Illinois Math and Science Academy

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DePaul University Mathematics and Science Partnership Internal Evaluator's Interim Report

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The DePaul University IMSP\(^1\) was designed as a longitudinal cohort program. Two cohorts of up to 25 teachers each will be supported. The second cohort is offset by one calendar year. Each teacher will complete a sequence of 12 university graduate-level courses (48 quarter hours), over two and one-half years, leading to a Masters of Science in Science Education (MSSE) degree. Thus, all successful participants will meet or exceed requirements of the designation “highly qualified” as described in the MSSE proposal quoted here.

The Masters of Science in Science Education program is designed to provide rich content-based professional development of middle school schools teachers in the Chicago area, in particular the Chicago Public School system. It is designed to enhance subject area mastery of science teachers in middle schools and to help create a cadre of master science teachers who will be leaders in their schools. By choosing a subset of seven courses, teachers can satisfy the content requirements for a middle school endorsement in science. (Narasimhan, Jabon, & Beck-Winchatz, 2004)

It is important at this point to recognize that the DePaul IMSP, with the MSSE at its core, represents a more intense and sustained professional education model than is required in the base formulation of a summer institute with academic year follow-up sessions. Instead, the DePaul IMSP was designed to span funding cycles, as allowed by the program:

Partnerships may be designed for single or multiple funding cycles. Each cycle must include a summer institute (Phase I) and follow-up sessions in the school year following the summer institute (Phase II). Proposals may include partnership designs for up to three sequenced, consecutive cycles, each building on the previous cycle. (ISBE, 2004, p. 4)

As a result, the evaluation plan developed for the original DePaul IMSP proposal (Narasimhan, Jabon, Beck-Winchatz et al., 2004), and revised for the project continuation application, is based on a period of three program cycles. Pre-intervention and post-intervention assessment activities will span a greater period in the DePaul IMSP design than for programs that are contained within a single cycle. At this time, therefore, evaluation of the DePaul IMSP has focused on establishing baseline and benchmarking data.

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\(^1\) IMSP is the acronym for the Illinois Mathematics and Science Partnership funded through the Illinois State Board of education (ISBE).
1 RESEARCH/EVALUATION QUESTIONS

The evaluation was designed to align with stated IMSP goals, program requirements, and characteristics of the MSSE cohort program. Because the MSSE is both substantive\(^2\) and sustained\(^3\), evaluation activities are able to be somewhat integrated and distributed within the program experience. This also facilitates our recognition, to some extent, of change theory both in the implementation of the program and in its evaluation. We hypothesize, for example, that gain in teacher content knowledge (attributed to the IMSP experience, presumably) should (in time) result in detectably improved science instruction in the classroom and a better learning environment. This in turn, should result (in time) in better science learning of students. And finally, this “value-added” learning is assumed to be measurable within a short timeframe of the intervention.\(^4\) It is similarly assumed that this learning is both relevant and sustained long after the post-intervention measurements are taken. While a discussion of the research on—and complexity of—these issues is well beyond the purpose of this interim report, suffice it to say that an attempt was made to design formative and summative evaluation activities with respect for the dynamics of “teacher change” in a major urban school system. With this in mind, our primary research questions are provided here, organized within the three goals of the IMSP program.

Goal I. To increase the content expertise of mathematics and science teachers.

**Question 1.01** Can it be shown by pre/post selected-response assessment that DePaul IMSP participants, over the course of the program, make measurable (statistically significant) gains in relevant content knowledge in science, mathematics, and technological design—as defined by the Illinois Learning Standards?

**Question 1.02** What credible evidence from teacher work artifacts (e.g., assignments, journals, and portfolios) might indicate growth in content knowledge attributable to the DePaul IMSP? (Guskey, 2003; McTighe & Ferrara, 1998; Pellegrino et al., 2001)

**Question 1.03** Do these assessments correspond (triangulation) in indicating teacher growth in conceptual development as indicated by specific concepts?

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\(^2\) By “substantive” we refer to the challenging and relevant science, mathematics and technology experiences and content represented in each of the MSSE courses and by the program overall. This “substance” of the program is defined by the ISBE standards as described in the original DePaul IMSP proposal.

\(^3\) Sustained support for the MSSE cohort is explained in the introduction of this report.

