CONSTRUCTING THE SCIENCE METHODS COURSE AS A SHARED INSTRUCTIONAL PRODUCT

(Paper 2 in Paper Set, Related Paper Set - Virginia Initiative for Science Teaching and Achievement (VISTA) - First Year Statewide Implementation)

Juanita Jo Matkins, School of Education, College of William & Mary

Donna R. Sterling, College of Education and Human Development, George Mason University

Jacqueline T. McDonnough, School of Education, Virginia Commonwealth University

Wendy M. Frazier, College of Education and Human Development, George Mason University

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Correspondence concerning this paper should be addressed to Juanita Jo Matkins, School of Education, College of William & Mary, Williamsburg,VA 23187. E-mail: jjmatk@wm.edu

Science methods courses at the university level are notoriously idiosyncratic, with wide variation across instructors and institutions. Various efforts to structure and govern such courses have been instituted at the local level, and national and state accreditation agencies have implemented standards that attempt to ensure quality delivery of courses that prepare effective science teachers. These efforts are undermined by current teacher shortages in science that have led to the hiring of many uncertified teachers who have science degrees but little or no teaching training (NCMSTTC, 2000; NRC, 2007). Also, short-duration teacher preparation programs often offer generic methods courses for secondary teachers, courses that fail to provide the specificity needed for focused science instruction. These deficits in science teacher preparation yield a dramatic and ominous result: Student achievement in science suffers.

A collaborative approach to the development and implementation of the science methods course, with testing of the effectiveness of these courses at multiple sites, holds promise for creating a reproducible, data-based product for distribution. The collaborative creation of shared instructional products is a process recommended by Morris & Hiebert (2011), responding to a lack of consistency in instruction in schools, and a consequent lack of consistent assessment of the effectiveness of instruction. Without consistent instruction, Kenney (2008) points out that there is no way to develop a "science of improvement". Morris & Hiebert specify the development of "shared, changeable knowledge products", enabling teachers to identify and solve instructional problems collaboratively. Popper (1972) classified one aspect of knowledge as public products that are shared, jointly constructed, stored, and improved. Systems that produce useful knowledge products exhibit three enabling features, (1) shared problems across sites, (2) small tests of small changes, and (3) multiple sources of innovation (Morris & Hiebert, 2011).

Large-scale interventions in science education, such as the project reflected in this paper and other papers in this set, encounter challenges that correspond to the challenges faced by all science educators. It is a risk to assume shared understanding about the goals of science education and the meaning of "reform". Marx (2012) points out that there are many meanings for "reform" and, though data on science education reform efforts over the past decades show some improvement in some areas of concern, there are other areas – e.g., income/achievement disparities -- where new concerns have arisen. Science educators interested in reform that endures must align their research so that (1) research findings accumulate and (2) policy-makers and practitioners care enough about the results that the results are put into practice. Marx points out that this might require a substantial time period, also pointing out that this "might be asking too much". Nonetheless, the Co-Principal Investigators in this project have attempted to define "reform" in the context of the project activities and in alignment with science education research.

This activity, offering a first science methods course to new science teachers, is a component of a large-scale intervention funded from the federal government. The funding requires a rigorous research study as a component of the project, which in turn places certain constraints on implementation. In a study by Plass et al. (2012) on the use of chemistry simulations in a high school chemistry class, the researchers found that incorporating fidelity of implementation (FOI) measures affected the size of their experimental group of classroom teachers. Teachers changed their practice enough that the researchers eliminated large portions of their sample, possibly based on their own professional judgment about what would work in their classroom. Thus, FOI was shown to be an appropriate aspect for scrutiny; this was borne out in the interactions with the research team in this secondary teacher project, that worked in collaboration with the other teams implementing the various activities that comprise the overall project. This course is one of those activities.

This paper will chronicle the development of the first course, and results from the first offering of the course at the three sites. Since the VISTA grant is a five-year program, this course will be taught 15 times, enabling "small tests of small changes" over time. This repetition of results, rather than a single set of results from a large study, is a valuable approach to data collection and knowledge building. Sir Ronald Fisher, the father of modern significance testing, saw results of repeated trials as the real measure of scientific work (Tukey, 1969), and the duration of the VISTA project supports repetition with small changes, over time. Data will be collected on course products such as the science unit, and on student perceptions of the effectiveness of the course. The VISTA secondary teacher activities are based on a treatment/control design; data from the randomly assigned treatment and control teachers will also include scores on statewide standards-based science tests as well as in-classroom data on secondary science teacher implementation of course topics such as inquiry-based instruction and instruction in the nature of science. It was anticipated that, over five years, there would be 300 treatment teachers and 150 control teachers.

