

Conference Strand: Research Symposium

Using Maps to Promote Spatial Literacy in Environmental Education

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A design framework is illustrated using an example of a middle school curriculum, Mapping Our School Site (MOSS), in which teachers and their students monitor a 10-meter by 10-meter site on their school campuses. The data collected is used to formulate and analyze the relationships between the abiotic and biotic components of the environment. Problem questions formulated by student research groups are analyzed using geospatial technologies, phenomena are modeled, and results are communicated visually. Mapping Our School Site (MOSS), a field-based program that explores and enhances student learning of earth and environmental science, is a way in which students can practice spatial cognition skills by field mapping and analysis using Geographic Information Systems (GIS). Middle school students' spatial ability was evaluated using a Spatial Experience Survey (SES) and the revised Purdue Spatial Visualization Test: Rotations (PSVT:R). Other sources of data include quizzes, end of program or unit test, interviews, group presentations, individual written conclusions, and mapping analyses. It was found that students' problem solving identification and ability dramatically improve as they collect, evaluate, report, and synthesize environmental data. The MOSS program integrates mathematics, technology, and science and is a possible vehicle for expanding student spatial cognition skills.

The perceptions of large amounts of information can be condensed and visualized using mapping and related technologies. The use of mapping and related technologies holds the promise of enhancing spatial cognition skills and promoting problem solving in

science instruction. Pallrand and Seeber reported that spatial ability enhanced student's ability to make sense of data. Spatial ability has been linked to logical and scientific reasoning and mathematics competencies . Since, from a constructivist perspective, interaction with the environment takes place in a three-dimensional space, the development of viable schemata of the world is linked to our spatial ability. In addition, mapping and related technologies can serve as a mechanism for inquiry learning in the classroom and improve earth and environmental science content learning.

The objectives of this study were to investigate if using GIS in the classroom significantly increased students' understanding of environmental concepts. Following the teaching of environmental science with GIS, other factors were investigated such as students' spatial abilities, experiences, and learning preferences. Students who excel at spatially related tasks may be more predisposed to this type of presentation and therefore able to better understand the concepts than those who are not. Finally, since qualified teachers who are confident in teaching with GIS are key to the success of the curricula , the effectiveness of the GIS workshop was investigated over a two year period.

#### POPULATION AND SETTING

The population of this study consisted of middle and high school teachers and seventh and eighth grade middle school students. The teacher sample consisted of all teachers (n = 12) enrolled in a one-week summer professional development opportunity and fall follow-up session. The students were seventh and eighth graders (n=164) in two public middle schools.

#### DESIGN AND PROCEDURES

The twelve teachers self-selected and became part of a professional development opportunity where they learned how to teach the inquiry-based problem solving science units using GIS, based on problem solving by Swartz and Parks and Chen and inquiry by Bonnstetter . Teachers involved in the program received all of the necessary software and science equipment to use when implementing the project. Additional support included one fall follow-up meeting, e-mail support and school visits the following school year.

Three teachers from the summer workshop agreed to participate in the student study the next school year. All three teachers were experienced, certified teachers who had been at their schools for over ten years. In an effort to control for instructor differences, the instructors adhered to the same schedule of activities and used the same class assignments and unit quizzes, test, and final project. The classes were observed on a weekly basis, and the researcher provided additional support during the school year by answering questions, reviewing activities, providing technical support, and collaborating on lesson plans. All students in the study completed the online Learning Styles Inventory (LSI), Spatial Experience Survey (SES), and Purdue Spatial Visualization Test: Rotations (PSVT:R), before beginning the GIS units. These scores were used to measure spatial ability. All groups' collected similar data about their school campuses and used GIS to analyze patterns, formulate problems, and report results.

Twenty-four randomly selected student interviews and teacher interviews provided data on the nature and extent of their understanding of environmental content and GIS. Students were asked to reflect on environmental content and GIS items that they did not understand. The teacher interview guide also addressed teachers' perceptions

of their students' learning, the application of the technologies, and challenges of implementation. A Teacher GIS User Questionnaire was designed by examining past GIS workshop teacher interviews as well as research on the development of GIS use in the classroom .

