Science Methods Courses in the Context of a Five-Year Research Project: Using Year One to Shape Year Two

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> "Although many who enter teaching believe they do not need specialized training before they enter, most learn quickly that teaching is much more difficult than they thought, and they either desperately seek out additional training, construct a teaching style that focuses on control—often by "dumbing down" the curriculum to what can be easily managed—or leave in despair." (Darling-Hammond, 2009)

Large scale implementation of tested approaches to science methods courses, such as the VISTA courses, holds promise for increasing effectiveness of science instruction in our schools, yet the development of a model for science methods courses is problematic. One answer to this problem is a collaborative approach on the small scale, across a few sites, with the assistance of external advice from knowledgeable and trusted evaluators. Morris & Hiebert (2011) recommended a process of collaborative creation of shared instructional products in response to their findings of a lack of consistency in instruction and assessment in schools. They characterized these products as "shared, changeable knowledge products", supporting the development of a "science of improvement" (Kenney, 2008) in methods classes. This idea of a changeable product can prove paradoxical to the classic design of a scientific investigation, where the procedure is defined at the onset and is faithfully reproduced multiple times in order to achieve the statistical power required for confidence in measured results. One challenge faced by instructors in large-scale projects with multiple sites offering the same product is to maintain an acceptable level of fidelity, thus ensuring repeated trials, while differentiating appropriately for participants and the specific context at the site.

One of four major activities of The Virginia Initiative for Science Teaching and Achievement (VISTA), a five-year statewide project, is the offering at multiple sites of a set of two science methods courses for middle and high school-level science teachers in their first years of teaching (Matkins, Sterling, McDonnough, & Frazier, 2012). The science teacher educators tasked with the initial development of the Secondary Teacher Program Course I were all part of the initial leadership team for VISTA, a sizable i3-funded statewide project. They all had more than 10 years of experience as science teacher educators in addition to multiple years of teaching in K-12 schools. These were all experienced educators, all tenured associate professors, yet the task of developing a course to meet the needs of novice secondary science teachers presented numerous challenges. The process of course development took place while all members of the team were burdened with the various responsibilities of university professors. The timeline for creating the first course was limited and only one of the three had extensive expertise working with provisionally licensed secondary science teachers. The circumstances under which the first course was developed can be compared to that of many classroom teachers, limited time to reflect and make modifications. A growing trend in school communities designed to address this concern of limited time and expertise is the development of professional learning communities.

A professional learning community (PLC) is defined as a group of teachers "caring for and working to improve student learning together by engaging in continuous collective learning of their own" in Mundy & Stiles (2009). The six characteristics of a PLC (Dafour & Aker, 1998) are:

(1) Shared mission, vision, values, goals
(2) Collaborative culture
(3) Collective inquiry
(4) Action orientation/experimentation
(5) Commitment to continuous improvement
(6) Results orientation

Although the team of science teacher educators did not initially identify themselves as a PLC, over time the group evolved into one. Given that an underlying principle of the VISTA Project was "continuous improvement", reflection on and actions related to the course set's impact on the participants developed organically. The instructors consulted literature about best practices for instructing novice teachers and regularly engaged in discourse about the course activities and their students' reactions to those activities. In addition, they used feedback from students' evaluations and from the grant evaluation team to make modifications to the subsequent courses. This team of educators exhibited a continuous cycle of reflection, action, and learning from their actions, applying their learning to the course (Mundry & Stiles, 2009), all salient characteristics of a PLC. Applying the characteristics of a PLC to their course instruction and activities, the instructors aspired to develop a PLC among their students.

As participants in the professional learning community, the lead instructors engaged in continuous dialogue about best practices for preparing teachers. Teachers who entered the profession with little knowledge of child development or of learning theories tended to rely on “rote-learning” strategies, used more authoritative strategies for classroom management, were less skilled at managing discussions and directing learning toward deeper understandings, were less likely to have skills to identify students’ learning styles and needs, and were more likely to blame the student when the student did not achieve. (Darling-Hammond, 2000, 2003). Teachers who have had courses in child development and learning theory and have had student teaching were twice as likely to stay in teaching (National Commission on Teaching and Teachers’ Future [NCTAF], 2003). The VISTA course development team had the daunting task of designing courses with the potential to yield teachers who, despite their lack of foundational knowledge of children and learning, would become skilled in supporting student learning, and would have the potential to stay in the profession.