Designing the Science Methods Course

The Virginia Initiative for Science Teaching Achievement (VISTA) contains a support system for new secondary science teachers (grades 6-12). The first leg of a three-leg support system for new science teachers is an initial science methods course, detailed in this paper. The other supports are (2) two years of just-in-time support provided by an in-classroom coach, and (3) a second, advanced, science methods course. The first VISTA science methods course was developed through a joint effort across three sites that exhibited the three enabling features described by Morris and Hebert. The lead collaborators were all secondary science methods instructors at their universities, all tenured faculty, all with primary responsibilities in overseeing secondary science education programs. The three members of the faculty course development team had consulted on aspects of their methods courses for several years, all drawing from the course materials of a common mentor, a senior faculty member at one of the institutions. Each team member brought specific expertise to the course, one was a published author on English language learners, one on gender issues in science, and two had published articles jointly on the development of self-efficacy in science.

While the course was being designed, recruitment efforts were underway to enroll sufficient students to meet the grant goals and hold the classes. Recruitment and assignment to treatment/control in the first year of the grant-funded program was problematic. Though the proposal for the project anticipated 20 participants per site, in the treatment group, the overall total of applications was 69. Randomization into treatment/control was accomplished at a 2/3 to 1/3 ratio. Subsequently, with eliminations from the pool due to ineligibility – for various reasons including too much teaching experience and school division reluctance to agree to terms – the count for all three sites was 49 secondary teachers who were eligible for the class. Of the 49, 37 were randomized into the treatment group and 12 into the control. At the first checkpoint for the class, in mid-September, only 12 teachers remained in the treatment group, with 11 in the control. Since the three sites were geographically distant from each other and the students had begun classes at each site, the project team decided to continue with the original intention of holding the courses at all three sites. Final enrollment at site A was eight, at site B was one, and at site C was three.

During the time for recruitment, the planning team continued to move forward on the syllabus, coursepack, activities and assignments for the class. Meetings were held via teleconferencing, and documents were shared via DropBox©. Figure 1 lists the assignments agreed upon, in chronological order, and gives comparative values for each assignment. Since the planning team had already been using similar syllabi, one of the first accomplishments of the telephone meetings was agreement upon a common introduction and set of goals for the class. The introduction read:

> CRIN S04 [varies by institution] is the first course in a two-part sequence of science methods courses for provisionally licensed science teachers. The course is designed to build fundamental knowledge of science teaching and learning including standards-based curriculum design and research-based teaching strategies. The course focuses on developing inquiry-based lessons for students to investigate science and assessing student understanding of science and the nature of science. The teachers will plan lessons for students to learn science, implement lessons in a secondary school classroom, observe students learning, and evaluate their teaching and student outcomes. Field experience (classroom teaching) is a required part of this course.
>
> The goals were:
>
> - Build a repertoire of science teaching and assessment strategies by reading, writing, observing, participating in, and reflecting on the teaching and learning of science via blogging and other collaborative tools;
> - Develop strategies to help students become scientifically literate, think critically and creatively, understand the nature of science, and see relationships among science, technology, and society in a problem-based learning context;
> - Plan standards-based (local, state, and national) units of science study including daily lesson plans for students that reflect research in effective science teaching and learning;
> - Construct science lessons and hands-on experiences that address the needs of a variety of student populations including English language learner, special needs students, and gifted and talented students;
> - Learn about science laboratory safety and plan teaching activities that highlight safety;
> - Work collaboratively with peers to teach and discuss science and science teaching.

The coursepack contained grading rubrics and checklists for the major assignments. The scores and criteria for those scores were agreed upon through discussion at the various meetings held by the planning team. Prior to planning meetings, the planning team shared sample assignment documents from students in previous semesters.

On occasion, a team member would recommend a topic or an assignment that the other team members had not used or were unsure about. One team member was using the Curriculum Topic Study (CTS) approach (Keeley, 2010) in her methods classes and, after explaining the general idea of the approach, this team member structured a training session via distance learning for all the team members. Each member acquired the CTS resources prior to training, and the experienced team member provided a virtual workshop for all, in the Curriculum Topic Study approach. The team agreed at that time that there was value to using CTS with the secondary science teachers in their VISTA methods classes. Consequent to this workshop, a CTS training session and assignment was added to the course, as shown in Figure 1.