\(^4\) We do not subscribe to such a simple or linear model suggested here. Rather, we anticipate that the complex interactions of curriculum, instruction, assessment, research, and contextual influences all serve to moderate learning outcomes. We believe, for example, that university educators are also learning, and that this also has value beyond ourselves.
Goal II. To increase teaching skills through access to the expertise of mathematicians, scientists, engineers and other such professionals, their technologies and resources.

Question 2.01 What is the extent of evidence for transference (Bransford et al., 2000) of knowledge, skills, and pedagogical content knowledge (PCK) (Shulman, 1986) of classroom, laboratory, and field experiences into the teachers’ practice?

Question 2.02 Do students recognize changes in classroom environment and instructional practice as indicated by temporally-spaced surveys of classroom environment?

Goal III. To increase the understanding and application of educational research pertinent to mathematics and science teaching and learning.

Question 3.01 To what degree is educational research, particularly findings from the literature on conceptual change (e.g., R. Driver et al., 1994; Rosalind Driver et al., 1994; Limón & Mason, 2002), evident in the MSSE courses?

Question 3.02 To what degree does subsequent teacher practice demonstrate use of education research in classroom practice (as indicated by surveys of classroom environment and coordinated action research).

2 METHODOLOGICAL APPROACHES AND VARIABLES ASSESSED

The evaluation plan is based on recent reviews of current best practices in scientific based research (National Research Council (U.S.). Committee on Scientific Principles for Education Research. et al., 2002). It employs a quasi-experimental multilevel assessment of science education achievement of both the teachers and their students using a non-randomized well-selected comparison group (Fitzpatrick et al., 2004). Improvement in the quality of science instruction is multifaceted, encompassing teacher content knowledge, use of new reform curricula, qualitative changes in classroom environment, and student content knowledge. We present an evaluation design that will allow us to document and analyze changes in the quality of science instruction at these multiple levels. Action research (Calhoun, 1994; Oja & Smulyan, 1989; Tonack et al., 1995) integrated into the university courses throughout the program, is expected to provide important qualitative and quantitative data about classroom environment, instructional practice, and students’ experiences of mathematics and science education.

For the teachers in Cohorts 1 and 2, we will identify a matched pair control group. For each teacher at a given school, we will select a teacher from among those at the school with a most similar teaching assignment. This method for choosing a control group is particularly appropriate in this study because it controls for the very significant differences between schools.
The changes occurring as a result of grant activities will be evaluated from four perspectives described below.

2.1 Growth in Teacher Content Knowledge

Initially we had proposed use of the Praxis II Middle School Science Exam. Wide use of this exam, specifically designed for middle school science teachers, and a national comparison group, seemed compelling reasons for use of this instrument. However, as preparations for Cohort I were being made, significant problems with this approach were identified. One concern was an ETS policy which would not allow on-site administration of this particular exam, instead, the Cohort would need to take the examination (both pre- and post) at an examination facility elsewhere. More troubling, the established dates of test administration would not align with our program schedule. The degree of congruence of the latent traits assessed in the Praxis II Exam with the learning goals and content of the IMSP was also undetermined, and beyond our control. And finally, the actual costs of test administration were found to far exceed the allocated budget (which had been calculated using advertised prices on other versions of the Praxis series). Ultimately, the Advisory Board decided to abandon the attempt to force the use of the Praxis II Exam in favor of an active search for a more applicable and viable indicator.

Therefore, initial content assessment for Cohort 1 was accomplished using a broad-content assessment using primarily released items from TIMMS (Trends in International Mathematics and Science Study, formerly known as the Third International Mathematics and Science Study) and the Massachusetts Comprehensive Assessment System. Permission to use the Massachusetts items for this purpose was sought and granted. Analysis of these data revealed certain general weaknesses in specific content (i.e., “photosynthesis”). These results have been reported (Jabon, 2005) to instructors and are being applied to set targets in the design of subsequent courses (i.e., the Spring Quarter’s “Biology for Teachers”).

