CENTER FOR ELEMENTARY MATHEMATICS AND SCIENCE EDUCATION

APPLYING RESEARCH ON SCIENCE MATERIALS IMPLEMENTATION:
BRINGING MEASUREMENT OF FIDELITY OF IMPLEMENTATION (FOI) TO SCALE

TECHNICAL REPORT # 1:
Pilot Instrument Development

PROJECT OVERVIEW
The Center for Elementary Mathematics and Science Education (CEMSE) in the Physical Sciences Division of the University of Chicago is engaged in a project funded by the National Science Foundation entitled “Applying research on science materials implementation: bringing measurement of fidelity on implementation (FOI) to scale.” This project is focused on developing instruments to measure the fidelity of implementation of standards-based science and mathematics instructional materials and has three phases of work: (1) the identification of a conceptual framework to study FOI; (2) the development of a suite of instruments for studying FOI; and (3) the identification of typologies of FOI which are associated with student outcomes. In order to develop the suite of instruments and identify typologies of implementation, we focused on answering the following questions: (1) What are the “critical components” of Full Option Science System (FOSS), Science and Technology for Children (STC), and Science Education for Public Understanding Program (SEPUP), Investigating Earth Systems (IES), Science Companion, and Everyday Mathematics?; (2) To what extent are these components implemented with fidelity, how is that evident in classroom instruction, and in what patterns and configurations (typologies) are they present?; and (3) What, if any, is the relationship between particular implementation typologies and student achievement?

This technical report describes our pilot instrument development process. There are several pilot instruments in the suite of instruments including a teacher instructional questionnaire, teacher attitude questionnaire, school leader questionnaire, teacher interview protocol, school leader interview protocol, classroom observation protocol, school-wide observation protocol, and a teacher instructional log.

OVERVIEW OF CONCEPTUAL FRAMEWORK AND CRITICAL COMPONENTS
“Critical components” are the elements of an instructional materials program that are essential to its implementation. They are the variables one must measure in order to determine fidelity of implementation of programs and in turn, their efficacy. Clearly articulating the critical components of an instructional materials program model is key to accurately measuring FOI.

In our work, program critical components reside in CEMSE’s conceptual framework for FOI. The development of a conceptual framework was an essential first step in our work because we intended to create instruments that could be used across our five identified programs as well as with other instructional materials. Thus, they needed to be grounded in a sound organizational structure that could apply to a range of interventions.
The framework (Figure 1) has two broad categories of critical components: 1) **Structural** Critical Components and 2) **Instructional** Critical Components. Structural critical components reflect the developers’ decisions about the design and organization of the physical materials. Instructional critical components, on the other hand, reflect the developers’ decisions about the intended teacher and student behaviors during classroom instruction.

Each main category has sub-categories that further classify the critical components. In the “Structural” category, *procedural* critical components are the organizing structural elements of the program including the step-by-step actions a teacher is expected to take in the classroom. In other words, they focus on expectations for what the teacher needs to *do*. The *educative* critical components, on the other hand, represent the developers’ expectations for what the teacher needs to *know*.

In the “Instructional” category, *pedagogical* critical components reflect the developers’ expectations about the instructional transactions. In other words, they identify beliefs about the instructional strategies the teacher needs to employ and interactions the teacher needs to have with students in order to use the program as intended. Similarly, there are *student engagement* critical components that reflect the developers’ expectations for student behaviors and interactions during instruction. Together, the Instructional critical components represent the developers’ beliefs about the nature of the instruction that will lead to desired student outcomes.

**FITTING CRITICAL COMPONENTS WITH INSTRUMENTS - CRITICAL COMPONENT/INSTRUMENT MATRIX**

The instrument development process and identification of the critical components was an iterative process. But once we arrived at a solid set of critical components (constructs), we considered the best way to measure them across the suite of instruments. We developed a matrix to facilitate this process with each critical component having a column across the length of the matrix and each instrument listed in a row down the height of the matrix. Most critical components could be measured in a variety of instruments, so we needed to take into account the best fit between construct, item and instruments. We decided to measure each critical component in at least two instruments. We also took into account the time for instrument administration and the level of detail we could obtain about each construct in each instrument. For example, one could ask which parts of a lesson a teacher usually teaches in an interview, but it would be more efficient to ask in a questionnaire and then compare that data with observational data.

