Overview of ATOMS project

In 2011, researchers in the Department of Elementary Education at [redacted] were awarded a $3.1 million grant from the National Science Foundation to conduct a five-year study of the outcomes of a STEM-focused elementary teacher preparation program, initiating ATOMS, the Accomplished Elementary Teachers of Mathematics and Science Project. Over the five years of the project, the ATOMS research team is studying the development of teacher candidates as they progress through the elementary education program into their first years of teaching. Incorporating a mixed methods approach, the ATOMS research project is designed to examine pre-service teachers’ development in the areas of science and mathematics content knowledge, pedagogical content knowledge, self-efficacy beliefs, and teaching practices, and to later examine the relationship between these constructs and teacher effectiveness.

What are the major goals of the project?

The major goal of this project is to evaluate a promising STEM-focused elementary teacher preparation program called Accomplished Elementary Teachers of Mathematics and Science (ATOMS). To do this, our goals include:

- Assess pre-service teachers’ development on the knowledge dimensions of mathematics and science content knowledge, pedagogical content knowledge (PCK), and teaching beliefs (i.e., self-efficacy and epistemic) from the participants’ time in the program into their second year of teaching;
- Assess how pre-service teachers develop on inquiry-based mathematics and science teaching performance;
- Assess pre-service teachers’ perspectives on the program, specifically focusing on which aspects of the ATOMS model contribute to their development of the content and teaching dimensions mentioned above;
- Assess how ATOMS teachers’ scores on instructional measures correlate with scores on content, PCK, and/or teaching beliefs measures (i.e., self-efficacy and epistemic);
- Assess how ATOMS teachers compare on measures of content knowledge, PCK, teaching belief (i.e., efficacy and epistemic), and teaching performance with non-ATOMS teachers after one and two years of teaching; and
- After matching on demographic and school characteristics, compare how student achievement gains in classrooms served by ATOMS beginning teachers compare to student achievement gains in classrooms served by other beginning teachers in the state.

Major Activities

1. Hired a full-time research associate [redacted] and two doctoral students researchers [redacted]
2. Developed and implemented procedures for conducting 20 longitudinal, qualitative case studies of pre-service teachers. To do this, we:
   - used assessment data to divide the potential case studies into three strata based on their measured content knowledge and then selected students randomly from within those strata to ensure variance across individuals
   - developed 7 cognitive interview protocols
   - conducted interviews around course assignments
- observed videos of lessons taught
- participated in social events with participants to encourage commitment

3. Conducted focus group interviews with 47 students on their perspectives on the ATOMS program
4. Had all interviews and focus groups transcribed into electronic files suitable for analysis with Nvivo
5. Designed and developed two new instruments for collecting quantitative data on mathematics and science instructional practices (see Appendix A)
6. Wrote and obtained a $55K NSF supplement to conducted two pilot studies for the development and refinement of the instructional logs
7. Conducted assessments of three cohorts of students (N=180) on a battery of knowledge dimensions: content knowledge, PCK, efficacy, beliefs.
8. Conducted analyses of above assessments (see Results)
9. Wrote two articles and submitted them for publication (see Results) with one more in progress (see Results)
10. Made 3 national presentations (see Results)

Specific Objectives

To summarize the specific objectives of the 2012-2013 year, we quote our project evaluators from Horizons Research, Inc. (HRI) from their annual evaluation report, which states, “In summary, the project team accomplished many objectives during Year Two. Among them, the team expanded and shifted responsibilities as needed, collected multiple waves of data, began developing instruments, field tested new measures, and started planning for analyses, all while incorporating many of the recommendations made by advisory board members and the evaluation team” (p. 2-3). Most significantly, our objectives were to:

1. Develop appropriate, sound measures of science and mathematics instructional practice, based on the program theory, hypotheses of the study, and research literature on best practices. This resulted in the instructional logs, pilot studies of the logs, and preparation for full implementation of the logs during the 2013-2014 year.
2. Develop appropriate, sound measures of participants’ thinking and development as teachers. This led to the development of the: Introductory Interview, Math Cognitive Interview for First Semester Math Lesson, Getting to Know You Interview, STEM Cognitive Interview, Math Cognitive Interview for Second Semester Math Lesson, Science Assignment Cognitive Interview, and End of the Year Interview.
3. Obtained data from CIPP identifying all current Public school teachers in their 1st year of teaching who were traditionally prepared by a public teacher preparation program- data included a wide array of pre-treatment variables.
4. Used propensity-score matching to identify all first year teachers who match ATOMS 2012 graduates on a group of variables for the comparison study.
5. Recruited 31 (of 36) ATOMS 2012 graduates and 74 (to date) comparison teachers for the Year 3 comparison study. In doing so, sophisticated and complex recruitment procedures (See Outcomes and Achievements section) were developed to entice and commit participants.

Significant Results
Results of this study to date are descriptive only, and include: 1) a description of the ATOMS program, 2) a description of the content knowledge growth across the program, 3) a description of the engineering/design process and pre-service teachers’ perspectives on that process within the ATOMS program, and 4) the relationship between pre-service teachers’ mathematics and science teaching efficacy and their content knowledge and PCK. Each of these findings is elaborated below.

