepts in science on a daily basis. Research on student learning and motivation shows that effective teaching is *grounded in students' prior experiences* and provides ample opportunities for students to explore more of their natural world in a *social* context [2]. The need for hands-on experiences for middle schoolers is vital to creating a developmentally-appropriate science classroom experience, and hands-on experiences should continue and be built upon in the high school years [2]. Through these opportunities, students gain new conceptual knowledge and skills in science while increasing their overall interest in the science disciplines [2]. The goal for pre-service teachers enrolled in science methods courses is for them to be exposed to a variety of content, curricula, and methods designed to shape their future teaching practices so that their future middle and high school students will be motivated learners.

An additional aim of this particular science methods course is to provide pre-service teachers with numerous experiences in science teaching to empower them as they strive to become effective middle and high school science teachers. As they utilize experiences gained in the course while continuing in their lifelong learning and development of their teaching practices, they will become more and more capable of providing experiences in their classroom that, in turn,

will enable their own students to make informed decisions, seek new opportunities, and continue in their progress as lifelong learners.

Feasibility of Using a Project-Based Approach in Asynchronous Science Methods Courses

Often, faculty members in teacher preparation programs are asked to make courses accessible to more pre-service teachers. One way in which that can happen is via an asynchronous environment. Easy. Said. Done. Right??? At first glance, it might seem that all of the lectures could be taped and pre-service teachers in class could be taped participating in class activities. The result would be that an on-line student would be an inactive observer of what goes on in an on-campus course. Adopting this strategy, the on-line student would be similar to a middle or high school student who sits in the back of class and effectively does nothing. This is not exactly the epitome of empowerment. Instead, a project-based approach was utilized so that pre-service teachers would become actively engaged in the preparation and creation of products that would not only mimic those they would be creating when employed as a teacher, but also could be used in their future teaching [3]. Via this approach, the methods instructor serves as a facilitator as the pre-service teachers perform an extended study that results in the creation of a product. Methods instructors designed science methods curricula containing a set of extended projects aligned with Virginia's *Standards of Learning in Science*, as well as the National Science Teacher Association's *Standards for Science Teacher Preparation* [1, 4]. An overview of each project in the science methods course is outlined below.

Performance Evidence	**Standards for Science Teacher Preparation (NSTA)**	**Standards of Learning**
Information About You Project	5, 10	All 6-12 science SOL
Practicum Project	1-10	All 6-12 science SOL
Curriculum Map Project	4, 5, 6	All 6-12 science SOL
Hands-On, Minds-On Science Project, including Safety Test	2, 3, 4, 5, 6, 8, 9	All 6-12 science SOL
Science Around the World Project	1, 5, 7	All 6-12 science SOL
Experiment Report Project	1, 2, 3, 4, 5, 9	All 6-12 science SOL
Getting Prepared Project	2, 4, 5, 7, 9	All 6-12 science SOL
Developing an Inquiry-Based Unit Project	3, 4, 5, 6, 7, 8, 9	All 6-12 science SOL
Assessment Project	5, 6, 8	All 6-12 science SOL
Teaching Philosophy Project	5, 10	All 6-12 science SOL

Information About You Project — This assignment is in two parts. The first part consists of a series of questions designed to gather more information about pre-service teachers so that the projects can be fine-tuned to better meet their needs. In the second part of the assignment, pre-service teachers reflect on their teaching philosophy.

Practicum Project — Through this project, pre-service teachers complete practicum hours that are required by the Commonwealth of Virginia for teacher certification. During the practicum, pre-service teachers work with an in-service teacher toward satisfactory completion of their practicum requirements. Pre-service teachers maintain daily reflection logs, reflecting on their placement in terms of the NCATE standards for teacher preparation, and begin collecting documentation to satisfy requirements for portfolios that will be submitted in final draft form at the end of student teaching.

Curriculum Map Project — In this project, pre-service teachers develop a yearlong plan for teaching a particular middle/high school science course. Thinking about their yearlong plans before they begin teaching each school year is very important. This plan will provide the foundation for developing and organizing the sequence of pre-service teachers' units of instruction. Once pre-service teachers know the amount of time allotted for each unit, then they will have a framework to work within as they develop their daily lesson plans. There are a variety of factors that determine teachers' yearlong plans, and through this project pre-service teachers examine some of them while developing their own curriculum map for their first year of teaching science.