**EXISTING INSTRUMENT REVIEW AND ITEM IDENTIFICATION**

Working with our instrument construct matrix as a starting point, we set out to identify or develop items that would best measure the construct variables. We began the instrument development process with a comprehensive review of 69 instruments from fields such as health, business, and education. Of these instruments, 44 were in the area of education and 19 were specific to mathematics and science. These

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<thead>
<tr>
<th>Structural Critical Components</th>
<th>Instructional Critical Components</th>
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<tr>
<td>Procedural</td>
<td>Educative</td>
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<tr>
<td>Pedagogical</td>
<td>Student Engagement</td>
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Figure 1. Basic FOI Framework
instruments purported to measure a variety of phenomenon including fidelity to health programs and classroom interactions. During the review process we considered each item to determine if it could contribute to measurement of instructional materials use. When an item appeared to be a particularly good fit, it was added to a list for a total of 252 items. Where data was available, the psychometric properties of the instruments were also noted. The items from other instruments were then put in a critical component/instrument matrix. The matrix was organized by critical component and instrument type (interview protocol, observation protocol, etc). Each item identified was then placed in a cell where it had the closest fit to both categories.

**ITEM CREATION**
Having completed the critical component and instrument matrix and item identification process, we began to populate the critical component instrument matrix with the actual items (in place of the “x”). This included both the items and how we intended to measure them (e.g. open-ended response, select options, Likert-scale). We decided to ask some questions in multiple ways to explore which approach yielded the best data. Many of the Instructional-Pedagogical and Instructional-Student Engagement critical components were framed in terms of both quantity and quality. For example to measure “Students contribute to small group work” (an Instructional student engagement critical component) we asked, “How many students generally contribute to group work?” as well as “At what stage of development are most of your students when contributing to small group work (e.g. novice, proficient, expert)?”

We took cues from the other instruments and measured what seemed to be similar constructs in the same instruments. For example, Wang and colleagues had many useful items such as “Teacher uses questioning” which translated into our critical component “Teacher use of a variety of questioning strategies” (Wang et al, 1984). For other items, we used the verbiage of the actual critical component. For example, for the critical component “Students predict”, we had an observation protocol item that asked observers to rate the percent of students that predicted during the observed class session. We also looked at the instructional materials for specific indicators of each critical component. Indicators of “Teacher facilitation of group work” came from the section “Encouraging Discourse” in the FOSS Teacher Guide. These indicators included use of group roles, the teacher circulates among groups, and interacts with groups.

**INSTRUMENT CREATION**
Once the matrix was populated, we developed our first draft of each of the instrument forms (teacher questionnaire, observation protocol, teacher interview, school leader questionnaire, school leader interview, walkthrough, log). If an instrument was too long, we divided the questions into multiple forms. The teacher questionnaire has four forms for each program and the teacher interview has two forms. In each form of the same instrument, there are some similar and some unique items.

**Instrument/Item Revision**
Using existing items from the item matrix when possible, two team members developed the first draft instruments. Then, three additional team members reviewed the instruments and commented on wording, flow, and type of response format. Other team members reviewed all of the instruments, commenting on specific items, wording, or the overall flow of the instruments. Another team member reviewed the instructional log. After two to three rounds of revisions with each instrument, we placed the instruments into common forms. All instruments were made into forms in Adobe, which the Interview was placed in Microsoft Word.

**USER'S NOTES CREATION**
After the initial round of instrument revisions, two team members created User’s Notes. The User’s Notes gave information about the constructs measured in the instrument, the expected amount of time to administer the instrument, and items measured on each form of the instrument (for the teacher questionnaire and interview). The observation protocol includes coding notes that provide guidance for users on item ratings.