Infusing Engaged Learning Strategies and Modeling Software into Sixth Grade Classrooms: The Achieving High Academic Standards Project (AHAS)

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Abstract: The Achieving High Academic Standards Project (AHAS) of the Illinois State Board of Education (ISBE) is an ongoing in-service and dissemination project that provides an engaged-learning professional development program for sixth grade teachers using modeling tasks. The project included thirty-eight sixth grade classrooms (approximately 1000 students) in eight public school districts and three private schools throughout Illinois. The classrooms selected are all low SES, high mobility and high special education enrollments. The project provided classrooms with a new computer, pedagogy and technology for model building. The educational goals were selected to achieve the math standards of data collection, representation, and interpretation. Results indicate an actual cost, including a new computer and wiring, of $225 per student participating in the project. Teacher surveys and observation in classroom visits indicate over 80% active use of modeling software by students in modeling energy systems within their schools. Over 70% of teachers report that they will continue using the modeling software beyond the project end. The AHAS Project is a collaboration among the National Computational Science Alliance (NCSA), the North Central Regional Technology in Educational Center (NCRTEC) and the participating school districts. Funding for $0.25 million is from the ISBE. Partial funding and support are also provided by NCRTEC.

Keywords: Collaboration (university/school/industry), Improving Classroom Teaching, Modeling Tools and Activities in Education

Introduction:

The Achieving High Academic Standards Project (AHAS) is a collaborative partnership between 8 public school districts, 3 private schools throughout the state of Illinois, the ISBE, NCSA and NCRTEC. This collaborative partnership seeks to infuse technology into the ecology of sixth grade classrooms in order to help students access and attain mathematics standards. The project has six main goals:

- Facilitate staff development in the use of engaged learning strategies and modeling software with students

- Coordinate continued research of modeling technology use in in-service professional development

- Provide action research projects for teachers

- Facilitate further development and dissemination of Modeling and Visualization curriculum materials by NCSA Education Outreach and Training Division (EOT) and the NCRTEC

- Coordinate the development of teacher- and student-generated web sites to communicate ideas and strategies learned in technology-rich engaged learning units

- Facilitate development of a system of outcome measurement and accountability to the Illinois State Board of Education (ISBE)

Engaged learning in professional development

The thirty-eight teachers participating in the project attended five workshops throughout the year to develop engaged learning units around the topic of electrical energy conservation within their school, the development of action research questions and plans, the use of computer based tools such as spreadsheet and modeling software within the context of the engaged learning unit, and the creation of web sites for communication. Teachers also received just-in-time support for implementing the project and for using a distributed interpersonal communications multi-user, collaborative work environments, the NCSA Habanero technology (), provided by the third author, a graduate student from the University of Illinois. Additionally, teachers received in-person support plus instructional videotapes produced by the principal investigators about how to use spreadsheet software, modeling software, and web development software.

School selection process

Schools were selected to participate in this project based upon a matrix that represented low SES, mobility rate, bilingual population, and special education %. A summary of these percentages per school follows:

Table 1: School Selection Process Data

District	**School**	**Total Enrollment**	Hispanic %	**Black %**	**Low Income %**	**Limited English Proficiency %**	**Truant Rate %**
Aurora East	C. F. Simmons	729	72	12.9	55	18.7	17.8
Aurora East	H. W. Cowherd	497	51.3	31.2	58.1	0	7.9
Belleville	Union	436	0.5	27.5	43.1	0	0.5
Carpentersville	Carpentersville Middle School	1136	37.8	10.7	34.2	26.1	4.6

Cahokia	Elizabeth Morris	389	0.7	57.6	73.3	0.0	1.0
Cahokia	Centerville	511	0.0	87.1	73.0	0.0	1.6
Crystal Lake	North Middle	728	3.8	0.1	9.3	0.0	0.0
Crystal Lake	Lundahl Middle	914	2.6	0.9	3.3	0.0	0.0
Crystal Lake	Beardsley Middle	805	5.8	0.7	8.3	1.2	0.0
Mt. Vernon	Dr. Andy Hall	179	2.2	26.8	48.0	0.0	1.7
Palatine	Virginia Lake	660	30.5	10.3	32.4	13.2	0.0
Wabash	North Middle	628	0.0	1.0	33.6	0.0	3.2

Thirty-eight teachers were directly involved in the project. These teachers involved 140 clock hours of training and professional development. Approximately 1000 students were involved.

