Learning by Doing: A Case Study of a Clinical Model for STEM Teacher Preparation

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ABSTRACT

The United States Department of Education estimates that the nation will need 100,000 new science, technology, engineering, and mathematics (STEM) teachers during the next 10 years. Thus, preparing new STEM teachers has been identified as one of the nation's priorities. This article describes the collaborative process used by one Midwestern university as it designed and implemented an experimental teacher preparation program, drawing STEM professionals from industry to become teachers in "high-needs" secondary schools. Following a description of the collaborative development process, the experimental curriculum is presented along with findings gleaned by an evaluator not associated with the program. Implications for preparing future STEM career changers who wish to become teachers are discussed.

Keywords: STEM, Conference Proceedings, Teaching Quality, Best Practices

PROGRAM BACKGROUND

The United States Department of Education estimates that the nation will need one million new teachers by 2014 (Duncan, 2009), including 100,000 new science, technology, engineering, and mathematics (STEM) teachers during the next 10 years (Obama, 2011). Simultaneously, recommendations for collaborative planning in teacher education using a clinical model (Levine, 2010; National Council for Accreditation of Teacher Education [NCATE], 2010) have emerged amid the clamor for change in education and teacher education (Cochran-Smith & Power, 2010). As a result, preparing new mathematics and science teachers for today's classrooms has been identified as one of the nation's priorities.

In one response to this need, in 2009, six Michigan universities were selected to participate in the national Woodrow Wilson Teaching Fellowship program (WWTF). Their participation was funded, in part, by the W.K. Kellogg Foundation of Battle Creek. The universities' task was to develop a cutting-edge teacher preparation program that would attract the best and the brightest STEM professionals to the teaching profession. Their common goal was to create an experimental, clinically-based program that required candidates, called Fellows, to spend at least 51% of their preparation time learning on site in "high-needs" secondary classrooms.

Grand Valley State University (GVSU), a regional university in Michigan serving more than 24,000 undergraduate and graduate students, was one of the six Michigan universities selected to participate in the WWTF program. The WWTF offered an unusual opportunity for West Michigan K-12 educators, GVSU arts and sciences faculty, and GVSU education faculty to collaborate on the design of a unique, cutting-edge program.

At GVSU, the program began with conversations between the university's president; the provost; and the deans of the College of Liberal Arts and Sciences, the College of Education, and the College of Engineering and Computing. The involvement and support of these individuals provided the incentive and buy-in needed for participation in program development by GVSU faculty and administrators. University educators who represented the fields of education and the

STEM disciplines — and who were identified as being open, creative, collaborative, professional, and committed to quality education for students in high-needs schools — were invited to participate. Even the dean of the College of Engineering and Computing became personally involved because he was intrigued by the opportunity.

The program's development team also included 13 public school educators drawn from three partner school districts in the region. To identify these partners required a common understanding of what "high-needs" secondary schools were. Ultimately, they were identified by meeting one of the following criteria: (a) 40% or more students were eligible for free and reduced lunch subsidies; (b) more than 34% of teachers did not have a major or minor in their main assignment field; or (c) more than 34% of teachers teaching core subjects, such as mathematics and science, did not have a major or minor in their assignment field (U.S. Department of Education, 2001).

PROGRAM DEVELOPMENT PROCESS

From the onset, the development team's focus was to reflect the current best thinking about teacher education and create a "coherent curriculum focused on clear outcomes" (Dietz, 2010, p. 442) that would enable GVSU to reach the goal of preparing STEM graduates to be effective teachers. The development team members decided that a shared purpose should guide their work. Because existing research on effective teacher education programs often lacks clarity, it was clear that identifying the most powerful features would add to the literature and enhance GVSU's existing teacher preparation programs.

To ensure the WWTF program's goals would be met, the development team used curriculum development principles that foster shared understanding, promote collaboration, and emphasize keeping the outcome in mind (Tyler, 1949; Wiggins & McTighe, 1998). When faculty from biology, chemistry, geology, physics, mathematics, engineering, educational foundations, special education, curriculum and instruction, reading, and leadership came together with public school science and mathematics teachers and curriculum specialists, different perspectives quickly became evident. To flesh out these ideas, the team engaged in the question, "What should our teachers know, understand, be able to do, and display in their attitudes and actions to make their students achieve and be successful?"