One aspect of the shared methods course was an outcome of work done by the team in planning other aspects of the grant-funded project that this course fit into. That work involved reaching consensus on several key terms, and developing operational definitions for those terms. The terms were "inquiry", "hands-on learning", "problem-based learning", and "nature of science". Several face-to-face meetings occurred in the months prior to first class meetings in August; these meetings resulted in the shared definitions that served as themes throughout the courses. The planning team considered these terms as exemplars for science education reform at the teaching level, and developed a shared vision for their implementation in the classroom. This vision was translated into the instruction implemented at all three sites.

Implementation of the Plan

Actual implementation of the three iterations of the course yielded additional information about the effectiveness of the ideas laid out by the planning committee. Two of the courses, sites A and B, began class meetings by holding class each day, all day, for a week in August. Site A had 9 students and Site B had 3, initially. Further complicating scheduling of the meetings of the courses was the recruitment of additional students after the August startup. Site B incorporated four additional students who entered after the weeklong intro to the course in August. This was accomplished at Site B by adding in two full weekends in September, for the four. Once those weekends were done, the new students attended class with the students from August, on Monday nights. Three new students were assigned to Site C, which had not held August classes. One of the Site C students was driving several hundred miles to attend the class and thus classes could not be scheduled on a weeknight. This meant that classes at Site C met on Friday nights, Saturdays, and sometimes even Sundays. It also meant that assignment schedules sometimes led to several assignments coming due over one weekend, concentrating the preparation load for the students in the class.

In addition to coursework, students at all three sites traveled to the state science teachers' Professional Development Institute (PDI), towards the end of their course. At the PDI, students attended concurrent sessions on topics of their choice, and also participated in general sessions where speakers focused on various topics including the Next Generation Science Standards (VAST, 2011). After the PDI concluded, students received an additional day of training, focusing on nature of science and on using an online modeling and simulation product.

Assignments	Points
1. Science Philosophy and Vision	15
2. Annual Plan	45
3. Safety Plan	30
4. Discovery Lab and Design Brief	30
5. Female/Minority Scientist	20
6. Curriculum Topic Study	20
7. Teach a Lesson	40
8. Science in the News	20
9. Unit Module, draft and final copy	200
10. Synthesis of Key Elements	30
11. E-Portfolio Working Draft	200
12. Reflection on VAST conference	100
13. Microteaching Presentations	100
14. Inquiry Analysis/Lab Rubric	50
15. Community of Practice Credit	100
Total	1000

Figure 1. Assignments and Point Values for VISTA Secondary Science Course One.

Throughout the class meetings at each site, instructors observed that the new teachers were under a great deal of stress because of their new jobs, and instructors attempted to ease the load by making sure assignments were clearly presented, by giving time in class to begin assignments, and even giving more time for assignments to be completed. One instructor commented that she found herself reluctant to alter the course assignments because of the collaborative nature of the development of the courses and because of the constraints placed upon the project in order to deliver courses that could be subject to a research study. Fidelity of delivery across sites was a clarion cry heard over and over in conversations during planning and implementation of the courses.

The nature of the first year of teaching is that it is difficult and time-consuming; teacher dropouts within and at the close of the first year are problematic to school districts. The profile for the three classes reflected these problems. At Site A, though more than ten students signed up for the class, six students completed. One student had already had a similar class, one dropped out of teaching and one left because she became pregnant. At Site B, three students started and one completed. At Site C, three students started and three completed.

Conversations about the Next Offerings of the Course

Team debriefing sessions were held within 30 days of the last class meetings across, for the purpose of describing what worked, what didn't, and to design strategies for improving upon the aspects that didn't work. Instructors had worked diligently to preserve fidelity across sites, yet felt a tension with their own best professional knowledge. During the first debriefing call, one instructor stated she was hesitant, yet needed to "air her dirty laundry", following that warning with the confession that she had eliminated the Inquiry Analysis/Lab Rubric assignment, telling her students they did not have to do that assignment. Laughter came close upon that revelation, as the instructors at the other two sites revealed that they, too, had eliminated that assignment. All three agreed that (1) the assignment was redundant and its goals had already been addressed in class topics and other assignments and (2) the students were overstressed and one more assignment would unduly add to their stress. What all three realized was that, for the next offering of the courses, the instructors needed to have regular conversations about lessons learned, and questions about upcoming topics. The three agreed that instructors for the three sites should talk once a month during the offering of the course. After realizing that all three sites had simultaneously and independently decided to eliminate that assignment, the instructors discussed times in class when they wanted to drop something but kept it because they felt obligated to maintain the fidelity of the delivery across sites.

