Session Title:
Examining Fidelity of Implementation of a Year-Long Curriculum in 9th Grade Physics

MSP Project Name:
A TIME for Physics First in Missouri

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Project Session

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Summary:
Curriculum materials play a key role in improving science education; however, curricula alone will not lead to enhanced student learning. Factors such as students' opportunity to learn and the way in which teachers present science content can influence student learning. Therefore, attention to teachers' fidelity of implementation of new curricula is an important consideration in evaluating impacts on student learning. As part of an NSF-funded Math and Science Partnership, thirty-seven school districts throughout a Midwestern state were engaged in the implementation of a year-long course in freshman physics. We examined teachers' curriculum implementation through three different indices, which we used to develop 'typologies' of implementation. These implementation data are currently being linked with student outcome data.

Section 1: Questions framing the session:
Measuring and monitoring implementation
How can we conceptualize 'implementation fidelity' in terms of a year-long course in freshman physics? In what ways can we gather relevant data to examine teachers' implementation fidelity? How can we use this data to evaluate impacts of the curriculum on student learning? How do we know what aspects of the curriculum and/or implementation are contributing to the difference?

Section 2: Conceptual framework:
Fidelity of Implementation

In order to understand the learning that occurs in freshman physics classrooms, as researchers we must consider how teachers implement the curriculum and how closely their instruction aligns with the intent of the curriculum developers. Such information is tantamount to drawing conclusions about the influence of new curricular programs on student achievement, and consequently, can guide program developers to revise programs.

As we examined the first full-year implementation of the curriculum by the first cohort of teachers (n=25), we were interested in understanding implementation fidelity both to enable valid interpretations about the impact of the curriculum on student learning and to serve as a feedback loop to the curriculum development team.

We utilized a mixed-methods approach and triangulation design (Creswell & Plano, 2007) in which both quantitative and qualitative data were used to inform the results as a whole and were interpreted together to better understand teachers' curriculum implementation. The Table of Contents Inventory (Tarr, McNaught, & Grouws, 2010) served as the primary data source. This consists of an itemized table of contents for each unit of the curriculum, with space for teachers to indicate whether a specific laboratory activity, reading page, etc. was a) not taught; b) taught primarily using the curriculum; c) taught with additional supplementary materials; or d) taught primarily through alternative materials. Analysis of teacher responses results in three indices that capture the nature and extent of teachers' adherence to the curriculum: (1) opportunity to learn index (OTL), (2) extent of textbook implementation index (ETI), and (3) textbook content taught index (TCT). Qualitative data sources included teachers' written responses regarding units taught, narrative vignettes describing implementation of a specific lesson, and blog/discussion postings relevant to teachers' implementation of the curriculum within the project's online forums.

Section 3: Explanatory framework:
We first examined indices for the Table of Contents Inventory in relation to the curriculum itself. The mean OTL index for all units was 49.01 (standard deviation = 17.07), indicating that students were presented with an opportunity to learn about half of the material addressed in the curriculum. This is perhaps not surprising, given the length of the school year (180 days) and the fact that the curriculum as a whole contained 312 separate instructional resources (laboratories, practice problem sets, assessments, and reading pages). When we examined OTL at the unit level, we found variation in the degree to which teachers taught each of the units. The individual unit OTL indices were highest for Uniform Motion (87.70) and Forces & Newton's Laws (77.54) and lowest for the last three units: Heat (10), Waves (21.45), and Planetary Motion (14.88). Mean ETI was 42.21 (standard deviation = 16.69), and ETI for individual units fell along a similar pattern to the OTL, being greatest for Uniform Motion/Forces & Newton's Laws and least for the last three units in the curriculum. While the first two indices seem to suggest teachers did not use much of the curriculum, and could be interpreted as low fidelity, the TCT results showed that, *when using the curriculum*, teachers tended to follow the curriculum as written. Mean TCT index for all units was 86.69 (standard deviation = 17.8), and ranged from 64-91 for the first six units of the curriculum; the last three units ranged from 16-21 on this index. In comparing all three indices across resource type (laboratory, practice problem, assessment, and reading pages) we found no significant difference in teachers' use and implementation.

We then examined indices with the *teacher* as the unit of analysis. Four distinct typologies emerged from our analyses of teachers' curriculum implementation: a) Local Adapters, b) Pickers & Choosers, c) Curriculum Users, and d) Curriculum Discounters.

Local Adapters (n=3) addressed the same concepts included in the curriculum, but did so using primarily alternative resources and materials, often of their own creation. Teachers in this group had prior experiences teaching 9th grade physics and indicated distinct preferences for particular sets of materials they had been using for some time. The largest group were **Pickers and Choosers** (n=14), who tended to teach only part of the curriculum, but were likely to adhere to the curriculum lessons as written. That is, they selected the activities from the curriculum they wanted to use, and implemented them as intended. Teachers' choices in this case were often influenced by constraints of time and district-specific guidelines for the sequencing of topics. **Curriculum Users** (n=4), interestingly, tended to be newer teachers (less than 3 years experience). These teachers had higher scores on all indices, reflecting their implementation of the curriculum as written. Overall, this group was enthusiastic about the curriculum. Finally, **Curriculum Discounters** (n=4) tended to not utilize the curriculum materials and, when they did, they were less likely to use the materials as written. Teachers in this group had OTL and TCT indices more than one standard deviation below the mean. Almost all had prior experience teaching physics and/or 9th grade physics and tended to be outspoken in their discontent with the way the materials were written and structured. The exception to this was one teacher who was asked by her district to integrate 9th grade physics and engineering into a single course, which afforded additional constraints to her implementation of the curriculum.

Section 4: Discussion:

Evaluation of the fidelity with which a curricular intervention has been implemented is necessary so that a valid assessment can be made of its contribution to student learning outcomes. Unless such an evaluation is made, it cannot be determined whether a lack of impact is due to poor implementation or inadequacies in the design of the curricular program itself. Given that there is greater potential for inconsistencies in implementation of the curriculum in real classrooms as opposed to strict experimental conditions, it is important that research identify and assess factors that influence teachers' use and fidelity of implementation of curriculum materials (O'Donnell, 2008). Creating the chain of evidence necessary to link student learning to teaching learning, professional development, and policy is a formidable task (O'Donnell, 2008); however, there is value in studies, such as this one, that examine components along that chain. The four typologies identified in our study have the potential to allow for interpretation of student outcomes *in light of* the degree to which a curriculum is implemented as intended. While it is commonly assumed that a high level of implementation fidelity is desirable, in a project such as ours where the curriculum is newly developed and intended for revision, it can be useful to understand where local adaptations and teacher modifications to the curriculum may actually *enhance* the effectiveness of the curriculum, so that a continuous feedback loop is created. Teachers' written comments from their implementation of the curriculum can provide useful insights into necessary and important revisions.

Section 5: How will you structure this session? What is your plan for participant interaction?

We will begin by engaging the audience in sharing their own ways of conceptualizing 'implementation fidelity'

We will then invite participants to examine a sample of our Table of Contents Inventory and compare/contrast this to other means of gathering data regarding implementation fidelity in terms of strengths/weaknesses and robustness of the data

Next, we will explain how we analyze teacher responses to create the three indices: (1) opportunity to learn index (OTL), (2) extent of textbook implementation index (ETI), and (3) textbook content taught index (TCT)

After, we will present a description of our four typologies (using 'profiles' generated from quantitative and qualitative data), and invite the audience to consider the utility of these in evaluating impacts of a curriculum on student learning and in informing subsequent revisions to curriculum innovations. (Currently, our analyses are focusing on linking student outcome data with implementation fidelity data).