Hands-On, Minds-On Science Project With Safety Test — In this project, pre-service teachers develop a hands-on, minds-on experience designed to support their review and further learning of science concepts that they may be asked to teach in the future. Along with developing the activity, pre-service teachers develop sheets to support student learning during the activity, along with a set of questions that will give them feedback from both middle/high school students at their practicum site and their cooperating teacher in the areas that they choose (e.g., choice of activity, wait time, choice of questions, organization of materials, equity of questions and attention, the activity sheet, safety, ethical concerns, etc.). Pre-service teachers lead their practicum class in the activity they develop. Pre-service teachers address these experiences in

terms of student learning, questioning strategies, safety issues, ethical concerns, and applicability to their future teaching. Finally, pre-service teachers make additions to their curriculum maps that will support hands-on learning, and reflect on these additions by completing a chart.

Science Around the World Project — As teachers teach different topics throughout the year, it is important to illustrate that our science knowledge is the result of a long historical development that involved a diversity of individuals. Too often, scientists are portrayed to middle and high school students as white, middle-aged, glasses-wearing male nerds who are not anything like the students themselves. While not discrediting the numerous contributions that individuals fitting the previous description have made, there are others who have been grossly ignored in terms of their contributions to science or their parallel developments of scientific understanding. Even teachers who desire to portray a broader diversity of scientists find that standard secondary textbooks are of no help. In this project, pre-service teachers research the contributions that individuals of non-European descent have contributed to a selected science discipline. Through this assignment, pre-service teachers not only broaden their own knowledge of the contributions made to science by these individuals, but they can also utilize their findings in their future teaching.

Experiment Report Project — Experiments are a vital part of science instruction. Middle and high school students must have opportunities to design and perform investigations, and they must be allowed to share their findings with others to help determine what real-world significance their findings may have. Not only do experiments require that students actively engage in "sciencing," but experiments require students to interact socially with others in positive, meaningful ways. In this assignment, science methods pre-service teachers design, perform, and record a controlled experiment answering a question of their choosing that is related to a specific standard. After pre-service teachers write their experimental reports, they use the provided rubric to assess their work.

Getting Prepared Project — In the first part of this project, pre-service teachers collect responses from teachers in the field and develop their own reflective responses to a variety of scenarios. Science classroom instruction is shaped by the nature of science in numerous ways—some obvious and some not so obvious. Because science instruction generally uses numerous hands-on experiences for students, there is a need for teachers to be prepared for the numerous safety

situations that might arise. These hands-on experiences in the science classroom also need to be supported by classroom management strategies that will foster a safe environment for middle and high school students. Through their reflections and data gathering, pre-service teachers see how the nature of science, context of science, safety precautions that include the ethical use and care of living organisms, classroom management issues, and differentiated instruction practices work together to shape science classroom instruction.

In the second part of this project, pre-service teachers reflect on the course and how it impacted their curriculum maps and statement of teaching philosophies.

Developing an Inquiry-Based Unit Project — In this project, pre-service teachers develop an inquiry-based unit of instruction according to a set of assumptions and guidelines provided in the unit rubric. The 5-E Approach is used to structure the unit, as well as daily lesson plans [5]. This unit consists of five lesson plans that should be developed according to guidelines presented in the lesson plan rubric. For each lesson plan, pre-service teachers locate, modify, and/or create sheets for middle/high school students to use during instruction.

Assessment Project — This project requires that pre-service teachers think about their units backward by creating an instrument that will be distributed to their middle and high school students, and is designed to assess student learning over the entire unit. Next, methods pre-service teachers design a rubric that can be used to assess student performance on this assessment. Then the bad news: the middle and high school students didn't perform as well as the teacher hoped. In this part of the assignment, methods pre-service teachers watch a video that describes how teachers use differentiated instruction to meet ***all*** students' needs in the classroom. After watching the video, pre-service teachers develop two lesson plans that address middle and high school students' poor performance using differentiated instructional strategies. However, these extra two lesson plans take up time in the curriculum map. Pre-service teachers are asked to reflect upon the implications of poor student performance and the need for extra time on a given unit or topic in their curriculum maps.

Teaching Philosophy Project — For this assignment, pre-service teachers write a one to two page, double-spaced reflective essay that identifies and explains their commitment to education, their role as a teacher, and their goals for their students. Through the writing of this philosophy, pre-service teachers share with others their beliefs about teaching and learning.