As the team's ideas were listed, common areas of agreement emerged and the team members saw they all desired certain characteristics in prospective STEM teachers. These characteristics included the following:

- Understand how students learn, and respond respectfully to students' varied cultural and linguistic backgrounds.
- Develop relationships with peers, students, and parents while being culturally aware.
- Demonstrate a love of the discipline.
- Employ caring and effective classroom management that promotes learning.
- Provide a student-centered classroom that sets high expectations for all learners and teachers.
- Plan and implement effective instructional units, lessons, and assessments using appropriate technology, experiments, manipulatives, resources, and interdisciplinary connections.
- Demonstrate professionalism (e.g., set high expectations; demonstrate commitment and reflection; continue professional development; serve as a role model).
- Use research-based decision making.

- Display dispositions of compassion, being genuine, persistence, and empathy.

After a common understanding of the desired characteristics of teachers completing the new program was achieved, a delineation of the tasks facilitated collaborative planning. After an extensive discussion; a review of the literature; and comparisons of various frameworks, philosophies, models, and standards, the team chose a cohort-based clinical model with "rotations" that reflected aspects of the medical education model. The clinical model ensured that Fellows, who had little or no teaching experience, would have immediate and sustained opportunities to observe and implement theories and practices they were learning while participating as a member of a supportive environment. In addition, the development team members decided that Fellows would be guided to view pedagogical content knowledge, project-based learning, and disciplinary literacy through the lens of Universal Design for Learning (UDL) (Rose & Gravel, 2010). They selected UDL as the approach most likely to meet the needs of all students, including those with different cultures, socio-economic status, special needs, and languages.

Universal Design for Learning is based on several premises (Rose & Gravel, 2010). One premise is that the goal of education should stretch beyond mastery of knowledge and content to mastery of learning. Within a UDL focus, the learning process is emphasized as much as, if not more than, content. A second premise requires an acceptance of diversity as the norm, not the exception; curricula, instruction, assessments, and environments designed for the average achieving student unnecessarily exclude countless others. A third premise is that flexibility and multiple pathways to designing and providing curricula, instruction, assessments, and environments strengthens opportunities for teachers to meet the needs of more students. A fourth premise rejects the "one size fits all" view of education in favor of designing curricula, instruction, assessments, and environments with flexibility and multiple pathways at the outset, as the latter approach is more efficient and effective than retro-fitting and accommodating later (Center for Applied Special Technology [CAST], 2008). The development team decided that Fellows should gain knowledge of, and apply, these UDL guidelines throughout their program. The Fellows needed to have practical opportunities to design curricula, instruction, assessments, and environments that would demonstrate their knowledge of UDL principles and guidelines.

Once the project team identified the conceptual framework for the program, standards developed by the Interstate Teacher Assessment and Support Consortium (Council of Chief State School Officers, 2010 draft, 2011 adopted) were analyzed and aligned with proposed course topics and clinical experiences. The Professional Standards for Michigan Teachers (Michigan State Board of Education [MSBE], 2008) and the National Council for Accreditation of Teacher Education (NCATE) standards (2008) further informed program development. Interestingly, the process included most of the recommendations made by the NCATE Blue Ribbon Panel on "Transforming Teacher Education Through Clinical Practice: A National Strategy to Prepare Effective Teachers," which was issued in November 2010, after GVSU's program was in the approval process (NCATE, 2010).

CURRICULUM

Realistic views of the current educational environment, including classroom management and curriculum planning, are essential for teachers in high-needs schools. The development team felt this perspective included the "conventions and strategies that are essential to success in American society" (Delpit, 2006, p. 222). Involvement in schools throughout the week was thought to be essential for Fellows to understand the culture of middle and high schools.

Moreover, unlike traditional secondary teacher preparation programs that require one or at most two field/practicum experiences, the Fellows would be immersed in the classroom beginning with the first day of school and ending on the last day of school. To accomplish this and have enough time for all of the necessary coursework, the team developed a 15-month program that would begin in May with GVSU's spring/summer term and end in August the following year.