Engaged learning models

The project sought to provide teachers with instructional pedagogy that they could use within their classrooms to help students access and achieve mathematics standards identified by the Illinois State Board of Education. The use of engaged learning models as an instructional pedagogy has strong research support in cognitive research regarding the effectiveness of active engagement of students in the learning process. (Posner, Strike, Hewson, and Gertzog, 1982; Shuell, 1990). In addition, empirical research has demonstrated that the effectiveness of actively engaging students in the learning process helps students achieve academic success. (Roth, 1994; Conrad, 1996). In Illinois the second author has used his experience providing engaged learning curriculum and in-service training, first as part of the Collaboratory Visualization Project (CoVis), (Pea, 1994) in the design of the AHAS project. Related work in the development of infrastructure for schools () has been used by the AHAS project team. Future plans for AHAS are informed by NCSA developments of new portals for education (Zaritsky, 1997; Zaritsky, 1998)

Teachers used an engaged learning model that was roughly based upon the work described by Cheek (1992). Based upon the work of Soloway, (1997, 1998) Krajcik (1998) and a common theoretical perspective (Collins, 1988) (Morrison, 1998), teachers used reflective software () to develop a concept web for their unit. Teachers then identified three to four standards that they would like to address in the unit and they developed teaching events and assessments for these standards. Teachers identified a method for engaging students in the electrical energy project. For example, some of the teachers developed a Request for Proposal Model that was presented to students by Business Department personnel. Teachers then identified a process whereby students would be able to demonstrate their learning at the end of the unit. Some teachers developed the culminating project of presenting their findings before a meeting of the School Board.

Modeling software

An important element of this project was to help teachers infuse modeling software into the ecology of their sixth grade classrooms. Work done by Soloway et al (1998) demonstrate, through case studies, the effectiveness of Model-It software in helping high school students achieve academic success.

Teachers in the AHAS Project participated in two days of workshops at the NCSA where they learned how to use EXCEL software to collect and organize data as part of an energy audit of their school. Additionally, teachers learned how to use Model-It software and Stella software to create simple models of budgets and a modified model of the electrical energy system of the average school building.

Teachers received the hardware and software necessary for their students to use and create their own models. Teachers and students received just-in-time support from a graduate student and researchers from NCSA. They also received videotaped programs produced by the authors demonstrating how their students could use various modeling software including: Excel software, Model-It software, and Stella software. Teachers also received a videotape produced by the authors of how to use a commercial web construction software package () and were provided the software for producing web sites to describe their project. One of the project teams produced a web site () where various engaged learning and modeling artifacts can be found.

Preliminary results of the project indicate that teachers and students are not only using the technology within the context of the Electrical Energy Project but that they are also using it in other projects. For example, one of the schools created a model called "Garbage" that they use as part of their Recycling Unit. Other teachers are using the modeling software as part of their mathematics units by having students model their budgets and allowances.

Action research and project communication

As part of the staff development component of the project, teachers participated in a full day workshop to learn how to conduct action research around questions that they develop related to their engaged learning project. Research by Schon (1983), Todnem and Warner (1995) demonstrates the importance of self-reflection and action research in helping teachers improve their practice and ultimately improve the academic success of their students.

Guy Todnem from the Illinois Math and Science Academy conducted two full day workshops with teachers. He actively engaged the teachers in a mini-action research project where they used a four-step action research model: Develop a question, Plan a Study, Collect the Data, and Interpret the data. Teachers used this model in a mini-action research project that they conducted at the workshop.

During a full day workshop, researchers and graduate students from NCSA involved teachers in initiating a web site for their projects using NetFusion. Teachers received the software and just-in-time support from the graduate students in the development of local web pages. This work is currently in progress.

Preliminary results and accountability

Preliminary results conducted with a sample of 30% of the schools who specifically requested additional training demonstrate a 90% participation in workshops and on-line communication. 80% of this sample reported professional development outcomes of the production of visions for engaged learning and working in teams to experience and model exemplary group processes. 90% of this sample reported regular technology usage throughout the project, and finally 90% reported student use of technology.

The ISBE funded the AHAS Project for $0.25 million. Policy requires that the infusion of engaged learning models and technology into the ecology of sixth grade classrooms can demonstrate students outcomes of access and achievement of one or more of the state of Illinois Standards for Learning. It is imperative for the authors as principal investigators to develop initial systems for reporting results to policy makers in order that data be used in further decisions with regard to support for promising instructional pedagogies and instructional technologies.

Prior to the project many of the schools who signed on to the project did not have computers within their classrooms. These schools demonstrated significant demographic deficits of low SES, high mobility rates, high percentage of special education students, and second language learners. The AHAS project provided these schools with the hardware, software, and staff development necessary to carry out technology-rich engaged learning units within their schools.

