# Summary of

# Aurora University Summer Institute in Mathematics
# Year 1 (2009) and Year 2 (2010)

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## Introduction

Aurora University (AU) and its educational and community partners collaboratively developed and implemented an innovative Summer Institute Program in mathematics with science connections. This program was designed to meet the goals of the Illinois Mathematics and Science Program (IMSP) for improving the teaching of mathematics in high needs school districts. The foci of the evaluation are the IMSP project outcomes, which are based on professional development outcomes articulated by the Council of Chief State School Officers. These outcome areas are: (1) Quality of Professional Development, (2) Change in Teacher Content Knowledge, (3) Change in Instructional Practices, (4) Student Achievement, and (5) Sustained Administrative Support.

The two-year Summer Institute was developed to expand teacher-participants' understanding of subject matter in mathematics and enable them the opportunity to gain expertise and experiences needed to become school and district-based intellectual leaders in mathematics. As a result of a needs assessment, a two-year program was designed to provide teacher-participants understanding of mathematical content knowledge by focusing on concepts and their applications, as well as emphasizing strategies to increase competence in problem solving. The program was also designed to emphasize action research to assess and improve individual teaching and at the same time incorporating technology to enhance mathematical instruction and understanding.

The 2010 AU Summer Workshop/Institute in the Mathematics completed the second two week summer workshop in problem-based learning (PBL) integrated with strong mathematics content. University faculty delivered instruction in content-area curriculum and in action research. The Illinois Mathematics and Science Academy delivered a two-day workshop on problem-based learning. Mathematicians, scientists and engineers among some of the collaborative partners provided on-site, real world applications of mathematics aligned with the principles of IMSA's PBL model.

## COLLABORATIVE PARTNERS INVOLVED IN THE WORKSHOP

The Challenger Learning Center for Science and Technology, Woodstock

The Illinois Mathematics and Science Academy (IMSA), Aurora

The Robert Crown Center for Health Education, Hinsdale

The Packer Foundation Center for Applications Based Learning, Naperville

Fermi, Batavia

Aurora University, Aurora

**This report is a summary of both the 2009 and 2010 two-week intensive immersion in problem-based learning (PBL) in mathematics and results of the program thus far.**

**Participants:** Twenty-five teachers from two school districts participated in the program in 2009. All results of 2009 represent twenty-five teacher-participants. Teacher-participants' backgrounds varied in subject and grade level – 8 (Math), 3 (Science) and 14 (other subjects). Twenty-one teachers participated in the program in 2010. Some 2009 teacher-participants dropped out of the program and others were added. Again, teacher backgrounds varied in subject and grade level and not all taught mathematics. Of the 21 teachers in the 2010 summer workshop, 6 taught (Math), 4(Science), and 11 (other subjects). The eleven other subjects included: 4 elementary teachers, 1 high school Music teacher, 1 high school Industrial Tech teacher, 1 ESL teacher, 1- 7/8 Spanish and History teacher, 1 sheltered teacher position, and 2 administrators (no teaching assignments).

**Goal of the Summer Institute:**

- Increase teacher-participants' content knowledge
- Expand pedagogical knowledge
- Improve student math achievement
- Integrate problem-based learning in math instruction

**Workshops included the following topics:**

- Introduction to problem-based learning (PBL) and the nature of scientific inquiry
- Mathematics and science applications in aviation
- Mathematics and science applications in student alcohol abuse and student obesity
- Mathematics and science applications in space flight, robotics, and telescopes
- Mathematics content using coursework adapted from Vermont Mathematics Initiative
- Action based research
- Problem-based learning
- Inquiry-based learning
- Provide insight into various research developments
- Mathematics and science applications in particle physics
- Instruction in teaching Algebra, Geometry, and Geometer Sketchpad software
- Mathematics and science applications in robotics
- Various technology experiences

**Program Design:** This program used a one-group pre-test post-test design, with a mixed-method approach representing both qualitative and quantitative components.

**Quantitative Data Collection and Findings:**

**Diagnostic Teacher Assessments in Math and Science (DTAMS) pre/post test:**
DTAMS were used to assess teachers' content knowledge in mathematics. DTAMS were given at the beginning and end of the 2009 two week workshop with scores analyzed for increase in content knowledge, and again at the beginning and end of the 2010 summer workshop. The posttest for 2009 was used as the pretest for 2010. The Mathematics

assessments measured four areas: memorization/factual design, conceptual understanding, reasoning and problem-solving, and pedagogical content knowledge.
**Findings:**

**CCSSO Matrix Outcome B (Changes in Teacher-participant Knowledge)**
**DTAMS** : Cronbach's Alpha was calculated for pre test and post test

| Pretest Mean | Pretest SD | Range-low | Range-high | Pretest N | Pretest Missing |
|---|---|---|---|---|---|
| 22.52 | 9.3 | 4 | 36 | 25 | 0 |
| Post Mean | Post SD | Range-low | Range-high | Post N | Post Missing |
| 22.56 | 8.2 | 4 | 35 | 25 | 0 |