Fellows enrolled in 10 credits of coursework designed to provide them with a foundation for teaching. The spring/summer courses included:

- Becoming a Teacher
- Content for Teaching
- Cultural and Social Development of Adolescents
- Facilitating Learning Environments
- Connecting Curriculum, Assessment, & Instruction

As part of their coursework, Fellows participated in an inquiry project in which they were immersed in a problem-based learning experience. The inquiry project served two purposes: it helped establish cohesion among the cohort of Fellows, and it helped them obtain a firsthand experience with the excitement, uncertainty, and motivation needed to collectively solve a real-world problem. In addition, Fellows tutored Upward Bound students who spent a few weeks on campus in the summer. This firsthand experience with actual high school students was valuable since some Fellows had never taught adolescents, and after doing so, they realized teaching was not their calling.

The fall semester included coursework and daily clinical experiences in partnership schools. These courses included:

- Facilitating Learning Environments (an extension of the summer course)
- Connecting Curriculum, Assessment, & Instruction (an extension of the summer course)
- Inclusive Practices
- Disciplinary Literacy for Adolescents

Combined with each fall course was a "rotation" in which Fellows applied what they were learning in their coursework while in the classroom. Clinical experiences in the fall provided an overview of what it meant to be responsible for teaching classes; Fellows partnered with their cooperating mentor teachers for two classes every morning and all day on Fridays. In addition, Fellows expanded their learning by observing and being involved in activities that took them to other classrooms, schools, and learning environments.

Winter coursework was designed to be completed along with a full-time clinical placement in one of the partner schools. Winter courses included:

- Connecting Curriculum, Assessment, & Instruction (final segment of this course)
- Content Pedagogy
- Secondary Education Practicum

Fellows expanded their clinical experiences during the winter semester when they worked in partnership schools all day, Monday through Friday. It was an intensive experience in which Fellows assumed all classroom responsibilities, with their semester extending through the end of the K-12 school year in June.

Technology was integrated into all program courses, with specific concentration in one course: Connecting Curriculum, Assessment, & Instruction. The program faculty modeled using technology and expected Fellows to do the same, which addressed the expectations of both the

Professional Standards for Michigan Teachers (MSBE, 2008) and NCATE standards. Levine (2010) has noted the contrast between many of today's students, both in the K-12 setting and those who are entering teacher education programs. They are "digital natives," having grown up with technology, but are being taught by educators coming from "analog" schools and teacher education programs (p. 20). The program development team, like Golas (2010), felt that an emphasis on using technology was an essential part of teacher preparation to ensure effective use in K-12 classrooms.

EVALUATION PROCESS AND FINDINGS

Eleven Fellows participated in GVSU's initial WWTF program cycle, which occurred between May, 2010 and August, 2011. To determine the effects of this experimental teacher preparation program on the 11 STEM graduates' ability to teach, an evaluator not associated with the program collected several sources of data during the first year of implementation. The data sources included: grade distribution; pass rates on the Michigan Test for Teacher Certification (MTTC); feedback from cooperating teachers, Fellows, and program faculty; and SAMPI lesson observations.

Grade Distribution And MTTC Pass Rates

Fellows enrolled in the experimental program earned grades ranging from 2.7 to 4.0, based on a 4.0 scale. Areas in which Fellows received the poorest grades included coursework on gathering and using data, as well as conducting action research. Fellows received the highest grades in courses focused on facilitating learning, connecting curriculum assessment and instruction, and developing awareness of the cultural and social development of adolescents.

For teacher candidates to receive a Michigan teaching license, they must take and pass a normed, criterion-referenced teacher certification exam in their respective area of licensure. GVSU's Fellows sought secondary certification in mathematics, biology, chemistry, and physics. When compared to other teacher candidates at GVSU, Fellows had the lowest pass rates of any other group, with 67% passing on the first attempt. Those who did not pass the MTTC on the first attempt were required to pass the test before being permitted to enter their clinical placement in the fall. Two Fellows took the test multiple times without passing and ultimately discontinued the program.

Feedback From Cooperating Teachers

Cooperating teachers were surveyed mid-year and at the K-12 school year's end in June. They were asked to provide specific feedback and suggestions about the experimental WWTF program. A qualitative analysis of surveys revealed the following findings. First, teachers felt the Fellows carried heavy workloads, leaving them sleep-deprived, stressed, and pressed for time. Second, teachers felt the Fellows were not in the classroom enough during the fall semester. It was believed their absences due to attending university-based classes interfered with the Fellow's ability to build relationships and maintain awareness of the daily instructional process. Most teachers felt Fellows should be focused more on their teaching responsibilities instead of coursework.