Significant to this study was the availability via distance education tools of a graduate student instructor who could be called upon to solve simpler questions quickly via technology, or would within usually a week make a trip to a school to provide more directed on-site support. Using this model of a working help and support staff available to make "home visits" was a significant addition to the project plan.

A sample of 30% of the classrooms participating in the project was used to provide the preliminary results reported below. This sample represents schools that have requested visits. It will be expected that subsequent visits to the remaining schools will demonstrate lower percentages of implementation, probably in the range of 50-65%. It again should be noted that the authors suspect that our initial sample is biased towards higher number due to it representing schools who have requested additional training and were visited first by researchers from NCSA.

Table 2: Preliminary Results

Category	Outcomes reflected at the 90% level	Outcomes reflected at the 80% level
Professional Development	Teacher participation in workshops and on-line communication	Creation of a vision for engaged learning Working in collaborative teams to experience and model exemplary group processes for learning
Technology Use by Teachers	Implemented Internet technologies as routine communication tool Used e-mail communication Authored web pages	Functioned as a learning community through web site collaboration Trained in one or more of the following software: Excel, Stella, Model-it, NetFusion4
Technology Use by Students	Collected information from on-line resources Used software to represent real world data Analyzed data using appropriate software	Used one or more of the following software: Excel, Stella, Model-it, NetFusion4

Ongoing Results

The AHAS Project is ongoing. It is anticipated that aggregate state testing (forthcoming, June 1999) will be used to assess success of the program. Additionally, the following measures will be used to assess the success of the program: direct observations, videotaped activities, focused interviews of students and teachers, teacher and student surveys, student performance assessment measures, student standardized test scores, and teacher and student artifacts.

Preliminary focus groups with teachers within the project have provided a ranked listing of the utility of the various software used in the project in the following way.

- Most comfort with Excel
- Some comfort in using Stella within their classrooms for specific tasks
- Least comfort in using the Model-It Program due to bugs in the program

In focus groups, students reported:

- Most comfort with Model-It and noted potential for additional usage
- Some comfort in using Excel
- Least comfort in working with Stella for specific tasks

Results of Classroom Observation & Discussion

The goals for modeling by students and teachers were seen to differ. One of the interesting results of early surveys was that when presented the two types of modeling programs, Stella and Model-It, the teachers preferred Stella and the students preferred Model-It. The reason for this is probably two-fold, one has to do with the "bugs" in the Model-It commercial program and the other has to do with elementary conceptions of science. The Model-It program supplied to the teachers for their PC's had many initial glitches that made it uncomfortable for the beginner to use. Since the start of the project the company took care of many of these glitches and the program became much easier to use. The students saw only the corrected Model-It version – the one without the glitches; whereas, the teachers remember the frustration associated with the original glitches.

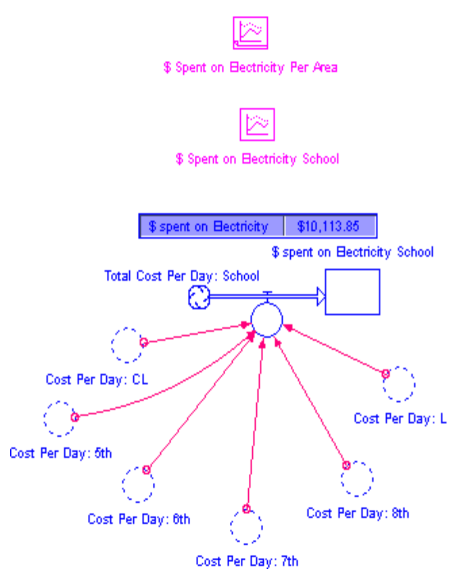
However there may be another reason for the difference between student and teacher preferences for modeling software. Stella is a program that works with exact numbers and equations; whereas, Model-It works only with relationships and need not have any numbers at all. For Model-It, an Y=X graph is represented as X increases Y increases about the same. However, Y and X would be known as the variable they each represent. So, an $Y=X^2$ graph would be represented as X increases Y increases more and more. For the sixth grade audience these textual representation are easier to understand and easier to employ. For trained Mathematics and Science teachers this approach can come across imprecise and unscientific. However, the Model-It process is a good tool to understand relationships and if preciseness is needed later it is a good starting point for a Stella model.