In *Teacher Education Around the World: Changing policies and practices* (2012), Darling-Hammond analyzed the status of teacher education around the world and listed promising practices for the improvement of teaching around the globe, including:

(1) Financial subsidies for training can be a valuable component of the recruitment of highly able candidates into the profession. Companion qualities for recruitment included competitive salaries, and common components in teacher preparation across the culture.
(2) The connection of theory and practice in the context of coursework and explicitly connected field experience. Field experiences -- including student teaching -- were best accomplished in a setting where good teaching practice was supported.

(3) Induction models that provide skillful mentors for beginning teachers, and that include collaborative planning and reduced teaching loads. The time gained in reduction in teaching loads was used for professional development.
(4) Professional development that consistently and purposefully enabled teachers to learn with and from one another, both within and across schools and universities.
(5) Capacity building within the profession, providing opportunities for sharing of research and classroom practice, spotlights successful practices, and enables teachers to develop as leaders of the system as a whole.

In the first year of implementation, the first VISTA science teacher preparation class (STP I) was taught at three sites, to small groups of new teachers. Though initial goals anticipated 20 treatment teachers at each site, actual numbers varied and were much smaller (six at site A, one at site B, and three at site C). Plans included placing an entire week of coursework (9:30 a.m. to 3:30 p.m. Monday through Friday) in early August, prior to new teacher workdays in many school divisions. In summer 2011, due to the recruitment of additional students after the first week of coursework, site B added several weekend makeup sessions to its schedule. Site C, which had not offered the week of coursework in the summer, provided the entire course on various Fridays, Saturdays and Sundays. At all three sites, STP I included 15 assignments, with five assignments counting for 80% of the course grade. Along with the VISTA methods courses, during the academic year teachers were to receive the in-classroom support of a coach, an experienced secondary teacher. It was anticipated that coaches would meet their teachers during the August coursework week. Since coaches were matched to content area and location of the course participants, coaches were not recruited for sites B and C until the academic year was underway (Matkins, et al., 2012). These conditions set the stage for challenges in the initial effectiveness of the first methods course across sites.

While the first three offerings of STP I were underway, an independent evaluation of the course occurred (Bell, Heinecke, & Maeng, 2012). Evaluators provided a draft of their preliminary results in late July, 2012, in anticipation of a second offering of Course One in August 2012. They cited three areas for concern: (1) course attendance/format/fidelity of implementation, (2) course design/participant overload/participant learning, and (3) lack of clarity of the coach role. The report showed the attrition rate from the treatment group was 65%, with 56% (18) dropping out before Course One began, and 9% (3) dropping out afterwards. Reasons given by teachers who left the treatment group included feeling overwhelmed by teaching responsibilities and also perceptions of the extensive amount of work and time commitment of Course One (Bell et al., 2012). In addition, the evaluation team found that the instructional model adopted for the project, Learn-Try-Implement, had been inconsistently applied across sites. Though the report provided by Bell, et al., (2012) was preliminary, the second offering of Course One was imminent, and the decision was made to incorporate many of the preliminary recommendations into the second iterations of the first course.

While STP I-Year Two was being planned, the first offering of the second course in the two-course sequence (STP 2) was looming. The students for this course would be the

completers from STP I-Year One. This course would also be offered in the fall semester. The instructors would be either university faculty and/or VISTA staff members.