1. **Description of Teacher Preparation Program.** This exemplary program called the Accomplished Teachers of Mathematics and Science (ATOMS) is characterized by four key features: 1) program coherence; 2) rigor in the general education program; 3) innovative, conceptually-focused methods courses; and 4) extensive field work aligned with coursework. A manuscript detailing the program was submitted for publication, with the features of this highly scalable program described in detail, illustrated through participant reflections, and contextualized in the research literature on effective teacher education programs. (See Products for citation.)

2. **Content Knowledge Growth.** We are measuring content knowledge growth by giving a battery of science and mathematics tests developed for teachers at four different time points across the study. Because our cohorts are staggered, we have average scores for different cohorts at the Preliminary results are included here using two time points taken from one cohort. Tests included the Diagnostic Teacher Assessment for Math and Science (DTMAS). Preliminary analyses were completed using two time points, post methods and post student teaching, taken from the same cohort. Statistical analysis using repeated measures ANOVA indicated a significant effect of time on the life science scores (F [1, 25] = 29.40, p < .001, partial η² = .54), but not the physical science scores (F [1, 29] = .00, p = 1.00). Means and standard deviations from the science tests are shown in Table 1. These preliminary analyses should be interpreted with caution, however, due to a low sample size (N = 26) at this point in the study.

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<tr>
<td>Physical Science Post Student Teaching</td>
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3. **Engineering Design in Elementary Education.** In this analysis, we described how the engineering/design process was taught in the elementary education program, one course assignment that required candidates to integrate engineering concepts with the teaching of mathematics and science, and the candidates’ responses to the assignment and course. The teacher candidates participate in a semester long engineering design methods course that is closely tied to the mathematics and science methods courses. This program reinforces the importance, relevance and appropriateness of the engineering design process for elementary students through explicit integration and modeling within the teacher preparation courses and field placement work. Participation in this program encourages the candidates to value the engineering design process and work to implement it into their classrooms, as reflected by end of year interviews with current and former students of the program. Participants implement an interdisciplinary STEM assignment during their first semester of methods courses. Many had naive impressions of teaching, falling back on their experiences as students (Ball, 1988). Further, many struggled with goals for eliciting rich learning reflections from students, developing deep
knowledge of the science concepts of force and motion or sound and rich mathematical understandings of the meanings behind measurement. Children having “fun” or behaving were ultimate goals for some candidates and the learning curve to additionally focus on rich student learning of content and processes required a self reflective leap. The preparation of final presentations for peers required candidates to fully evaluate and reflect on student learning and their own development as teachers and their abilities to facilitate student learning STEM-focused interdisciplinary goals. In addition, based on an analysis of interviews of graduates and alumni of the program, students believed the course had a positive impact on their teaching and their integration of the engineering design process during their student teaching and into their first few years of teaching. Three themes emerged from these interviews: attitudes and opinions toward engineering design; connections between mathematics, science, and engineering; and opportunities to practice integrating the engineering process. Further, many students believed the course gave them an advantage in their future teaching positions. The candidates both noticed and cared about the lack of engineering design in their field placement schools, showing that they value the engineering component of their education. The interviews made it clear that the professors of the course need to make the connections between the engineering design process, the content, and the content specific instructional practices explicit. Two publications resulted from this early analysis, one under review and the second in progress. (See Products for citations.)

4. Relationships Among Content Knowledge, PCK, and Efficacy. An analysis of scores on assessed measures of 55 participants at the beginning (time 1) and end of their senior year (time 2). In-depth, semi-structured interviews augment quantitative findings and assessed participants’ views of their teacher education preparation and their beliefs about teaching. Significant correlations were found between the participants’ science PCK (pretest, time 1) and science outcome efficacy (time 2, \( r = .61, p < .05 \)) and math outcome efficacy (time 1, \( r = .38, p < .05 \)), suggesting that pedagogical and content knowledge (PCK) correlates with outcome expectancy beliefs (goals set for their future students). Also, we found that mathematics and science outcome expectancy beliefs (time 1) highly correlated \( (r = .85, p < .05) \), and also high correlations were found \( (r = .61, p < .05) \) between science personal efficacy (time 1 and 2). These findings suggest that content knowledge, PCK and efficacy beliefs are strongly interconnected and influence each other. Multiple regression analysis indicated that generally, mathematics and science content knowledge didn’t predict participants’ efficacy beliefs; however, their PCK science overall score (time 1) predicted participants’ (time 2) science outcome expectancy beliefs \( (R^2 = .03, F(1,51) = 1.96, p < .05) \), suggesting that PCK could be more important for efficacy beliefs development than content knowledge. Additionally, results showed that previous efficacy beliefs (time 1) are more likely to predict future efficacy beliefs (time 2). Interview data revealed that participants’ pedagogical and content knowledge played an important role in their teaching confidence and how they planned teaching practices. (See Products for citation.)