Results of On-Line Support for Teachers via distance education technologies:

A key component of the distance education was that of support by e-mail or on-site visits. After the teachers were brought together for seminars on engaged learning and instruction in the various software it was often months before they put this learning into effect. Also whereas in the seminar sessions they were given a general education of the software, support was needed later as teachers needed answers to problems with their specific model or with program bugs. Some of the support necessary for a refresher on the software and specific questions could be answered through e-mail. However, the most effective support was that of an on-site visit. Six of the eight participating school districts had an on-site visit, including one district that had two visits. Four of these visitations were for teacher support, in preparation for teaching, so that they could then share with their students models and resources. The other two were for co-teaching in the classroom of their students. This co-teaching served two functions: a refresher for the teachers and an introduction to the students. These meetings lasted at most four hours and would not have been possible without the seminars.

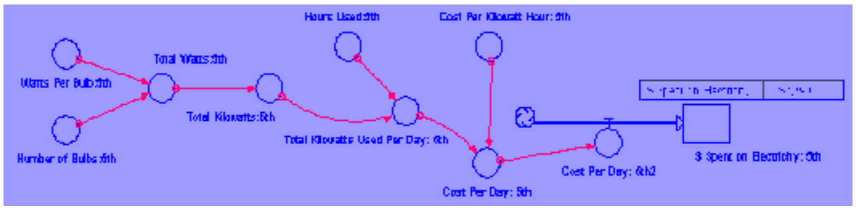
VNC and Habanero technology were used to provide distance learning opportunities between schools and the NCSA. Distance education without these technologies struggled as the transmissions of what was being presented in class were fuzzy and almost incomprehensible. To address this problem the presentation of the modeling program was put forward with VNC using Habanero, a distance collaboration tool developed at NCSA. With this the distance education students could read the screen and understand the presentation. This solved the problem of the distance people comprehending what was going on in the classroom, but it brought up another problem. This problem was the difference in teaching styles between distance and local education. If the presentation was made to the local people in the classroom then the distance people found it occurred too quickly and they could not understand. If, however, the presentation was made for the distance education people, the local people found it slow and boring. Distance learning that uses VNC and Habanero technology is a good beginning in helping classroom teachers and students understand the mechanics of modeling software in representing and experimenting with complex systems.

A key aspect to this project was that students were presented with authentic tasks. Not only were these tasks authentic, but they gave the students power to help in the situation. To demonstrate this point and to expound on the use of modeling in this project a further description of three of the projects and their models will be presented. The first model shows modeling of the electrical supply in the students' school building (see model 1)

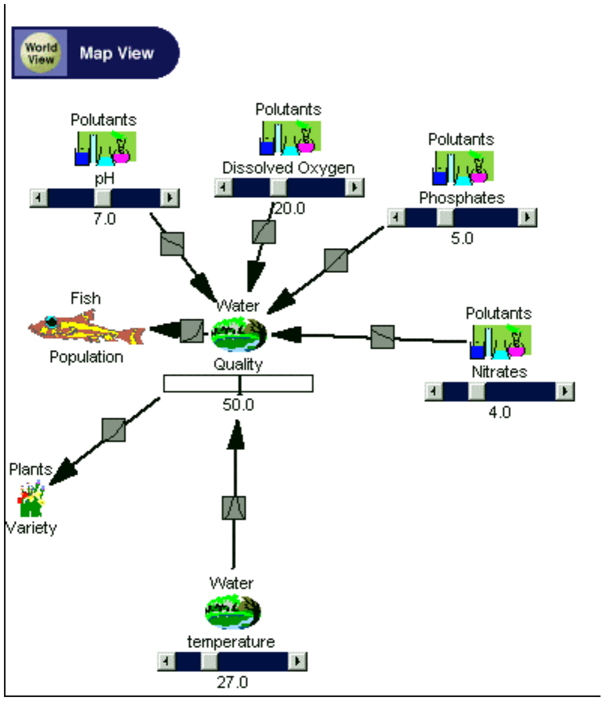


Model 1: In this project the students, at the middle school in Mt. Carmel Illinois, collected information of the power usage in their building. They then used the