## ANALYSIS AND RESULTS

Descriptive statistics of the quizzes and test scores, rubrics using multiple assessors to determine inter-rater reliability for the analysis, conclusions, and lab reports, and student interviews revealed that students did understand environmental content and the use of GIS to solve environmental problems. Students commented that the units were different from what they normally did in science because they went outside, used the computer, did more mathematics, and worked longer and more in-depth. Student interviews, conclusions, and analyses using GIS showed that all students' problem identification and problem solving skills improved.

An ANOVA was used to compare the spatial reasoning test score (PSVT:R) to school or group, sex, and factors on the SES such as handedness, academic courses (geometry, shop class, 3-D courses), non-academic activities (toys, computer games), and sports activities. Sex ( $p < .001$ ), shop class ( $p < .05$ ), and computer games ( $p < .05$ ) were significantly different when compared to spatial reasoning scores. Males scored higher than females on the spatial reasoning test, students that played computer games scored higher than those who never played computer games, and the fewer shop classes taken the higher they scored. Most students (60%) seemed to play computer games weekly or daily. Additional data regarding student computer use was collected during the interviews. All students interviewed reported that they liked computers and used them

regularly. This agrees with the results of the SES in which most students (60%) seemed to play computer games weekly or daily. Students reported a wide variety of computer uses with 63% playing computer games, 54% using the Internet and emailing their friends, 38% doing their homework, and 33% doing research projects. Individual interests mirrored a variety of computer uses. For example, one student said that he liked painting on the computer because he was interested in art, another student played math games because math was his favorite subject, two students did research about animals, one specifically about horses because she was a horseback rider and others listened to and downloaded music. This finding indicates that these students in general had a positive attitude toward computers and that they used computers for a variety of tasks related to school and personal interests.

Consideration was given to the possibility that if an individual had a higher spatial reasoning ability then he or she would possibly score better on the unit test, quizzes and/or the written conclusions. There was a significant difference ( $p < .05$ ) between the spatial reasoning test scores on the unit tests and quizzes ( $p < 0.1$ ). Students who scored higher on the spatial reasoning test also scored higher on the unit test and the quiz.

Teachers were asked to complete a 17-item questionnaire regarding the degree of GIS implementation in their classroom teaching. A score of one or two indicated use of GIS to a great extent, a score of three indicated use of GIS often, and a score of four or five indicated little or no use of GIS. Overall a mean score of 3.5 or a rating of often was reported regarding GIS implementation. Seventy-five percent of the teachers in the workshop reported using GIS in their teaching with twenty-five percent reporting using it little or not at all.

Many of the teachers had presented their GIS projects to the faculty, taught another GIS unit, taught another teacher GIS, created their own GIS project, attended other GIS workshops, taught a GIS workshop or had written grants to fund their GIS projects. These results show an integration of the use of GIS into these teachers' curricula.

## CONCLUSIONS AND IMPLICATIONS

### Problem solving

Student's problem solving identification and ability to solve problems dramatically improved using inquiry strategies and new mapping technologies. Mapping technologies allowed the students to investigate and visualize many alternative solutions to their problem questions instantaneously. Students repeated and practiced the steps involved in problem solving thereby allowing them greater success in reaching logical conclusions, which they shared and discussed with their peers. Additionally, teachers noted that student's technology skills improved. Since this study shows that increased computer use aids students in developing spatial reasoning abilities, it is important to incorporate mapping technologies that address visual spatial skills into science instruction.

### Spatial reasoning abilities

Males did score higher than females on the non gender biased PSVT:R test for spatial reasoning ability. Spatial activities in school are limited with courses like art, shop, dance, and technology being reduced or eliminated in many schools due to budget concerns. Yet simultaneously, spatial reasoning and problem solving skills are important to a better environmental understanding. Since spatial ability has been linked to logical

and scientific reasoning and mathematics competencies (Clements et al., 1997), providing opportunities for students to practice these skills becomes important to their future success in science careers. In this study, students with higher spatial ability scored higher on the unit test and quizzes.

Mapping technologies incorporate spatial visualization tasks using meaningful content into the science curriculum and are a way to engage all students in spatial reasoning and problem solving that are important to their future success in these fields. Mapping technologies have the potential to significantly enhance the teaching and learning of earth/environmental science concepts by improving problem solving, spatial data analysis, and supporting interdisciplinary connections.

#### REFERENCES