Feasibility of Using *Blackboard 5.0* Web-Based Technology in an Asynchronous Science Methods Course

Blackboard 5.0 provides a means for pre-service teachers enrolled in the course to "drop" their work in the instructor's box for easy grading. The instructor can provide feedback to pre-service teachers on their work using the same mechanism. As instructors with experience teaching large numbers of pre-service teachers via distance learning, the preference is for pre-service teachers to use e-mail to submit their work to the instructor. The process is simplified if the instructor gives pre-service teachers a guideline for what should be typed in the title of the e-mail for each project, and if pre-service teachers are instructed in the basics of how to attach and send documents. The instructor can then provide quick and easy feedback to pre-service teachers by responding to their e-mails. The result is that the instructor has an electronic copy of all of the pre-service teachers' work. One particular difficulty with *Blackboard* at this time is that the instructor's box gets full very quickly. There is no way to organize the documents in the box into folders on *Blackboard.* Instead, documents must be downloaded to the instructor's hard drive where they can be organized, and this is a time-consuming task. Pre-service teachers like using *Blackboard* to submit their work because they feel more confident that their work has reached the instructor. When submitting work by e-mail, pre-service teachers sometimes doubt that the instructor has received it until they receive a response from the instructor.

Projects are uploaded into *Blackboard* using a template. This template informs pre-service teachers about their assignments in a logical manner that is repeated throughout the course, thus allowing them to become quickly familiar with the format. Each project consists of the following parts: resources, overview, objectives, context, activities, evaluation criteria, frequently asked questions, and instructions on how to submit work. Because pre-service teachers are in an asynchronous environment, it is the instructor's goal to provide them with as many resources as possible while they complete their projects. The drawback is that sometimes *Blackboard* screens look too busy, and pre-service teachers cannot find the pertinent information they need because the instructor has provided too many details. There is a fine line between just enough information and too much detail. This line has to be carefully monitored by the instructor for each student. Through e-mail conversations, the instructors have been able to provide pre-service teachers with strategies for locating the information they need to complete each project.

Potential for Creating Highly Qualified Teachers

Pre-service teachers in the course are enrolled in a selected Virginia state university's asynchronous master's degree in science education leading to teacher licensure in middle school. Admission requirements for this selected institution's program mandate that pre-service teachers must have a B.S. or B.A. degree, passing scores on Praxis I, an undergraduate GPA of at least 2.8, and a GRE score of at least nine hundred on the first two sections or a MAT score of at least forty-five. Pre-service teachers take courses that meet the Commonwealth of Virginia's stated academic competency requirements. Pre-service teachers must satisfy two undergraduate endorsement areas: mathematics with a minimum of twenty-one credits; English with a minimum of twenty-one credits; science with a minimum of twenty-one; or, social studies with a minimum of twenty-one credits. Approximately thirty-three credits of on-line education courses are then taken at the graduate level, along with a set of prerequisite courses that are also offered via distance learning. These thirty-three credits include methods courses with practicum and a one-semester student teaching experience. Additionally, pre-service teachers must pass Praxis II, maintain a GPA of 3.0, satisfactorily complete their comprehensive exam, and complete their exit interview. Upon completion of the program, the university completes licensure packets for the students that then are submitted to the Department of Education for approval.

The No Child Left Behind (NCLB) legislation of 2001 draws a distinct link between teacher quality and student achievement, and to date is the latest revision of the Elementary and Secondary Education (ESEA) Act. Title I of ESEA requires that all teachers of core academic subjects be highly qualified if hired after the first day of the 2002-2003 school year, and teaching in a program supported by Title I Part A funds. As required, each state must have a plan to ensure that all teachers of core academic subjects are highly qualified by the end of the 2005-2006 school year. When pre-service teachers receive their teaching license upon completion of a state-approved teacher preparation program, they are then considered "highly qualified" according to the Commonwealth of Virginia's response to this federal mandate. Furthermore, graduates of a state-approved teacher preparation program are "highly qualified" according to the Commonwealth of Virginia's response to NCLB because they have completed their Praxis II tests in their concentration areas, and have completed content coursework equivalent to an undergraduate academic major in their concentration areas as expressed in the content course requirements described by Virginia's Department of Education Division of Teacher Education and Licensure.

As mentioned previously, all projects correspond to specific standards as described in the *Standards for Science Teacher Preparation* [1]. These standards provide guidelines as to what science teachers should be able to do upon completion of their teacher licensure requirements. Rubrics are provided for each project, and each rubric is aligned with these standards. As of Fall 2004, eighteen pre-service teachers have completed course requirements for their on-line methods course. During the same academic year, sixty pre-service teachers have completed course requirements for their on-campus methods course. While both versions of the course had several pre-service teachers withdraw or fail to complete all course requirements, the findings presented here are comparisons between only those pre-service teachers in the on-line and on-campus versions of the course who actually completed all course requirements and received a passing grade in the course. A review of student performance based on rubric expectations reveals that pre-service teachers completing the on-line course are not adequately prepared in light of these standards in two particular areas: their ability to develop inquiry-based curriculum and their potential for being able to create a positive learning environment for students. Pre-service teachers' performances on two projects related to these areas of weakness are described.