Feedback From Fellows

The WWTF Foundation and the W.K. Kellogg Foundation — the entities that supported the development and implementation of this experimental teacher preparation program — surveyed

all Fellows during the second spring/summer semester of their preparation. The survey consisted of demographic items, items related to specific program components, and open-ended response items. Areas where Fellows had strong feelings of satisfaction included their GVSU professors and the feeling that they were prepared to enter their first year of teaching. Fellows reported that their GVSU professors were more supportive and helpful than the cooperating teachers. In addition, Fellows praised the cohort model used, feeling that peers also provided needed support throughout the program. Fellows reported some dissatisfaction with their clinical placements, most often noting concerns about the relationship they established with their cooperating teachers. Fellows made no mention of difficulties with students or with being placed in a high-needs school. A common concern was the heavy workload throughout the program. One Fellow said it was difficult to negotiate the simultaneous roles of teacher and student while satisfying both GVSU professors and the cooperating teacher.

Feedback From Program Faculty

Feedback from program faculty was collected via surveys throughout the first year of experimentation. There was agreement that the workload associated with the program was heavy and that it challenged Fellows to balance the expectations of both the university and the cooperating teacher. Communication was mentioned as an area for improvement. Faculty agreed that direct communication between program faculty and cooperating teachers could improve the cohesion between coursework and clinical experiences.

SAMPI Lesson Observations

Periodic classroom observations were completed by the evaluator using the SAMPI observation tool (Jenness, 2003). The SAMPI observation tool is a comprehensive protocol for observing, analyzing, and reporting data from observations of content-based lessons, and it is especially useful in mathematics and science classrooms. The instrument was designed to determine a teacher's ability to integrate content and pedagogy. The instrument may be used by those who have completed certified training, and thus some degree of reliability is expected. The evaluator of the WWTF program was trained and is certified to use the SAMPI tool. Fellows were observed in late May, toward the conclusion of their clinical field experience. The following results were documented.

Fellows implemented lessons in a variety of ways, and all Fellows appeared to be knowledgeable about the topic of the lesson. Fellows delivered standards-based lessons and often used technology when appropriate and available. Fellows were respectful of their students and planned lessons to engage them. Fellows were able to respond to students' questions. In many cases, they demonstrated expertise with the content by providing analogies or additional examples. While most Fellows asked questions during their lessons, some questions merely focused on recall and did not promote critical thinking. Most Fellows could strengthen their question strategies by encouraging students to justify or provide evidence for their ideas/answers.

In all classrooms, Fellows set clear behavioral expectations and were able to maintain a level of order that was conducive to learning. Students displayed a great respect for the Fellows teaching the lesson. However, in every classroom some students "flew under the radar" and sat quietly. Fellows did not actively seek to involve quiet or unmotivated students and appeared to be unaware of the lack of student participation. Fellows would benefit from using strategies for actively engaging all students in STEM lessons.

Lesson pacing was a challenge for most Fellows. Several ran out of time and were unable to complete the planned lesson. The lessons were rarely organized so that there was adequate time for students and/or the Fellow to reflect on the lesson. Fellows either did not plan for any type of whole-group closure or simply ran out of time, missing an opportunity to summarize what had been learned, make connections to future learning, or determine where students might have further questions.

With regard to connecting classroom concepts to real-world applications, there was a great deal of disparity among the lessons. Two lessons made no real-world connections at all. On the other hand, in one case, students who were using problem-based learning to design a wheelchair ramp for a disabled neighbor were heavily involved in determining the slope of the ramp, ensuring it would not be too steep. They also discussed ramp materials and worried that the ramp might become slippery when wet, so ways to increase friction on wet surfaces were discussed. Overall, lessons might be improved if Fellows pointed out how the content applies in real-world applications, or assigned students to create and discuss models to depict the concepts associated with a lesson.

CONCLUSIONS AND IMPLICATIONS FOR STEM PROFESSIONALS

Merely having a STEM-related degree and experience does not guarantee an individual can become a successful teacher. The assumption that teacher candidates with strong content preparation alone can easily transition to teaching must be questioned. The evaluation outcomes reported above indicate that despite having a STEM degree and work experience in industry, the types of content knowledge needed to teach the high school curriculum might not be apparent to STEM professionals seeking teacher certification. This is demonstrated by the fact that two of GVSU's Fellows were not successful at passing the Michigan Test for Teacher Certification, despite completion of a STEM degree, work experience, and significant efforts to prepare them.