Design/Procedure

Course One. The three original lead instructors of Course One continued in an advisory role, and in one case a co-teaching role, with the second offering of Course One (Two of the three leads became lead instructors for STP II). One of the three original instructors – the one with extensive experience working with provisionally licensed teachers – took on the role of advisor only, resulting in a site where the instructor who taught STP I-Year Two and STP II-Year One had no previous experience with VISTA courses, though the instructor had taught in the pilot program prior to VISTA. Cross-site debriefing sessions were held with instructors at all sites throughout the semester following year one, in preparation for year two. Non-tenure track instructors employed by the VISTA project took over the lead instructor role for STP I at all three sites. Results from assignments in year one, as well as observations and feedback from participants in the courses, were used in developing the "shared, changeable knowledge product" (Morris & Heibert, 2011) of this first science methods course. Among the initial changes determined by the new instructor-team was a reduction in the number of assignments and an explicit plan for connecting concepts and critical assignments across the semester. The full week of summer classes in year one was reduced to three days, in order to both enhance the initial preparation of new teachers while also reducing the initial load of assignments in year one. The instructors planned for enhancement of instructional aspects such as inquiry-based approaches and strategies for teaching the nature of science. In addition, all sites continued the practice of incorporating attendance at the Virginia Association of Science Teachers' conference into the course, with students remaining at the conference site after the conference ended, for further professional development.

Upon receipt of the preliminary report from the evaluation team of Bell, et al. (2012), the instructor-team met with the PI and co-PI's for the VISTA project and revised the syllabus and course schedule based on the preliminary recommendations. These revisions included an upfront emphasis on topics and assignments with practical application in the science classroom, e.g., safety, curriculum mapping, inquiry and the learning cycle, and the nature of science. Also, the team planned to bring in the coaches during several class meetings, in response to the perception of lack of clarity about the coach's role.

The three parallel sections were offered in Fall 2012, with a total enrollment of about 35 students across sites, tripling the enrollment of ten from year one (Fall 2011). Assignments were reduced from 15 to 10, and emphasis was placed on consistently applying the learn-try-implement model (Table One).

Course Two. STP II was designed to emphasize and enhance new teachers' ability to (1) use instructional technology effectively, (2) differentiate instruction to meet the needs of the range of abilities, learning styles, and other characteristics found in a given classroom, and (3) incorporate problem-based learning into instruction. The instructors planned several class sessions to focus on analysis of student work, varying the emphasis of the analysis to correspond to a course topic, e.g., inquiry, nature of science, and

assessment. This incorporation of the learn-try-implement model was a direct response to the preliminary report on STP I. Since the students in STP II were the veterans from STP I, each site had prepared their students to present a workshop at the Virginia Association of Science Teachers' (VAST) Professional Development Institute (PDI) in November. Consequently, two workshops at VAST's PDI were hosted by VISTA secondary teachers.

Results

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. These data will be reported in depth by the evaluation team and their partners in VISTA. This paper is intended as a complement to those results, adding information from the perspective of the instructional teams involved in the secondary science courses. The course profile is a "shared, changeable knowledge product" as it evolves each year. As the iterations of the courses are analyzed and the learn-try-implement model is applied across the concurrently offered courses and across the semesters as new cohorts take the courses, the result will be a highly refined model for the sequence of two science methods courses. The design of the two course set, STP I and STP II, and the underlying design carried over to the courses from the VISTA proposal, incorporated many aspects of Darling-Hammond's promising practices from around the globe.

Financial subsidies and competitive salaries. After Year One, a financial subsidy was provided to participants as an incentive. Though this subsidy was not sufficient to ensure all the teachers remained in the profession, it may in part explain the increase in enrollment in STP I-Year Two. The dropout rate of 65% of course enrollees for STP I – Year one should also be considered in light of the timing of the dropouts, with 56% dropping out before the course began. In that group, some dropped due to the rigor of the course, including the number and depth of assignments. It is possible that, had the education culture in the United States and Virginia evolved to allow lighter teaching loads for new teachers, the number of dropouts would have been significantly less. In contrast, these new teachers were expected to teach effectively with multiple preparations, in a high-stakes testing environment. Nonetheless, the financial subsidy, in addition to the provision of a classroom coach and travel expenses, provided some incentive to the teachers in STP I – Year Two and also to the cohort for STP II – Year One.