**Key outcomes or other achievements:**

Major achievements include:

1. Design and development of science instructional log, field tested in two pilot studies, including an exploratory factor analysis and item analysis.
2. Design and development of mathematics instructional log, field tested in two pilot studies, including an exploratory factor analysis and item analysis.
3. Development of sophisticated procedures for recruitment of teachers for like studies.
4. Recruitment of 31 2012 ATOMS graduates into comparison study and 74 (to date) non-ATOMS comparison teachers for first round of the comparison study of knowledge development, teaching performance, and pupil achievement.

Opportunities for training or PD has the project provided?

Two research assistants attended an academic writing workshop.

How have the results been disseminated to communities of interest?

Yes. (See products below.) Further, the team developed standards for future publications. This was described by HRI in their evaluation report:

“Due to the growth of the project team and external requests for ATOMS data, the principal investigator, along with the project manager, developed a research plan request form. All research efforts and dissemination products that relate to the ATOMS project are required to have an approved research plan. The purpose of the form and approval process is to protect the integrity of the data, making sure that each researcher is accessing the most current version of the dataset, and to eliminate duplication in research efforts and avoid inconsistencies across project products. The form is currently in use now and will be required for the next round of conference proposal submissions” (p. 2-3).

What do you plan to do during the next reporting period to accomplish the goals?

- Continue qualitative case study of teacher development with 20 cases
- Begin qualitative case studies with 10 new participants from younger cohort
- Conduct qualitative analysis of teacher development and perspectives on the program
- Conduct comparative study of knowledge development, teaching performance, and pupil achievement with 31 ATOMS graduates and 74 non-ATOMS graduates:
  - Conduct summer training on logging instructional practice
  - Assess participants on battery of tests and surveys
  - Track logging data
  - Videotape samples lessons
  - Conduct quantitative comparison of log data
  - Augment and validate log data with video data
- Recruit participants for second year of comparative study (N=110-140)

Products:

Publications

Conference Presentations


Participants
Individuals:

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<th>Name</th>
<th>Most Senior Role</th>
<th>Nearest person</th>
<th>Month Worked</th>
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<tr>
<td>Ellen</td>
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<td>PI</td>
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Primary Participants

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<tbody>
<tr>
<td>Ellen</td>
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<td>Sarah</td>
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<td>Jayne</td>
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<tr>
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<td>Michael</td>
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<td>Rebecca</td>
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<tr>
<td>Beth Grieve</td>
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<tr>
<td>Danielle</td>
<td>Research Assistant</td>
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<tr>
<td>Carrie</td>
<td>Research Assistant</td>
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Advisory Board

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<tr>
<th>Name</th>
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<tbody>
<tr>
<td>Jere Confrey</td>
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<tr>
<td>Richard Correnti</td>
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<td>Charlene Czerniak</td>
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<td>Geoff Phelps</td>
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Type of partner or organization:
Name: [Redacted]

Other Collaborators?
Rick [Redacted], science educator from [Redacted], consultant on science log
Carla [Redacted], [Redacted], consultant on science log
Kathy [Redacted], science educator from [Redacted] University, consultant on science log

Impacts

What is the impact of the development of the principal discipline(s) of the project?
None yet; however, the principal discipline of this study (education) is likely to be impacted by this study in two ways: 1) the study will contribute to the field’s understanding of the elementary mathematics and science instructional practices that most relate to children’s learning of those disciplines, and 2) the study will contribute to the field’s understanding of how to best prepare elementary teachers to teach mathematics and science in the ways that most contribute to student learning in those areas.

What is the impact on other disciplines? None yet

What is the impact on the development of human resources? None yet; however, this study is likely to produce three new extremely well-prepared STEM-education researchers (the research assistants on the project) and will enhance the skills of at least five other education researchers. The methodologies used in this study are state-of-art, the organization and leadership on the project is exceptional, the skill levels of the project manager and research associate are second-to-none, and the content knowledge of researchers is state-of-art. Because of the make-up of the team and the conduct of the study, the humans involved in this work are developing strong and lasting skills and understandings.

What is the impact on physical resources that form infrastructure? None

What is the impact on institutional resources that form infrastructure? None

What is the impact on technology transfer? None

What is the impact on society beyond science and technology? None yet; however, this study is likely to have an important impact on how teachers are prepared to teach in STEM areas, especially elementary teachers.

Change/Problems

To summarize changes in study design from the original proposal, we quote from the HRI evaluation report, “HRI noted in the memo that the team made important distinctions between the two main components of the project: (1) a developmental study of the pre-service program, and (2) a comparison study of program graduates and graduates from other teacher preparation programs. Differences between the two sub-studies exist in terms of the research design, measures, and analytic techniques,
but also in the types of claims the project is able to make about the elementary education program.”

Specifically, the changes in approach and reasons for change include the following:
- We added a strong qualitative component to augment the comparison study.
- We designed new instruments to better measure instructional practice.
- We changed our selection of content knowledge measures.

Actual or anticipated problems or delays and actions or plans to resolve them:
- None

Changes that have a significant impact on expenditures:

Teacher stipends for recruitment to attract and keep participants has been raised and will likely continue to be a major need.