EcoScienceWorks:

Teacher Professional Development Through a Collaborative Curriculum Project – an Example of TPACK in Maine

By Walter C. Allan, Jeryl L. Erickson, Phil Brookhouse, and Judith L. Johnson

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Abstract

Maine's one-to-one laptop program provides an ideal opportunity to explore conditions that optimize teacher integration of technology-focused curriculum into the classroom. EcoScienceWorks (ESW) is an ecology curriculum that includes targeted simulations and a code block programming challenge developed through an NSF-ITEST grant. The project was designed as a collaboration that included simulation software developers; middle school science teachers; the Maine laptop program; environmental educators; an external evaluator; and a lead organization experienced in teacher guided curriculum development. Thus, each of the elements of TPACK (technology, pedagogy, and content knowledge) worked together to produce the final ecology simulation-centered curriculum. In 2008-2009, the ESW curriculum became available statewide through the Maine laptop program. Partner teachers have transitioned their classrooms to more learning-centered environments through the use of technology and have become teacher leaders. The collaborative approach to technology focused curriculum development used in this project is a model for TPACK professional development.

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The NSF-ITEST (Information Technology Experiences for Students and Teachers) request for proposal was seen by the partners in this project as an opportunity to develop engaging, software simulations that feature guided inquiry in ecology for Maine's middle school laptop program. Since the major goal of ITEST is to increase student interest in information technology, including computer programming, within the constraints of the middle school curriculum (where computer programming is not taught), the project planned to re-design existing computer simulations in ecology (SimBiotic Software's EcoBeaker™) and add the capability for students to program their own simulations. However, despite having a one-to-one computer program for three years at the start of the EcoScienceWorks (ESW) project, Maine, like states without one-to-one computing, had few science-specific examples

of educational technologies. In addition, science teachers in Maine middle schools relied on activity-based and content-focused curriculum to teach ecology in their classrooms. Thus, it was recognized that not only would the project need to develop middle school appropriate computer simulations but also would have to integrate this technology into the classroom. The method of accomplishing this was to enlist teachers as pedagogical experts to write a curriculum that focused on this technology to teach ecology, thus placing teachers at the center of the integration of technology into their content and pedagogical knowledge.

The Maine Laptop Program

Introduced to seventh grade across the state of Maine in 2002, the Maine Learning Technology Initiative (MLTI) made it very clear that the initiative was about more than just the technology (Holcomb 2009). By 2003 every seventh and eighth grade teacher and student had a laptop. From the onset of the program, professional development focused on content areas, helping teachers understand how their classrooms could be more effective by integrating technology into good classroom practice. School administrators were also included in the workshops to promote technology integration into school goals, visions, and policies. By 2005 middle school teachers across the state were at various levels of technology knowledge and integration into their classrooms.

The laptop program resulted in ubiquitous computing in seventh and eighth grade Maine classrooms and led to the development of technology-competent students. Ideally, this allows teachers to transition into the role of facilitators, guiding their students to be autonomous learners. However, Figure 1 shows the challenges in this process for both teachers and students.

The EcoScienceWorks Project

Overcoming these challenges became an important part of the ESW project. The initial focus of the project was to provide the engaging and challenging inquiry software noted on the lower right of Figure 1 (the role of SimBiotic Software with teacher input). The project organizers also recognized the need to provide teacher professional development (lower left side of figure) and planned to do so in an indirect manner by enlisting the teachers as pedagogical partners.