In *The Death and Life of the Great American School System: How Testing and Choice are Undermining Education* (2010), Diane Ravitch argues that the American school system is plagued by vague standards, narrow curricula, top-down directives from those with little knowledge of learning and schools, a movement toward instructional uniformity, over-reliance on standardized test scores, catastrophic sanctions for "failing" schools, and a glut of market-based reforms that attempt to turn schools into corporate

enterprises. Instead, she contends, the "most durable way to improve schools is to improve curriculum and instruction and to improve the conditions in which teachers work and children learn" (p 225). The factors cited by Ravitch as negatives affected the participants in the VISTA secondary course sequence as they struggled to provide the high-quality science instruction they were learning through VISTA.

In the 9% who dropped out after STP I- Year One began, the instructor reported that one teacher left teaching altogether, due to “an extremely negative, unsupportive school environment”. The education culture in the United States falls short in recognition of the teaching profession as a highly valued component of society. Overall salaries for teachers remain mediocre, and the reputation of the profession has suffered in recent years from the perception of projects such as Teach for America (TFA), where content knowledge is emphasized, little attention is paid to pedagogical expertise, and persistence in the profession is not valued. There is an assumption in projects such as TFA that the teaching profession is in such crisis that even short-term interventions are better than what is currently being attempted within the teacher education community.

During the first offering of the courses across sites, in Fall 2011, the management team determined a staggered schedule for payment of the VISTA subsidy, with the goal of enhancing the likelihood of completing the courses. Nonetheless, this only in part compensated for the context: Virginia’s schools suffer from a condition common across the nation; that is, low status and low pay for the teaching profession and for teachers.

Connection of Theory and Practice. The lead instructors incorporated an emphasis on inquiry, nature of science, and problem-based learning into the VISTA courses. One embedded challenge that contrasted with the best practices defined by Darling-Hammond was that most of the participants in the VISTA courses were teachers who entered the professional through alternative licensure routes. Thus, the courses could be the first formal investigations of pedagogy and learning theory for the new teachers taking the courses. The courses also included various learn-try-implement approaches focused on topics considered essential to effective teaching, such as curriculum mapping, connection to standards, safety in the science classroom, and classroom management. Though these topics may seem mundane from the perspective of experienced classroom teachers, they were essential components of preparation for the novice teachers participating in STP I and STP II.

The first offering of STP I in Fall 2011 was a traditional methods course with some adaptations for the context of the students; this was satisfactory in some ways yet the instructors realized that connections of theory to practice were weak. In an effort to gain time for more authentic interactions with students, and for more discussion about individual teaching experiences, also in response to student feedback from Fall 2011, the number of graded assignments was cut from 15 in 2011 to 10 in 2012 (Table One). An effort was made to better connect assignments to practice, specifically in the unit. Assignments that were not considered essential were eliminated, and two assignments were added: the management plan and the analysis of student work. The addition of the management plan was motivated by several factors, including awareness of the research

on the difficulties new teachers experience with classroom management, and also by the need to bring the course more in line with coursework required for initial licensure in Virginia. Analysis of student work was added to introduce the participant teachers to the practice of using student work as a vehicle for learning and growth about their teaching practice.

STP I Assignments 2011	STP I Assignments 2012
1. Science Philosophy and Vision	1. Science Philosophy and Vision
2. Annual Plan	2. Annual Plan
3. Safety Plan	3. Safety Plan
4. Discovery Lab and Design Brief	Incorporated into unit, critique required
5. Female/Minority Scientist	Incorporated into unit
6. Curriculum Topic Study	Done in class
7. Teach a Lesson	Teach a Lesson became microteaching
8. Science in the News	Eliminated
9. Unit Module, draft and final copy, four weeks	5. Unit Module, draft and final copy, two weeks, video analysis included, female/minority scientist included, design brief included
10. Synthesis of Key Elements	Eliminated
11. E-Portfolio Working Draft	Eliminated
12. Reflection on VAST conference	6. Reflection on VAST conference
13. Microteaching Presentations w/video analysis	7. Microteaching done in class
14. Inquiry Analysis/Lab Rubric	Analysis done in class
15. Community of Practice Credit	8. Community of Practice Credit
	9. Management Plan added
	10. Student Work Analysis added

Table One. Assignments for STP I in Fall 2011 and changes in assignments in Fall 2012.