Results

With respect to on-line students' performance on the "Developing an Inquiry-Based Unit Project," all eighteen students completing the project utilized the 5-E Approach in their lesson development, but the 5-E Approach was not used appropriately to support inquiry-based instruction in sixteen out of the eighteen units submitted [5]. As a requirement of the project, not only do pre-service teachers need to incorporate the 5-E Approach into their lesson plans, but they need to use each phase of the 5-E Approach appropriately to support inquiry-based instruction. An analysis of the work submitted reveals that the most common mistake among the pre-service teachers when developing lesson plans was a failure to use the "Exploration" phase of the 5-E Approach appropriately. For this phase of their lesson plan, pre-service teachers incorporated introductory lectures on the science topic instead of creating a meaningful exploratory experience for students. As a result, their plans described classroom situations in which middle/high school students would use hands-on materials to verify what the teacher had told them. This finding is troubling in that no pre-service teacher (from a population of sixty) completing all course requirements in the same instructor's on-campus version of the course submitted a final version of her/his unit with this error during the same academic years in which this on-line course was offered. True, this error did occur among the on-campus pre-service teachers often during early work on their unit, but this error was quickly addressed as pre-service

teachers shared their unit plans during regularly scheduled "workshops" during classes throughout the semester. The lack of opportunity for on-line pre-service teachers to share early drafts of their lessons with the instructor and with other pre-service teachers enrolled in the course may be the reason that they failed to develop inquiry-based learning experiences for middle/high school students.

The "Getting Prepared Project" requires pre-service teachers to collect responses from teachers in the field and develop their own reflective responses to a variety of scenarios in the science classroom. Through their reflections and data gathering, pre-service teachers see how the nature of science, context of science, safety precautions that include the ethical use and care of living organisms, classroom management issues, and differentiated instruction practices work together to shape science classroom instruction. With respect to on-line students' performance on the "Getting Prepared Project," all eighteen of the on-line pre-service teachers completed all aspects of the project adequately according to rubric expectations and performed equally with pre-service teachers enrolled in the same instructor's on-campus version of the course during the same academic years. However, the rubric as designed does not measure the quality of pre-service teachers' work in terms of their ability to synthesize and evaluate different perspectives.

While all on-line pre-service teachers who completed the course passed this particular assignment, there was a definite lack of quality, depth, and thoughtfulness in their work among fifteen out of the eighteen on-line pre-service teachers, as compared to the general level of performance among the on-campus pre-service teachers. Two sessions during class for pre-service teachers enrolled in the instructor's on-campus version of the course may be responsible for this difference in performance. In the first session, the project was introduced, and pre-service teachers were encouraged to immediately begin by individually developing their initial reflections for each scenario during the next week. They were then to begin discussing particular scenarios with in-service teachers in the school in which they were completing their practicum hours. By stressing the need to begin this project early in the semester, the on-campus pre-service teachers had an extended period of time to complete their work. On-line pre-service teachers may not have begun their work on this project early in the semester and waited closer until its due date. In a follow-up session in the instructor's on-campus version of the course, each scenario was discussed in class among the pre-service teachers in both small groups and as an entire class with respect to the nature and context of science, safety issues, classroom management, and differentiated instruction. The lack of opportunity for on-line students to discuss this project with

the instructor and with other pre-service teachers enrolled in the course may be the reason that their work was lacking in quality, depth, and thoughtfulness when compared to the work submitted by the on-campus pre-service teachers.

Final Remarks

According to the Commonwealth of Virginia's response to guidelines established by NCLB, program completers are highly qualified once their set of coursework has been completed in their state-approved teacher preparation program [4]. While much has been done to develop this course in light of the *Standards for Science Teacher Preparation*, the potential for on-line science methods courses has not been fully explored nor adequately developed through this course based upon initial findings presented in this paper [1]. More studies, in terms of other projects completed in the on-campus and on-line versions of the course, are needed. Indeed, for several other projects in the course there are many occasions in which on-campus and on-line pre-service teachers perform quite similarly, and results of these comparisons will be presented in future work. This on-line course offering does much to increase access to the course so that pre-service teachers across the country can enroll and complete course requirements, but the quality of the course at this time needs to be further developed. While pre-service teachers have the opportunity to develop skills as described in the *Standards for Science Teacher Preparation* through the course's requirements, the quality of work submitted is not indicative of teachers prepared to plan inquiry-based instruction [1]. Based on the lack of quality, depth, and thoughtfulness in their reflections on scenarios which regularly occur in inquiry-based science classrooms, pre-service teachers completing the on-line course version do not appear to be as prepared to create a positive learning environment for middle/high school students, as compared to those completing the on-campus course. ■

References

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