The ESW project became a collaboration with many partners each of whom supplied portions of the technology, pedagogy and content knowledge (TPACK) needed. This collaboration was
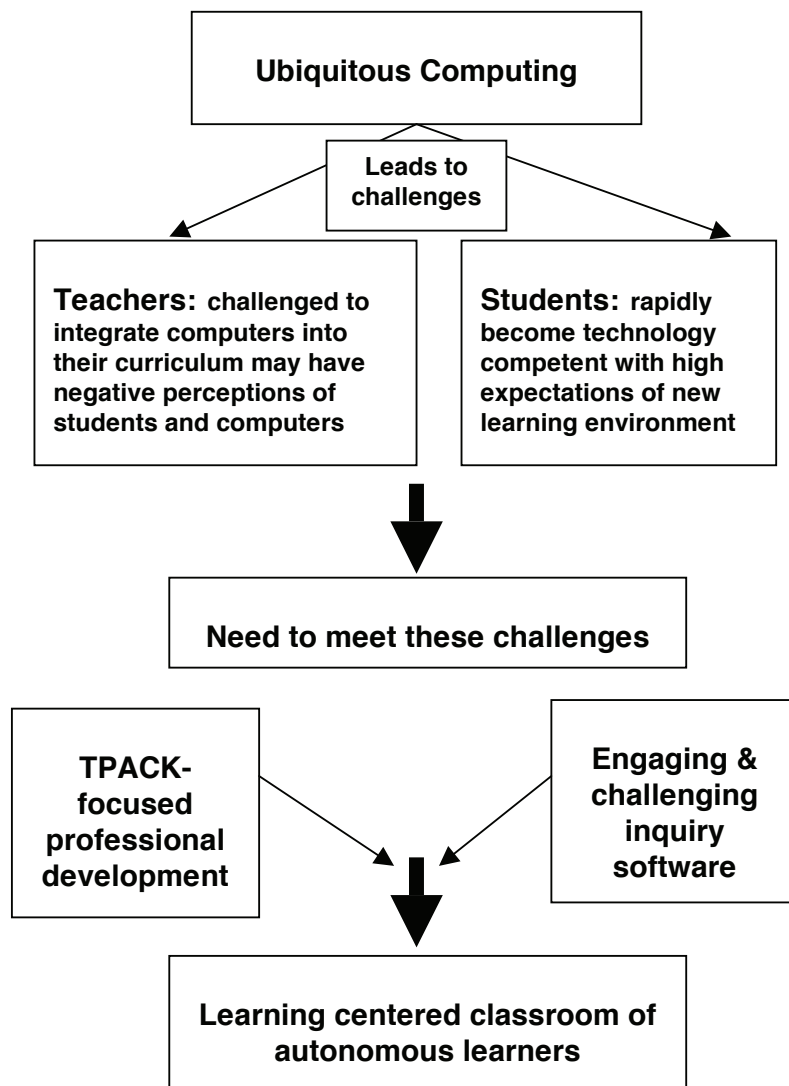

Figure 1. Challenges and goals in the one-to-one computer classroom

designed to provide teacher professional development as an outgrowth of teachers becoming involved in the project's tasks – specifically to write a curriculum that integrated the computer simulations into their teaching. While antedating the recent interest in TPACK, the ESW project, like other projects mentioned by Mishra et al (2009), models an approach to successfully integrating new technology in the classroom. The project partners and their roles are shown in Table 1 on the next page.

Using backward design, the teachers were tasked to develop the ESW curriculum to guide the use of the computer simulations and include an allied field experience that would give students a hands-on activity in ecology. Maine middle school science teachers were recruited from throughout the state and asked to write lesson plans with the help of the Maine

GROUP	ROLE
SimBiotic Software & MIT Teacher Education Program	software development Technology & Pedagogy
23 Maine middle school science teachers	write lesson plans to align with software, design field experiences Pedagogy & Content
Maine Learning Technology Initiative (Laptop program)	guide software and curriculum design Technology & Pedagogy
Kieve facilitators	leadership, team building, communication
Maine Audubon	environmental educators guide software, lesson plans, and field experience design Content & Pedagogy
JohnSilver Associates	external evaluator
FBR's ScienceWorks for ME	lead organization

Table 1. EcoScienceWorks Partners

EBME LAB	CONTENT
Beaver Pond Succession	Succession
Edgelands & Fractured Forests	Habitat fragmentation
Keystone Predator	Species interactions
Lake Invaders	Invasive species
Runaway Runoff	Non-point source pollution
Program a Bunny	Code Block Programming