Pretest reliability = 0.94 Posttest reliability = 0.92 Pearson = 0.92
*analysis of individual scores show that 15/25 teacher-participants showed gains in content knowledge following the two week workshops.

| Pretest Mean | Pretest SD | Range-low | Range-high | Pretest N | Pretest Missing |
|---|---|---|---|---|---|
| 22.56 | 8.2 | 4 | 35 | 25 | 0 |
| Post Mean | Post SD | Range-low | Range-high | Post N | Post Missing |
| 13.3 | 3.2 | 8 | 19 | 21 | 0 |

Pretest reliability = 0.92 Posttest reliability = 0.9 Pearson = 0.26

Of the 2010 teacher-participant individual scores, 9 improved their score from pretest to posttest, 8 scored lower on the posttest, and 3 remained the same. 2010 DTAMS analysis of individual scores in the four Knowledge Type categories show that 8 of 20 showed gains in Knowledge Type I (Memorized/factual knowledge), 4 of 20 showed gains Knowledge Type II (Conceptual), 7 of 20 showed increases in Understanding, Knowledge Type III (Reasoning and Problem Solving), and 8 showed gains in Knowledge Type IV (Pedagogical Content and Knowledge). It should be noted that (1) not all teacher-participants were math teachers, (2) they were learning content in a relatively short period of time, (3) the teacher-participant pool changed from year one (2009) to year two (2010), and (4) post tests were given following a two-week immersion program as opposed to a semester time frame as in other programs.

**Survey of Enacted Curriculum (SEC)**: This SEC assessment was given at the beginning of the 2009 workshop to provide a baseline for comparison. A second SEC was administered again at the beginning of the 2010 Summer Institute. These data were used to identify changes in practices from year to year among teacher-participants. The Survey of Enacted Curriculum (SEC) assessment was given at the beginning of the 2009 workshop and at the beginning of the 2010 workshop for comparison. These data are used to identify changes in practices from year to year among teacher-participants. In the area of Instructional Practices, results indicate that in the sub area of Time on Topic,

where various mathematical operations are identified for teacher-participants to record time spent, instructional techniques increased from 4% (2009 report) to 10% (2010 report). Other areas of Instructional Practices include procedures, demonstrating understanding, analyzing information, making connections and active learning. Changes were noted in procedures (3% increase) and active learning (9% increase). Areas of demonstrating understanding, analyzing information, and making connections remained consistent from year to year. In the area of student Content-Cognitive Demand, sub categories include memorization, performance procedures, demonstrating understanding, conjecture and problem solving and applying and making connections. Composite results show that memorization/recall increased from 20% (2009) to 24% (2010). Results report a decrease in time spent on performance procedures (3% decrease). Composite results of demonstrating understanding show a slight increase (19% in 2009 to 21% in 2010), and a slight increase in applying and making connections (17% in 2009 to 18% in 2010). Conjecture and problem solving remained the same at 18%.

**Learning Experience Evaluations by Participants:** Teacher-participants evaluated their workshop learning experiences through a locally developed instrument addressing course design, content and materials. Brief surveys and open-ended responses provided insight into program efficacy. Evaluations results are provided for both the 2009 summer program and 2010 summer program. Teacher-participants responded to each question with strongly agree, agree, neither agree or disagree, disagree and strongly disagree or N/A.

**Findings (Survey):**

**CCSSO A (Quality of Professional Development Activity) Course evaluations for course design, content, and instructional materials.**

| 2009 | Very Low | Low | Average | High | Very High |
|---|---|---|---|---|---|
| Course Design | 1 | 7 | 15 | 48 | 29 |
| Course Content | 2 | 6 | 19 | 51 | 22 |
| Instructional Materials | 6 | 5 | 19 | 51 | 19 |

| 2010 | Very Low | Low | Average | High | Very High |
|---|---|---|---|---|---|
| Course Design | 1 | 7 | 17 | 52 | 23 |
| Course Content | 1 | 9 | 19 | 50 | 21 |
| Instructional Materials | 3 | 8 | 17 | 52 | 20 |

**Illinois Standards Achievement Tests (ISAT) and Prairie State Achievement Exam (PSAE):** Math scores were analyzed and compared for indications of increased student achievement as a result of teacher-participant' effect on student performance. These data

were analyzed and compared from the first year to the second year. ISAT results for the summer program in mathematics for (2010) report that 83% of third graders (n=24) of teacher-participants met or exceeded state expectations, 93% of fourth graders (n=29), 85% of fifth graders (n=56), 77% of sixth graders (n=188), 86% of seventh graders (n=343, and 84% of eighth graders (n=605) met or exceeded state expectations. A total of 1216 students of teacher-participants met or exceeded state expectations.