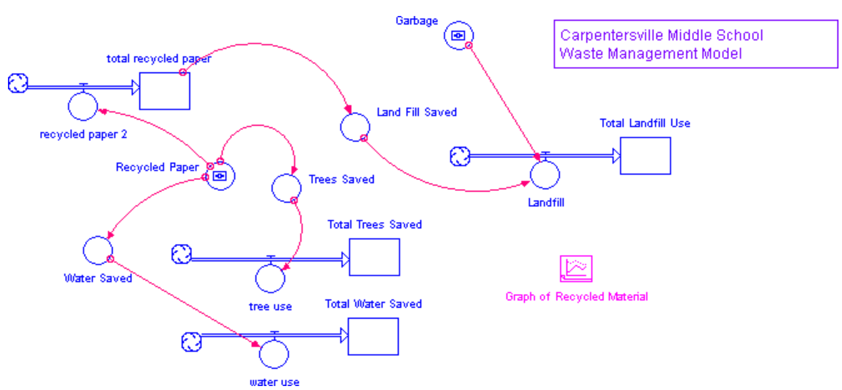
information to create a Stella model. As shown above this model assembled information on each of the areas of the school, and then compiled all of the areas to give them an approximation on the amount of electricity and money spent on electricity for a school year. With this information entered into the model they then could manipulate the model and ask what if questions. From this investigation they presented their findings to the school board on how the school could save money on their electric bills by turning off the lights. The model gave the students power to investigate change and then the school gave them power by taking serious their investigation and implementing the results.



The next model (Model 2) was that of water quality for a pond in Crystal Lake Illinois. This pond had become so dirty and polluted that the pond could only support a very specialized flora and fauna population and would not even freeze in winter due to its high saline content. The former was a concern because the pond had been a fishing pond and the later was a concern because the pond had been an outdoor hockey rink in winter. The park system decided to clean up the lake and the school district came along side to help. Before the water was drained the students collected water samples from the lake and are continuing to take samples to see water quality improvement. These samples are vital to the park district and it helps to have the extra work groups to carry out this task. Figure 2 is a copy of this model. This Model-It model allows students to paste in images appropriate to what is being modeled. This model helps the students to understand what is appropriate water quality to support the natural floral and fauna patterns, and then to insert their data and discover if the project is accomplishing its tasks.



In the last Model presented, students in Carpentersville, Illinois put together a model on their recycling project. Figure 3 demonstrates this model in Stella. The students were given the task of investigating recycling of paper and what that will do to save trees and reduce waste in their landfill. Again the students were given an authentic task that they could have some power over. They collected information on how much paper they discarded and what would happen if they recycled this paper. Again the Stella model gave the students power to ask what if question and simulate outcomes if current practices were changed. In another plus for this project the middle school work was tied into a more in-depth project being carried out by the high school science classes. This gave the high school students the opportunity to teach what they had learned to the middle school students, and it gave the middle school students an increase in motivation.



Conclusion

Largely these demonstration projects should be seen within the context of design research that Stephen E. Toulmin reifies as a process of moving from malfunction to function. Thus, if one can assume that competent in-service training was provided, that continued on-line support was effective, and that modeling has been demonstrated to be a powerful way to provide engaged learning experiences, motivating for both students and teachers, we are left with attempting to answer some politically charged questions of project cost, evaluation and scalability. While providing a simple number that reduces cost/pupil per learning outcome is what policy makers would like to have, the research community, but not the policy community understands that there are so many confounding questions and ways to question the validity of any such measure.

A project analysis that suggest learning occurred is fraught with difficulty for a project of this size. We have attempted to make these finding available to our state funders. Many may see this effort as politically naive, however as we are attempting to effect policy we must arrive at the table with some of the answers to costs, and maybe a few of the answers to proven outcomes. Further to engage the national discussion of evaluation and policy, we wanted to see what could be attempted with state level funding and limited research versus service resources. Finally we might some day feel compelled to sit in front of TV lights and across the table from critical policy makers. Thus we wanted a beginning set of answers, a first draft answer to the "what did it cost, and what did we buy" question. Also we hope we have added to a process that will ensure in Illinois granting decisions might be made on assessment outcomes compelling to policy experts as well as our research colleagues.

So finally, we did measure use, plus answer some essential questions of frequency of use that can inform comparisons within the state. Namely that in our project the cost of computer equipment and wiring as well as the cost of installing, training, and using modeling software within this project was $225 per student for year one of the project. However, the research generality of this finding may be quite limited to time with technology and opinions about technology use. Standard student test scores will become available in the late fall of 1999. Thick measures of student achievement remain both hidden in our video records and beyond a quick analysis at this stage of the project.

One further insight into this project, is to note that we have videotape of many classrooms that provide compelling exemplars, which can be used at both a policy level and at a professional development level. We hope in the future that some state or national repository of good practices-video will be structured as an attempt toward a comparative database of engaged learning with technology studies.

When you have professional development staff with over five years of effective experience, when you have a graduate student with over a year of supporting teachers with modeling, when you add new computers into a class that cooperates, and when you implement those factors at a cost of $225/ student, then you get the kind of changes we observed.

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