Table 2 - EcoBeaker Maine Explorer (EBME) Labs

Audubon environmental educators. Given the geographic size of Maine, a setting for the project's workshops needed to include overnight facilities. The project took on the work of developing the integrated EcoScienceWorks curriculum and software during two, weeklong summer curriculum institutes at Camp Kieve. Over the three years of the project, teacher professional development around a TPACK model was observed. The result of the ESW project was a curriculum that supports 5 targeted simulations in ecology based on Maine ecosystems and a programming module called Program a Bunny. The concepts and names of the simulations are shown in Table 2. More information about the curriculum can be found at SimBiotic Software's project site: http://simbio.com/Maine.

Evaluation Methods

Using the most recent guidelines set forth by the Joint Committee on Standards for Education Evaluation (1994), the evaluation plan was designed to be ongoing and provide assessment and documentation of the effectiveness and efficacy of the project activities to both the project staff and the granting agency. The evaluation consisted of observation as well as survey methodology. Specifically, the evaluator spent time at Camp Kieve observing process and recording impressions during the summer workshops and conducted telephone interviews and online surveys during the school year to collect data from teachers about their experience, successes, and concerns. Yearly formal reports to the project's principal investigator form the basis of the results.

Results

Twenty-three Maine middle school science teachers who taught ecology were recruited for the project. Teachers committed 3 years to the project and their response to surveys and interviews are reported. The results are organized to highlight the TPACK features of the project.

Evaluating EcoScienceWorks ITEST project as TPACK Professional Development

A TPACK professional development opportunity for middle school science teachers will ideally address a perceived need of the teacher and accomplish the following:
• Technology
• Expose teachers to new/relevant knowledge in technology as it relates to the content area (computer programming/modeling as an approach to deepen understanding in science and promoting skilled scientific thinking)

- Increase/deepen teacher comfort, knowledge, and understanding of how technology can improve teaching and learning in the content area
- Pedagogy
- Model the learning-centered environment that guides student inquiry, supports collaboration, and incorporates technology
- Content
- Increase/deepen teacher knowledge and understanding in the content area

Did ESW expose teachers to new/relevant knowledge in technology as it relates to the content area?

EcoBeaker Maine Explorer (EBME) is the focus of the ESW curriculum. At the beginning of the project, 47% of the teachers responded that they had little skill with simulation software and had never used it on their own or with their students. By the end of the ESW project, all stated that they included simulation software in their teaching and learning and integrated it effectively into their lessons.

Comments from teacher interviews demonstrated that they were enthusiastic about using the EBME computer simulations to teach ecology content to their students and included:

"I think that having available simulation programs that we can integrate into our curriculum has shown me the effectiveness of using these as part of hands-on learning. Seeing the actual increase in retention of material by the students has convinced me that these programs will become more and more part of the human learning process. My skill at integrating this into the classroom has overhauled how I utilize the laptops."

"As a result of the EBME program, I am offering more science instruction. It is an interactive unit which allows students to use and have fun at the same time. This program provides a new tool for students to use in their learning."

Programming is not listed as a Maine learning standard and requires teachers to see its value as an aid to teaching computational thinking, problem solving, and the underpinnings of simulations. The programming module allows teachers and students to explore computer programming via the code block interface and includes progressively more complex programming challenges. Prior to participating in the project, 76% of the teachers reported that using a programming language was very new to them and 88% noted that they had never used a computer language on their own or with their students. In the school year following the completion of the ESW project, 94% of the project teachers taught the programming module in their classrooms in addition to teaching at least one EBME lab. Teachers' comments regarding the value that the programming module, Program a Bunny (PaB), brings to their students included the following:

"Students were engaged and found it easy to work cooperatively. PaB also gave me a chance to demonstrate the scientific method, Predict-Experiment-Observe, watch students work and let students lead the critical thinking."

"It helps them to understand programming language and how the rules of the program govern the simulation."