Other viable means for assessing gains in teacher content knowledge are being actively explored. Meanwhile, longitudinal growth in teachers’ knowledge will also be assessed using professional portfolios, which include content- and reflective practice journals. We have developed the technology to support online portfolios.
2.2 Learning Environment

Another key feature of the proposed program is to bring about an enhanced understanding of the concepts and practices of mathematical and scientific inquiry. It is an explicit goal of the program to bring about change in the classrooms of the participating teachers to make them more inquiry-based and help shift them to a constructivist epistemology. In particular, we are examining how teachers shift from an emphasis on content coverage and a transfer-of-knowledge model in their classroom to an active model of learning science by practicing scientific inquiry in their classrooms. We will survey teachers and students of teachers in both Cohorts 1 and 2 and the matched pair control group with two survey instruments, the Constructivist Learning Environment Survey (Taylor et al., 1997) and the Beliefs about Science and School Science Questionnaire (Chen, 1997; Chen et al., 1998). Both instruments have been psychometrically validated (Aldridge et al., 2000; Fraser, 1998). The first instrument, CLES, has 36 Likert scale questions and measures characteristics of classroom environments central for developing scientific inquiry:

- Personal Relevance - the extent to which the science learned at school is relevant to students' out-of-school lives and work aspirations.
- Uncertainty - the extent to which teachers and students see science as a human activity involving values and assumptions, rather than an impersonal and objective study of the real world.
- Critical Voice - the extent to which students feel able to have a voice in what happens in the classroom and to question the teacher and the discipline.
- Shared Control - the extent to which students have a sense of agency about their learning, and an active involvement in choosing activities and assessment approaches.
- Student Negotiation - the extent to which students are allowed to learn together collaboratively through negotiating and constructing models.

The BASSSQ emphasizes students’ and teachers’ beliefs about the nature of science and how the beliefs affect actual classroom practice. The instrument has 41 Likert scale questions relating to the process of scientific inquiry in general, the process of science inquiry in science classes, certainty of scientific knowledge in general, and certainty of school science knowledge.

The CLES and BASSSQ will be administered each year to Teacher Cohorts 1 and 2 and those in the Matched Pair Control Groups. Teachers in the latter group will receive a $50 voucher each time they take and administer the CLES and BASSSQ.
The CLES and BASSSQ will give us both formative and summative feedback on teachers’ progress in meeting Illinois Standard 13.

The data analysis technique will be a repeated measures analysis of variance using a level two hierarchical linear model.

2.3 Action Research and Evaluation of Student Work Artifacts

As mentioned above, action research will be embedded in each course offered during the academic years of the program. The action research studies will evolve each year to a higher level of sophistication as teachers’ own knowledge and experience of research methods develops. Specifically, action research during the first year is guided and structured, based on reform curricula, with a high degree of methodology and support provided by the university faculty. During the second year, the action research will continue to be guided, with more of the design entrusted to the teachers themselves. Finally, during the capstone course, the action research will be open with the teachers designing the action research on their own, submitting its design to the review of their fellow teachers and university faculty facilitating the capstone experience.

Each quarter during the academic year, teachers will use an instructional unit focusing on scientific inquiry, mathematical inquiry and problem-solving or technological design. Each module will be selected to align with MSP priority standards. They will collect the work of their students, and analyze at least some part of that work collectively in their DePaul course. They will compile the work as part of a portfolio. The student work will become the basis for assessment of student achievement during the academic year.

The activities related to action research will provide formative and summative assessment on progress in meeting Illinois Standards 12, 16, 4, 8, and 10.

Qualitative data analysis techniques will be employed, including thematic coding and some statistical analysis of text frequencies or code co-occurrence (i.e., Gibbs, 2002; Richards, 2005).

2.4 Evolution of teacher epistemological framework for the teaching of science

All action research will be collected and compiled into a portfolio for each teacher. As part of the capstone course, the teachers in Cohort 1 will reflect on the overall implications of their action research and their own epistemological and meta-cognitive development over the entire program. The teachers in Cohort 2 will also compile a portfolio and be asked to reflect on this
portfolio in their last science course. We will evaluate the reflections qualitatively for changes in epistemological framework with regard to science teaching. The BASSSQ will also provide data on this important aspect of teacher development.

2.5 ISAT scores of students of participating teachers

For seventh grade teachers in the both the treatment group and the matched pair control group, we will collect ISAT science scores of all their students. We will then compare the mean ISAT science scores for the entire set of students of treatment group teachers with mean ISAT science scores for the entire set of students of control group teachers. By averaging over the entire set of treatment and control classrooms, we at least will average out significant natural classroom differences. The method of analysis will be a two sample independent samples hypothesis test; a parametric method will be used unless there are significant deviations from normality in the data.