Induction models with skillful mentors. Though VISTA could not guarantee optimal teaching loads and school-district-provided professional development, there was a mentor provided for each teacher through VISTA support. These coaches, as they were called, worked in the classrooms with the new teachers, providing support that ranged from grading papers and analyzing and discussing outcomes, to teaching model lessons in the classrooms. This in some ways provided support similar to Darling-Hammond's findings of reduced load and collaborative planning. In the VISTA project, the coaches were matched to the content area of the teachers, and coaches were trained on many of the same topics found in the methods courses, e.g., inquiry, nature of science, Curriculum Topic Study, assessment, and discourse. These same coaches were also employed by the project evaluator (UVA/Oregon State) to film lessons for later analysis by the evaluators. The evaluators, in their preliminary report, found that the role of the coaches was unclear. In response, the instructors for STP I and STP II, and other staff in the VISTA project, undertook collaborative planning and consistent cross-site implementation of coach training. One major impediment to effective mentoring by the coaches was the difficulty two of the three sites had in locating and keeping suitable coaches. Coaches became ill, and coaches went back into fulltime employment. At two sites, VISTA staff had to take on coaching responsibilities in addition to their other duties, limiting their effectiveness as staff and as coaches. One step taken recently to ameliorate the difficulties experienced with the coaching aspect of the project is the re-organization of responsibilities so that

one VISTA staff member is now the coordinator of all coaching activities across all sites. This staff member is an experienced instructor for STP I and STP II.

Professional development within and across schools and universities. The VISTA methods courses provided professional development that required teachers to "learn with and from one another", a quality noted by Darling-Hammond as important to high-quality approaches to teacher preparation. The topics addressed, and the learn-try-implement model, emphasized aspects of teaching that were part of the day-to-day environment of the students in the class. Distance learning was introduced in STP I – Year Two, and also in STP II – Year One (both in Fall 2012). Student groups at all three sites met virtually using Adobe Connect ™, with limited success. Though the three universities had access to state of the art equipment, bandwidth and compatibility issues caused some difficulties in transmission of student products and in supporting student interaction across sites. Within sites, distance learning was incorporated on an as-needed basis, with two sites using distance learning extensively for STP I – Year Two, due to situations with individual teachers such as ill-health, distance from campus, and also due to preference of the students in the class. One site offered no distance learning for STP I – Year Two, since all students could travel to class meetings. One student completing STP II at this site traveled over seven hours to get to classes, and she adamantly opposed using distance learning. She reported that her past experiences with distance learning had been for classes less focused on the support and use of a professional learning community, and that a great value of the STP I and II sequence was the community that thrived in the face-to-face setting.

Capacity Building within the Profession. Novice teachers, regardless of whether they enter the profession through the traditional teacher education program or through alternative licensure, find themselves engrossed and almost consumed by the day-to-day tasks of teaching. The designers of the VISTA project recognized these practical constraints while also realizing the benefits of inculcating the habit of participating in professional development and social networking beyond the school and school district. To that end, teachers were provided support to attend the Virginia Association of Science Teachers' Professional Development Institute (VAST PDI), and course meetings were held at the location of the PDI, after it ended. Teachers were also required to develop a workshop for the VAST PDI during the second course, on their products from the VISTA classes. With very few exceptions, all teachers in STP I – Year Two, and STP II attended the VAST PDI and the VISTA sessions afterward. This combination of financial incentives in the form of support to attend the conference and of course requirements led to teachers attending this statewide conference and gaining knowledge of the state of science education across the state, as well as confidence in their preparation through VISTA.

