**Abstract Title:** Enhancing Teaching to Enhance Learning in 9th Grade Physics

**MSP Project Name:** A TIME for Freshman Physics in Missouri

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**120 word summary:**

The vision of this project is to prepare Missouri's 9th grade science teachers to become intellectual leaders as they learn to teach a yearlong freshman physics course to their students. Leadership skills will be enhanced through research-based professional development that includes comprehensive physics content, inquiry and modeling-based pedagogy, research and evaluation. The project uses a quasi-experimental delayed entry design with two cohorts of teachers and their students. The first cohort of teachers began teaching their students in Fall 2010. We present the research and evaluation design, and describe our qualitative and quantitative definitions of student success.

## Section 1: Questions for dialogue at the MSP LNC.

Our project, which is in its second year, has begun engaging with students as of Fall 2010. Students have begun learning Physics First content using inquiry and modeling pedagogy. Teacher participants are using the same content and techniques that were used in the summer 2010 academy. Pre-test data has been obtained. While we do not yet have data about student success, we have anecdotal information regarding the challenges faced by teachers in engaging students, as well as successful strategies. Questions that we wish to discuss with colleagues include:

- What curriculum features and pedagogical strategies consistently help sustain interest among students?
- What methods assist with providing positive feedback that translates to real, measurable learning?

## Section 2: Conceptual framework.

### A. Context of work within STEM Educational Literature and MSP Project.

A TIME for Physics First is a partnership among the University of Missouri-Columbia (MU), and thirty-seven Missouri Core Partner school districts. Through this project, participants and university faculty will gain an expanded range of leadership expertise, content knowledge and pedagogical proficiency to share with others, as they become resources and catalysts for reform in science education at the secondary and post-secondary institutional levels. Ultimately, the overall goal is a significant increase in student achievement in science and science coursework.

Teachers' leadership skills will be built through research-based professional development (PD) that includes comprehensive physics content, pedagogy, research and evaluation. Along with the goals that accompany teachers' development, the following student-focused goals are articulated by the project:

- Strengthen 9th grade science teachers' and their students' understanding of physics and the application of physics to the world around them.
- Create a solid base of knowledge for students' subsequent science coursework.

The widespread practice of teaching students physics after they have taken biology and chemistry in high school dates back[i] to 1894. With this sequence, only 30% of U.S. high school students take any course in physics. The American Association of Physics Teachers strongly recommends[ii] placing physics first, at the freshman level, followed by chemistry and biology, since physics underlies chemistry content, which in turn underlies biology. In a previous Department of Education MSP project we developed a professional development curriculum for teachers that is inquiry- and modeling-based. In the current project we are developing a student version of this curriculum based on recommendations from past participants, who suggested that the materials include a workbook format with pre-lab questions, directions that allow flexibility for student design of experiments, post-lab discussion questions, practice problems, and reading pages. They also requested teacher resources with a list of objectives and sequence of concepts for each physics unit, teacher notes, materials lists, cross-listing to state standards and sample lab data. In development are digital resources such as podcasts and videos that teacher-leaders will produces in their third summer academy. The curriculum team consists of four physics faculty, four peer teachers and one science education faculty member. Three of the physics faculty members are primarily responsible for edits to the curriculum; the other members of the team have been very active in providing edits. The work of the curriculum team is guided by the Educative Curriculum Material (ECM)[iii] model, which recommends nine design heuristics to promote both teacher and student learning: supporting teachers in engaging students with topic-specific scientific phenomena, questions, designing investigations, making explanations based on evidence; and support teachers in dealing with students' ideas about science, using scientific instructional representations, anticipating, understanding, promoting scientific communication, and development of subject matter knowledge.

**B. Claim(s) or hypothesis(es) examined in the work**

Student success is expected to occur on several levels. The indicators below are qualitative and quantitative, and address content, pedagogy and overall interest in science. We expect gains in the following areas:

- Students' test scores in the MOSART[iv] and TUG-K[v] standardized tests, as described in Sec. 3 of the abstract. Researchers have used these tests over several years, and they match the content taught in the freshman physics course. They will be used as indicators of student learning.
- Students' ability to design and conduct laboratory exercises, interpretation of data to extract physical concepts and constructing models of physical phenomena. These processes are intimately tied to the pedagogical aspects of the curriculum, namely, inquiry and modeling.
- Students' use of multiple representations. This process will allow students with different mathematical abilities to understand concepts with a depth that a "standard" mathematics-based curriculum may not allow.
- Students' ability to conduct scientific discourse in a classroom. In the initial stages the teacher might lead the discourse. Later in the academic year we expect students to lead the discourse.
- Students' interest in science. This long-term objective will be assessed in students' senior year of high school.