Eighty-eight percent of teachers who taught the Program a Bunny unit in the classroom also encouraged their students to explore the unit on their own. Teachers' comments regarding the value they see in encouraging this include:

"I see a lot of value in guided exploration. Students first express delight in the freedom of exploration then confusion about how to proceed. When students explore, they confront their own misconceptions and build their own understandings."

"I place great value in controlled floundering and exploration. That's when I get to observe some great thinking."

Did ESW increase/deepen teacher comfort, knowledge, and understanding of how technology can improve teaching and learning in the content area?

EBME labs use spreadsheets to facilitate student skills in data entry and visualization by graphing. At the beginning of the ESW project, the majority of teachers (88%) responded that they understood the relevance of spreadsheet use and were at least beginning to use spreadsheet programs with their students. Most teachers were using spreadsheets for data entry and graphing with fewer having students use spreadsheets for calculation. By the end of the project all teachers were using spreadsheet programs for data entry and graphing, and

> *"The result of the ESW project was a curriculum that supports 5 targeted simulations in ecology based on Maine ecosystems and a programming module called Program a Bunny.*

53% of teachers were using spreadsheet programs in the classroom for calculation. At the conclusion of the ESW project, approximately one-third of the teachers indicated that they extended the use of spreadsheets in their teaching and learning beyond the ESW project and felt they were using them in powerful ways.

Did ESW model the learning-centered environment that guides student inquiry, supports collaboration, and incorporates technology?

As the project progressed it became apparent that teachers were adopting roles as full partners in the project's learning-centered environment. Teachers developed novel ways to increase student understanding of computer simulations and computer programming thereby demonstrating their comfort in innovating portions of the curriculum themselves. One team developed a game about habitat as it relates to predator/prey dynamics and another team developed activities called "Interactive Simulations" to help students understand the rule-based nature of programming. These activities were models for what takes place in the EBME simulation labs and PaB.

> *As the project evolved it became apparent that teacher change was occurring serendipitously through the collaborative curriculum development project with the emergence of teacher leaders.*

Further evidence that the ESW project modeled the learning-centered classroom for teachers is seen in the following comments from the evaluator's reports:

"The 'best part to the week' for the majority of teachers was working with other teachers, sharing practices, resources, and strategies, and interacting with colleagues to get other perspectives on teaching. Over a period of five days and nights, a collegial network developed and all were engaged and enthusiastic about regrouping for the piloting of the first draft of the curriculum during week 2."

When teachers were asked "What was the best part of the week for you?" comments included:

"Being in a positive learning community."
"Collaborating with other teachers."
"Working with and hearing about what other teachers have done, both with this project and with other classroom activities."

The evaluator noted:

"Teachers gained new tools with which to teach units about ecology and technology in their classrooms. They also experienced the collegiality that goes along with being together with other teachers on a daily basis, sharing teaching techniques, new knowledge, classroom experiences, meals, housing, and recreational activities."

Finally, teachers have become leaders as a consequence of their experiences in the project. All but one of the teachers stated that they had presented the ESW curriculum at a conference or workshop and 50% made 2 or more presentations. Teachers who attended a workshop led by ESW project teachers completed surveys following the workshop. Ninety-three percent of attendees indicated that having teachers who developed the ESW project present the curriculum was helpful and 95% said they plan to implement the ESW curriculum in the near future.

Did ESW increase/deepen teacher knowledge and understanding of ecology content?

Each unit features a Maine ecosystem and focuses on ecological concepts including succession, habitat fragmentation, predator/prey relationships, invasive species, and runoff. A retrospective pre/post survey revealed significant changes in teachers' feelings of preparedness to teach these ecological concepts following their involvement with the project. The concepts assessed were succession; food/energy chains and webs; predator/prey relationships; habitat fragmentation; invasive species; and non-point source pollution and runoff. With the exception of predator/prey relationships in which teachers felt they were equally prepared to teach the concept prior to the project as following it, all other concepts showed significant change (paired t-test, $p<0.01$). The most significant improvements were noted in teachers' feelings of preparedness to teach about succession, habitat fragmentation, invasive species, and non-point source pollution - the major concepts in four of the EBME labs.