Measures used in this program to evaluate impact on student achievement include relevant data from the Illinois Standards Achievement Test ISAT. In all four grades (5, 6, 7 and 8), the mean score in the math ISAT showed an increase from 2009-2010. Since the science ISAT is only administered at grades 4 and 7, it is not used as a Pre/post measure. The Prairie State Achievement Exam PSAE is only administered at grade 11. It was not used as a Pre post measure due to none of the teacher-participants taught grade 11.

School districts participating in the summer workshops have a high percentage of at-risk students and are considered high needs schools. It is encouraging that the mean score increased in all grades given the fact that there are at-risk students in the population.

**Reformed Teaching Observation Protocols (RTOP):** RTOPs were conducted between March and May of 2010 by university professors. The professors observed teacher-participants, looking to gather information on content, lesson design and implication, and classroom culture, for indications of reformed teaching. A typical observation was one class period. Scores ranged from 0 (never occurred) to 4 (very descriptive). Also included were teacher-participants who did not continue with the 2010 workshop, but did participate through the 2009-2010 school year, N=22. **Out of a possible 20 points for Lesson Design and Implementation**, five scored at least 18 points, and nine scored 15-17 points. Lesson design included instructional strategies, student engagement, student exploration before formal lesson, and encouraging students to seek alternative modes of problem solving. **Out of a possible 40 points for Content**, five scored at least 35 points, four scored 30-34, and eight scored 25-29 points. The two main categories for Content were Propositional Knowledge and Procedural Knowledge. Classroom Culture was divided into Communicative Interactions and Student/Teacher Relationships. Each had a possible of 20 points. Eight scored at least 35 of the total 40 points, three scored 30-34 points, and five scored 25-29 points. Communicative Interactions looked closely at students communicating their ideas, and student questions and comments to determine the direction and focus of discourse. Eight scored at least 18- 20 points, and two scored 15- 17 points. Observers recorded such comments as "did not encourage student exploration of lesson ideas", "students need to investigate and problem solve before formal presentation", and "did not encourage students to seek alternative modes of investigation". It should be noted that teacher-participants teach in high needs school districts and the districts have a high % of at-risk students.

**Qualitative Data Collection and Findings:**

**Surveys and Interviews of Organizational Leadership:** Aurora University and its educational and community partners collaboratively developed a Summer Institute Program in mathematics with science connections. Partners include Illinois Math and Science Program (IMSP), Aurora University, Challenger Learning Center for Science and Technology, Illinois Math and Science Academy (IMSA), Robert Crown Center for Health Education, Packer Education Center, SciTech Interactive Museum, and Fermi Lab. These partners responded to the evaluation questions and their responses are summarized below:

1. All partners worked well together throughout the development of the math and science project. When surveyed, they were asked for their perceptions about their collaborative efforts. All responses were extremely positive.

2. Partners were then asked to explain what they considered most effective about the development and maintenance of the collaboration process. The partners responded with favorable comments about Aurora University, the organized planning of workshop activities, the strong leadership and coordination of the program, and the availability of a quality contact person when needed.

3. Partners were also asked what could have been done to improve the collaboration process. They felt more time might have been allocated to planning the project. One respondent stated that more time may have allowed him the opportunity to view other partners' curriculum outlines. Two partners stated that the state's time-lines were difficult for planning, and that budget expectations were a hindrance.

4. When asked what was most effective in terms of actual implementation of the workshops the partners responded positively toward holding individual workshops at the partner locations rather than the university. This allowed partners to use their own personal resources which made experiences more "real". Respondents also stated that the "demonstrations" were dynamic, and that partners who attended more than one workshop day found connections among all workers were reinforced.

5. When asked how the workshops could have been more effective the partners responded that more reasonable communication and cooperation with ISBE was needed. They also felt that a more clearly defined, homogeneous group of educators would have provided a personalized program specific to grade levels, and that more cohesion with activities rather than a series of independent activities would have been beneficial.

6. Finally, partners were asked for suggestions for improving the development and implementation of future workshops. Partners felt that mutual planning of workshop content and pedagogy would be helpful. They also stated that a repeat of the same model used in Year One of the program should be considered. In addition, partners suggested that learning experiences that would be relevant to the diverse group of teachers and less of a challenge to the partners/instructors (due to the range and diverse backgrounds)

could be developed. Finally, partners stated that more time for planning would be helpful, but they also understand that the time limits were unavoidable due to the timing of approval and budget coordination

**Learning Experience Evaluations by Participants**: Teacher-participants recorded their workshop experiences using a Professional Development Activity Log (PDAL). These reflections were recorded on an on-line "Moodle" computer program that teachers could access at the end of each day of the workshops. Teacher-participants continued to record their experiences using the Professional Development Activity Logs (PDAL) once a month from September through May using the on-line "Moodle" program through the university. Teacher-participants logged 144 entries, with entries for teacher-participants ranging from 4-9. Detailed teaching lessons, changes in instructional practices, and lessons learned through the summer workshop and implemented in the classroom were noted on the PDALs. Teacher-participants again recorded their experiences after the 2010 workshops and will again record their monthly reflections during the 2010-2011 school year.