In addition to specific connections to the Darling-Hammond characteristics, several aspects specific to the VISTA courses and the rigor of the research had the potential to impact the overall effectiveness of the courses. Consistently throughout the semester prior to teaching the course and during the semester when the course was offered, the instructors expressed concerns about where their attempts to differentiate the course may

threaten the perception of fidelity of implementation. Whenever choices were made to vary the course from practices at other sites, that choice was made based upon the instructors' belief that the change was necessary for the course and students at that site. For example, two sites employed distance-learning (DL) technologies for many or all the students in their cohorts, with DL being the delivery mode for most class meetings. One site employed traditional, face-to-face meetings for all class meetings. These decisions were based on individual contexts at the different sites. Preliminary observations by the evaluation team of one class meeting held by DL at two sites and compared to the traditional class offering at one site found that the classes were not equivalent.

Another example of variance across sites was the schedule for class meetings, caused in part by the decision to incorporate distance learning. The sites that used DL held most of their class STP I – Year Two and STP II - Year One meetings on weeknights, whereas the site that used traditional face-to-face meetings met on Friday nights (STP II-Year One) and on Friday nights and some Saturdays (STP I-Year Two).

The scheduling for the course across sites was influenced by the school year calendar, which varied as much as three weeks in the start date, across the geographic "reach" of a site. Since new teachers are usually required to participate in new-teacher orientation as well as the back-to-school days all teachers are required to attend, and since most of the dropouts from STP I – Year One occurred before the first classes in August in Year One, the instructional team decided to start classes either on the last Saturday of August (STP II-Year One) or the second week of September (STP I- Year Two). This aspect of the course offerings was consistent across sites, though the specific days of the week utilized varied across sites. All sites achieved 45 contact hours for the three-credit classes.

Analysis

The practices that characterize the best international education systems (Darling-Hammond, 2012) also characterize the VISTA course sequence. However, the local (Virginia) context and indeed the national context dilutes and sometimes mutes the ability to implement fully the activities and ideas that characterize high quality teacher development. Primary among the difficulties are the low status of teaching and teachers, lack of school-district-based support for professional development and capacity building, and, in Virginia and nationally, an over-emphasis on quantifiable measures for student learning and teacher effectiveness. The teacher who emailed "HELP" is only one example of the pressures teachers find themselves under, to "dumb down" the curriculum so that untrained and unskilled administrators and teachers can understand the instruction provided. Inquiry-based and student-centered science instruction, two practices central to the preparation of a scientifically literate workforce, were not recognized as important in the high-states testing environment currently in place.

The instructors for the courses discussed their own perceptions of the course in the process of preparing this paper. Two of the three sites had staffed the two courses in the sequence by assigning one instructor to each course, whereas the third site's courses were co-taught by the tenured faculty member and members of the VISTA staff. At all three

sites, the instructors determined to co-teach future offerings of the course sequence. The instructors expressed the desire to be able to get and give feedback to each other, to improve their instruction and their responses to students. Also, they recognized that situations may arise – as happened at two of the three institutions – where an instructor had to be out for an extended period of time, and through co-teaching the instruction would not be disrupted. The instructors stated that "talking with a co-teacher makes it so much better - planning, together, pre-planning, reflection, and, it's good modeling for students of the action-reflection-revision model of professional learning communities." When the instructors were reminded that co-teaching was not a common practice in their regular teaching loads at the universities, they commented on the difference they saw, with the VISTA participants: "We almost feel this class is more important than regular students. Their time is precious, our input can be a life-saver. They are fragile; they need us." One instructor commented, "We're doing triage with these teachers".

The collaborative nature of the course development, over two years, and the results from the multiple iterations of the course, will provide a public product – a course syllabus, schedule of activities, assignments and specific methods course lessons – that promises to yield a model for science methods courses. This "shared, changeable knowledge product" will be available 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. The collaborative approach to the planning, and, in the teaching as planned for the next course offerings, and the development of a professional learning community among the instructors and among the participants at each site, offers hope for the development of a high-quality product incorporating theory and practice.

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