Did ESW meet the challenges teachers confront as a result of ubiquitous computing?

Evidence that the project also impacted teacher reservations about using computer simulations to teach ecology is suggested by teacher comments about their intention to continue using the curriculum when asked, "Will you continue to teach ecology using the ESW curriculum after the grant period?". Comments included:

"ABSOLUTELY! I love the simulation. Students are just getting used to their computers, so they are engaged. It is also a great way to teach students how to collect accurate data, and publish and analyze data."

"Yes! My students have enjoyed the ESW curriculum very much and have learned a great deal without realizing how hard they have been working."

As mentioned above, in the school year following the completion of the ESW project, 94% of the project teachers taught both an EBME lab and the PaB unit in their classrooms. In addition, the project has produced software that delivers on the promise of the laptop program for students. Teachers provided feedback comments that attest to this:

"It has been so rewarding to see kids engaged and successful. Even those kids who are always saying, 'I don't get it... I don't get it...' are getting this and loving it."

" I find it inspiring that the EBME program has such a high perseverance across the spectrum. The language is difficult for kids at the second or third grade reading level and if this had been a paper activity, they would have given up. They did not, and that is AWESOME!"

Discussion

The EcoScienceWorks curriculum was developed as a way for students to use technology to experience science in realistic ways. Ecology is a science content area that is frequently taught in the seventh and/or eighth grade when all Maine students have a laptop. The ESW project teachers were a self-selected group with an interest in ecology. Some of them, however, were tentative about using computers to teach ecology, believing activity-based and content-focused curriculum was the most powerful approach. These reservations by teachers are challenges that need to be faced in implementing a one-to-one computer program (see Figure 1). Through their participation in the ESW project, all of the teachers recognized how experiential learning ("doing science") could take place not only through a field experience but also, and perhaps more meaningfully, through the use of simulation software and simple programming challenges. The ESW project was able to harness teachers' enthusiasm for teaching ecology to develop a pedagogically sound curriculum focused around targeted computer simulations aligned with Maine learning standards. Integrating teachers into the curriculum and software development team was seen by the project organizers as a way to overcome the challenges to integrating technology into the middle school science curriculum. What was surprising to the project leaders was that teacher professional development with a strong TPACK focus also occurred. As the project evolved it became apparent that teacher change was occurring serendipitously through the collaborative curriculum development project with the emergence of teacher leaders. The results show the project addressed several important aspects of professional development:

Teachers increased their understanding of computer simulations and models and increased their technology skills. Through involvement in the development of EBME, teachers' familiarity with and understanding of computer simulations and models in ecology increased. This allowed them to recognize the value of a simulation as a learning tool and facilitated its integration into their classrooms. Teachers reported that the use of computer simulations was a powerful way to teach ecology and felt that it surpassed hands-on learning experiences in stimulating their students' interest and engagement. They also noted the software promoted perseverance even in low functioning students. A common theme of research dealing with teachers' decisions to adopt new technology is the need for teachers to be convinced of the impact on students' motivation and learning (Sugar, Crawley & Fine, 2004).

Teachers increased their pedagogical skills as facilitators in the learning-centered classroom. The project provided teachers the opportunity to work with colleagues who shared an interest both in pedagogy and in integrating technology into the science curriculum. It not only provided the time necessary to successfully complete the assigned tasks, but also allowed for informal conversation and building strong personal and professional relationships. Teachers and other project partners noted how students used and responded to the technology-rich curriculum in both expected and unexpected ways. They explored the conditions that would support students as autonomous learners and began to be more confident in their roles as facilitators in the learning-centered classroom of technology-competent students. These observations support the conclusions of Windschitl and Sahl, (2002),

"...it is important for teachers to have consistent work time with colleagues who share a desire to advance their teaching while exploring their use of technology in the classroom. Such

relationships, in conjunction with professional development opportunities, may play a key role in sustaining growth in instructional sophistication and technology. Conversely, the conditions of professional isolation and minimal preparation time during the school day virtually assure that teachers will not make fundamental advances in their instruction or experiment with technology." (page 203)

Teachers increased their content knowledge. All ESW teachers had been teaching ecology prior to joining the project, yet data from the retrospective pre/post survey suggest that involvement with the ESW project significantly improved teachers' feelings of preparedness to teach ecological concepts. The findings support the observations of others that providing teachers with scaffolded tasks and the opportunity to collaborate with experts and peers enhances teacher learning (Schneider, 2009).