**Reflection Samples:** Data was collected through self-reported reflections and answers to survey questions. The open-ended responses of the teacher-participants provided numerous indications of enthusiasm and success. Comments from teacher-participants indicate that the workshops were successful in many respects. One teacher-participant spoke about the first goal of the summer workshops, which is increased teacher-participant content knowledge. "I believe my learning will trickle down to my students. I am excited about teaching this area to my students." A second teacher-participant commented, "Today's information was awesome! It was a refresher course for me and I wish I could learn it and teach it every day! I love higher level math!"

With improving student math achievement, some teacher-participant comments included, "Students love to use manipulatives--they aid in the concrete to abstract understanding as students learn and internalize math concepts". Another stated, "I learned that in order to create interest around a problem you must first harness the students' attention by making a connection, then having the students gain confidence by drawing out the information they already know, then presenting the problem." Regarding the presenters, one teacher-participant stated "I was impressed with this presenter today and how he presented the information." Another stated, "The presenter taught us ways to keep our students engaged. This was most valuable." And finally, "I am already trying to see how/where I can incorporate these lessons within our curriculum. I am even thinking of starting the year off reviewing skills using the activities from this workshop.

With teacher content knowledge in mind, enthusiastic comments were made by teacher participants regarding an outcome of increased teacher knowledge. "I can organize and understand the systematic approach to Problem Based Learning (PBL) as a result of this workshop." Similarly, "PBL will increase academic achievement, because it will encourage higher-order thinking and engagement". Another stated, "I can and intend to use the information from today's lesson to explain the use of math and STEM skills in the real world." And finally, "The guidance given by the IMSA staff. They are encouraging and extremely helpful in designing our PBL."

Teacher-participants felt more prepared to integrate problem-based learning (PBL) in their math instruction and put into practice some of the learned approaches. Some statements that emerged include, "I hope there will be further studies of PBL. I think it makes me a much better teacher and keeps me fresh in learning new and exciting information. Another comment, "I felt I empowered my students this past year and see them getting even more learning this coming year! I am going to integrate the different activities into my curriculum", and "I really like the way that the presenters modeled PBL coaching." And finally, "Hearing other teacher's experiences with PBL helps me learn."

Outcomes of student achievement will be assessed after the school year as teacher-participants implement content, knowledge and skills learned from their participating in the program. Many reflective comments pertained to the ideas learned from the program and how they will be utilized when teaching.

**Data collection to follow:**

**Action Research Project** *will continue to be* developed by each teacher-participant and demonstrated in the classroom and at Aurora University at the end of the 2011 school year. Key to this project will be indications of program effects on teacher-participants' content knowledge, pedagogical understanding, as well as increased student achievement.

## Conclusion

This was the second year for the workshop and will be the second year for teacher-participants to incorporate lessons learned in their classes. One part of the program measurement consists of teacher-participants' journal entries and reflections. Teacher participants used the technology on AU's "Moodle Site" to post their surveys and thoughts. Surveys and reflections were recorded daily during the two week workshop, and monthly from September until May. The teacher-participants recently reflected on the 2010 workshops. The teacher-participants were enthused, as reflected in their entries and were motivated to, once again, test what they learned in the program. Whether it was technology, problem-based learning, or incorporating critical thinking into lessons or strategies learned, they went back to their classrooms inspired. One teacher-participant wrote that she invited a representative from Packer Foundation Center to come to her classroom and help introduce the GPS unit to her students. They also made personal connections with the presenters and they intend to continue to access them for their expertise. From the teacher-participant reflections, it is evident to this evaluator that the teacher-participants are incorporating in their lesson plans what they learned from the summer program, and that they are doing everything they possibly can, to help their students achieve academic success.

According to the results from year one (2009) to year two (2010), the AU Summer program in Mathematics has developed and implemented a successful professional development program that has met the original goals set for the summer program. These goals include (1) increase teacher-participants' content knowledge, (2) expand

pedagogical knowledge, (3) improve student math achievement, and (4) integrate problem-based learning in math instruction. As shown in their teacher reflections, the teacher-participants believe they have strengthened the quality of their instruction methods and they feel more confident in their approach in assisting students increase achievement in mathematics.