Although only a few months of the academic year have passed, we have received anecdotal reports from coaches who visit the teachers' classrooms regarding student responses to the curriculum and associated pedagogy. They have reported a high level of student engagement in several classes, even excitement at "being in physics class every day." In a class where the teacher opens the class with a short quiz, students (estimated at 80%) come to class well prepared. Coaches fill observation forms for each visit, and a summary of the forms will be presented in the poster.

- Section 3: **Explanatory framework**.

**A. Evaluation and/or research design, data collection and analysis:**

The project evaluation is based on a utilization- and needs-based design, and includes formative, process and summative components. Formative and process evaluation focuses on fidelity and decision-making across project activities.

For summative evaluation, a quasi-experimental, random-assignment, delayed-entry control group design of two cohorts of teachers was applied. Following recruitment and acceptance of teachers to the program, math scores from standardized tests for each school were used to assign schools randomly to Cohort 1 or Cohort 2. Teachers from the same schools were assigned to the same cohort so as to minimize contamination effects. The research model is multilevel, with students nested within teacher within schools.

Initial treatment teachers (C1) began their project activities in the summer of 2010. Control teachers (C2) will enter the project one year later and will be delayed in their exposure to treatment by one year. C1 and C2 teachers receive the same treatment in physics content and pedagogy. The two cohorts differ in the following way: C1 receives monthly classroom visits by a trained coach during the academic year, while C2 receives online support by a similarly trained mentor. This approach allows C2 teachers to serve as controls for the programming presented to C1 teachers and the C2 teachers' students to serve as control students for C1 students. Data for any teachers entering the project after cohort selection or otherwise not included in the randomization process are excluded from treatment/control analyses. Of a total of 69 teachers enrolled in the project at the end of Year One, 58 were included in the randomized control design.

Summative evaluation aims primarily at examining the experience of the project in achieving its specific goals and objectives and broader MSP program goals. Additionally, six evaluation questions, likewise aligned to project goals, are concerned primarily with summative considerations of assessing the efficacy of the treatment model. These evaluation questions addressing various issues related to teacher leadership, student physics content knowledge gains and interest in science course-work, and institutional change.

Evaluators are assessing physics content gains for both teachers and students via pre/post- delivery the MOSART High School 9-12 Physics Test and the Test of Understanding Graphs-Kinematics (TUG-K) test. MOSART tests probe for any conceptual shift(s) as a result of professional development activities or course work, and the TUG-K investigates the ability of students to interpret kinematics graphs. Success for treatment students will be gauged by differences between their content knowledge gains and those of comparison students. While gains from pretest baselines will be followed over the course of the project for both cohorts of teachers, new groups of freshman physics students are being tested each year for each teacher in order to evaluate changes in patterns of students' gains as a consequence of project treatment. Student tests are delivered at the start and end of the physics course. In Year One, complete sets of pre/posttests were collected from 811 students of C1 teachers and 907 students of C2 teachers. Depending on the complement of additional student data eventually available, a range of multivariate analyses will be applied in order to consider the dynamics behind optimal achievement of student objectives for the project: enhanced gains in physics content knowledge and greater interest in and subsequent increases in science course taking.

**B. Key insights that have value for the Learning Network**

In addition to commitment to achieving the specific goals and objectives of the project, A TIME for Freshman Physics anticipates that, enabled by its evaluation and research design, several insights may be possible. Initial research efforts in this regard have focused on identifying the dimensions of practice in which teachers lead[vi], their leadership through formal and/or informal roles, and their implementation of leadership action plans within their respective contexts. The opportunity to compare outcomes between treatments that incorporate an online learning community versus sustained classroom coaching will contribute to continued discussions in the field on how best to apply teacher support resources and to make appropriate use of emerging technologies. The ability to look more closely at the relative merits of Physics First curriculum versus traditional STEM coursework staging will further ongoing research on the issue. Additional consideration of the pathways through which teacher leadership positively impacts student achievement also will add to the field's understanding. Insights into relating the new curriculum to student performance in physics, the success of varied groups of students as they use inquiry and modeling methodologies and students' interest in science are all of interest.

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[i] Project ARISE http://ed.fnal.gov/arise/arise_lml/arise_why.html. (This date is widely quoted).

[ii] Guide to Physics First, American Association of Physics Teachers, December 2006.

[iii] Elizabeth A. Davis and Joseph S. Krajcik, *Designing Educative Curriculum Materials to Promote Teacher Learning*, Educational Researcher Vol 34, 3, pp 3-14.

[iv] http://mosart.mspnet.org/index.cfm/11773

[v] Beichner, R. (1994). Testing student interpretation of kinematics graphs. American Journal of Physics, 62, 750-762

[vi] York-Barr, J. & Duke, K. (2004). What do we know about teacher leadership? Findings from two decades of scholarship. *Review of Educational Research, 74*(3), 255-316.