2.6 Survey of Enacted Curriculum

We will use the Survey of Enacted Curriculum (SEC) with our teachers so that they become more aware of the tight linkage between instruction, curriculum, and assessment. All teachers in all cohorts will complete the survey annually. Instructors of MSSE courses will be asked to complete the SEC as a means to test the correspondence of course content with detected changes in teachers’ (self-report) practice.

3 PRIMARY ANALYSES, FINDINGS, INTERPRETATIONS, AND CONCLUSIONS

Work to date has been to establish baseline data, program development, and especially the introduction of Cohort One to action research. Three examples are provided here as a means to illustrate initial progress.

3.1 Teacher Content Knowledge

Baseline assessment of teacher content knowledge was accomplished using a constructed selected-response instrument (described earlier). Analysis of this assessment was completed by Dr. David Jabon and reported at an instructor’s meeting so that evident content area needs could be addressed in subsequent courses. Results and interpretation are given in detail in Dr. Jabon’s report (Jabon, 2005) and therefore, is not reproduced here.
3.2 Action Research and the BSSSQ

Earlier we explained that the action research aspect of the evaluation plan would proceed progressively from structured and highly guided early in the program to “open inquiry” in the capstone course. Cohort One was introduced to action research by inviting them to examine their own students’ views on science using the BSSSQ. Teachers conducted and reported studies on their own classrooms. Methods and characteristics of the instrument were provided in papers of the original BASSSQ developers (Chen, 1997; Chen et al., 1998). A summary of initial (baseline) results is provided in Table 1 (see note5) and Figure 1, below. The instruments (Student and Teacher forms) are provided as attachments to this report.

Table 1: Initial BASSSQ Student Results

<table>
<thead>
<tr>
<th>Scale</th>
<th>No. of Items</th>
<th>Australia (N=27)</th>
<th>Taiwan (N=50)</th>
<th>Chicago (N=555)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process of Scientific Inquiry</td>
<td>8</td>
<td>2.9</td>
<td>3.1</td>
<td>2.9</td>
<td>0.4, 0.5, 1.3</td>
</tr>
<tr>
<td>Status of Scientific Inquiry</td>
<td>8</td>
<td>3.6</td>
<td>3.4</td>
<td>2.9</td>
<td>0.5, 0.5, 1.3</td>
</tr>
<tr>
<td>Process of School Science Inquiry</td>
<td>9</td>
<td>4.1</td>
<td>3.7</td>
<td>3.6</td>
<td>0.4, 0.6, 1.3</td>
</tr>
<tr>
<td>Status of School Science Inquiry</td>
<td>8</td>
<td>3.6</td>
<td>3.1</td>
<td>3.3</td>
<td>0.4, 0.7, 1.2</td>
</tr>
</tbody>
</table>

Figure 1 - Initial BASSSQ Student Profile

![](image)

5 Including Australia and Taiwan teacher profiles is for illustrative (not comparative) purposes only. These data were reported in the BSSSQ design report used as a model for the teachers. Eventually, a second administration of the instrument will produce a profile for an appropriate comparison.
3.3 Summer Institute Evaluation

The summer institute was evaluated according to the procedures defined by the state-level evaluation coordinator, Dr. Bret Wholeben. This report was discussed at a DePaul IMST team meeting to debrief the summer classes. We anticipate that this report should be useful again as preparations commence for the second round of summer courses (Cohort One and Cohort Two).

3.4 Survey of Enacted Curriculum

A wealth of data is now available from the Survey of Enacted Curriculum. Initial qualitative comparisons suggest that the DePaul IMSP is generally representative of the population of Illinois teachers who have completed the SEC (this is not necessarily representative of all Illinois teachers). For example, Figure 2 provides the contour maps of the ISBE standards for both elementary and middle-level science. This is followed by Figure 3 in which the self-report teacher responses of the DePaul IMSP cohort (N=22) is compared with all Illinois teachers who have responded (N=599). We note that the Figure 3 maps are far more similar to one-another than each is to the maps in Figure 2.

Figure 2- SEC Illinois Standards Profile
Figure 3- SEC Teacher Reports: DePaul IMSP comparison to all Illinois completers
REFERENCES


National Education Association, Washington, DC.