Some critics claim that teacher candidates do not get the hands-on training they need (Duncan, 2009; Levine, 2010). Both Fellows and cooperating teachers voiced this concern. The results from the SAMPI lesson observations indicate that, despite spending an entire school year in the classroom, Fellows still struggled with essential pedagogical aspects of teaching. These included challenging students with higher order questions, engaging all students in lessons, connecting classroom concepts to real-world situations, and pacing lessons to allow for synthesis and reflection of the content. These findings suggest that learning to teach well involves a combination of content knowledge appropriate to teaching and well-developed pedagogical knowledge. It appears as though pedagogical knowledge is best learned through experience over time.

Some policy makers claim that teacher candidates are not taught how to use data to improve instruction and boost student learning (Duncan, 2009). In GVSU's WWTF program, the program development team purposely designed and taught a course on gathering and using data for the Fellows studying to be teachers. Even though Fellows were trained STEM professionals, who most likely had previous experiences with collecting and analyzing data, few Fellows were able to apply this knowledge and reflect on their own practice even after taking the course.

Developing high-quality teachers is a complicated process that takes time. Preparation programs must emphasize both content for teaching and pedagogical competence. The data collected in this case study indicate that despite the well-developed content knowledge of the STEM professionals entering the WWTF program, and despite GVSU's efforts to experiment with cutting-edge approaches to teacher preparation, more guided practice in learning how to

teach is necessary. Future research should carefully examine the mentoring aspect of pre-service STEM teacher preparation to identify the salient features and experiences that lead to greater pedagogical competence.

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REFERENCES

Center for Applied Special Technology. (2008). *Universal design for learning guidelines version 2.0*. Wakefield, MA: Author.

Cochran-Smith, M., & Power, C. (2010). New directions for teacher preparation. *Educational Leadership*, *67*(8), 6-13.

Council of Chief State School Officers. (2011). *Standards developed by the Interstate Teacher Assessment and Support Consortium.* Washington, DC: Author.

Delpit, L. (2006). Lessons from teachers. *Journal of Teacher Education, 57*(3), 220-231. Doi:10.1177/0022487105285966

Dietz, M. E. (2010). It is complicated: Unpacking the flow of teacher education's impact on student learning. *Journal of Teacher Education, 61*(5), 441-450. Doi:10.1177/0022487110372927

Duncan, A. (2009). *Teacher preparation: Reforming the uncertain profession.* Retrieved from http://www2.ed.gov/news/speeches.2009/10/1022009.html

Golas, J. (2010). Effective teacher preparation programs: Bridging the gap between educational technology and its utilization. *International Form of Teaching and Studies, 6*(1), 16-18.

Jenness, M. (2003). *Using standards-based inquiry-focused criteria for assessing science and mathematics program improvements (SAMPI).* Kalamazoo, MI: Western Michigan University.

Levine, A. (2010). Teacher education must respond to changes in America. *Phi Delta Kappan, 92* (2), 19-24.

Michigan State Board of Education. (2008). *Professional Standards for Michigan Teachers.* Lansing: Author.

National Council for Accreditation of Teacher Education. (2008). *Professional Standards for the Accreditation of Teacher Preparation Institution.* Washington, DC: Author.

National Council for Accreditation of Teacher Education. (2010). *Transforming teacher education through clinical practice: A national strategy to prepare effective teachers.* Retrieved from http://www.ncate.org/LinkClick.aspx?fileticket=zzeiBIOoqPk%3D&tabid-715

Obama, B. (2011). *State of the Union address.* Retrieved from http://www.whitehouse.gov/the-press-office/2011/01/25/remarks-president-state-union-address

Rose, D. H., & Gravel, J. W. (2010). Universal design for learning. In E. Baker, P. Peterson, & B. McGraw (Eds.), *International encyclopedia of education* (3rd ed., pp. 119-124). Oxford, UK: Elsevier.

Tyler, R. W. (1949). *Basic principles of curriculum and instruction.* Chicago, IL: University of Chicago Press.

United States Department of Education. (2001). *No child left behind act.* Washington, DC: Author.

Wiggins, G., & McTighe, J. (1998). *Understanding by design.* Alexandria, VA: Association for Supervision and Curriculum Development.

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