Another assignment that was changed at all three sites was the microteaching assignment. As originally intended, students in the class would be videotaped while teaching two bell-to-bell lessons. The student would view the tape of the first lesson, revise their practices and goals based on their observations of themselves teaching, and would then teach and tape a second lesson. The microteaching presentation involved showing their instructors and classmates selections from the tapes, and describing their initial goals, what they learned, and the goals they had for themselves at the end of the class. Since the students were assigned in-classroom coaches, one of the three legs of support for the secondary teacher activities for the grant, the course instructors anticipated that coaches would videotape the students and debrief with the students. Thus coaches would add their expertise to the set of ideas generated by the two teaching experiences and the videotaping. In actuality the coaches were also working with the project research team and, early in the academic year, were assigned the task of videotaping the teachers for the purpose of research. This tape could not be kept in the school and in possession of the coach or teacher. Coaches had great difficulty building in time for two tapings, and teachers had difficulty with all the arrangements for this assignment that, in better circumstances, could yield valuable reflections and durable gains in practice. When instructors discussed the microteaching assignment after classes ended for the semester, it became clear that the larger classes were more successful at completing the assignment, perhaps because there was more opportunity for problem solving about scheduling, taping and coaches, among students at those sites.

Though the nature of science (NOS) was one of the core aspects of the overall project, the three instructors agreed that they wanted to incorporate improvements into the second offering across sites. One site felt they had success with teaching their students to teach the nature of science, remembering that they regularly asked students questions about incorporating NOS once the topic was introduced with Female/Minority Scientist assignment. One site instructor said the topic seemed to "get lost", and that instructor resolved to make incorporation of NOS more explicit across the course content and topics, in subsequent offerings.

Student Feedback:

When asked to rate the various assignments for the class, students varied in their rating of several of the assignments. One student who was resistant to moving away from lecture-based instruction rated the use of the learning cycle low, through other students rated it high. The Curriculum Topic Study assignments was also rated low by some, though the instructors expressed a belief that this assignment is worth keeping due to its ability to familiarize students with resource documents for teaching science.

Conclusions, Implications, and Further Research

With the advent of the Next Generation Science Standards, it is critical that new science teachers have a shared understanding of science education practices, those understandings that are often clustered together as reform-based. The shared operational definitions that served as the foundation for the course delivery at sites provided a reference tool that strengthened the instruction at each site. The team of faculty who collaborated on the development and implementation of this course exhibited a sense of unified vision about the goals of this class. Faculty used their shared observations and reflections on their own practice to develop recommendations for the next iteration of course offerings. The habit of regular reflective conversations before, during, and after each course offering promises to yield a set of data that accumulates over time and is translated into practice – supporting Marx's (2012) recommendations for reform that endures.

In order for that data to have credibility beyond the local research community, it must reflect certain protocols, including fidelity of implementation (FOI) across years and iterations. As documented in this paper, a tension existed between efforts to create and preserve FOI and efforts to adapt to the needs of students and to the realities of the first iteration of the three-site effort. Plass, et al., experienced some of the same tensions in their selection and sometimes elimination of treatment group members. This balancing act between freedom for instructors to make professionally based choices and the need for consistency across sites is one which must be negotiated between the research team and the instructional team for such projects. Fortunately, the grant-funded project that this paper set reflects enjoys a research team that includes experienced classroom teachers who readily engage in discussions and clarifications when FOI dilemmas arise. It is essential, though, now that the first year of activities is accomplished, that those conversations continue with the same careful focus on the dual roles of the team members – as stakeholders in the research and also as instructors for the courses.

The collaborative nature of the course development and the results from the first three iterations of the course – in the fall of 2011, provide a public product – a course syllabus, schedule of activities, assignments and specific methods course lessons – that promises to yield a much more effective course than could be developed in isolation. This "shared, changeable knowledge product" will be published on the VISTA Website for use by anyone interested in taking advantage of the information. As changes are made to the course, over time, those changes will be published, along with explanation for the basis for change.

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