Teachers had their concerns about ubiquitous computing addressed. Improving access to computers does not necessarily result in comprehensive adoption and integration of technology in the classroom. Our findings that teachers were initially more interested in introducing the field experiences into their classrooms and getting students outside (away from their computers) support the conclusions of the Office of Technology Assessment which suggest that teachers must be convinced of the feasibility of using a particular technology before adoption and integration occur (Office of Technology Assessment, 1995). Having computer scientists, environmental scientists, and classroom teachers work together to develop the curriculum including the EBME software resulted in all partners becoming convinced that students can reap the benefits of "doing science" through the use of simulation software.

The results also suggest that the project promoted the emergence of teacher leaders, another outcome of good professional development. The extended period of collaboration led to numerous mentoring relationships that continued beyond the face-to-face conference time. While observing other teachers during the piloting of the curriculum and hearing feedback following the field test, teachers reflected on their own practices, an important aspect of becoming a teacher leader (Loucks-Horsley, 2003). The project teachers modeled improved classroom practices motivating others to adopt the curriculum. Integrating computer use into the classroom is not spontaneous even in one-to-one computing projects unless teachers understand and value the role it can play (Schofield, 1995).

Conclusions

The findings from the EcoScienceWorks project provide insights into a model for technology-focused curriculum development that promotes TPACK skills in teachers. The ESW project resulted in significant teacher gains in technology skills, new knowledge in the use of simulations in teaching, positive changes in pedagogy, and increased content knowledge. In addition, it fostered teacher skills in establishing a learning-centered environment in the classrooms and the emergence of teacher leaders. Data presented in this paper suggest that a collaborative curriculum development project may be an excellent model for TPACK teacher professional development.

A next step for the ESW project is continued promotion of the curriculum to middle school science teachers who were not involved directly in the project. While over 100 teachers have downloaded the curriculum as of fall 2009, this represents about a third of the science teachers in Maine middle schools. Further dissemination is an achievable goal given that the software is already on all teacher and student laptops. Despite the inability to deliver TPACK skills to all teachers directly, the project developed software and detailed unit and lesson plans that incorporate the three pillars of TPACK – technology that emphasizes ease of use, curriculum that emphasizes sound pedagogy, and content that is rich in ecology. The challenge is to bring the curriculum to the attention of the remaining middle school science teachers.

A novel approach to indirectly promoting the curriculum to teachers began in January 2010 with the creation of a statewide programming contest open to all seventh and eighth grade students whether they have used the Program a Bunny code block module in their classrooms or not. The contest challenges students to come up with the most successful code compared to other entries. Students' code will have to be uploaded by a teacher or school librarian. It is hypothesized that students will introduce teachers to the EBME software in this manner thereby increasing teachers' awareness of the ESW curriculum. The impact of disseminating Program a Bunny directly to students will be evaluated for its potential effect on teacher uptake of the ESW curriculum.

Walter Allan is the consulting scientist to ScienceWorks for ME, the out-reach education division of the Foundation for Blood Research in Scarborough, Maine and was the principal investigator for the EcoScienceWorks project. He has a Masters in Biochemistry from the University of Missouri and has a Medical Doctorate from State University of New York, Upstate Medical Center. He has an interest in secondary science education and curriculum development.

Jeryl Erickson is the out-reach education coordinator for ScienceWorks for ME at the Foundation for Blood Research in Scarborough, Maine and was the project director for the EcoScienceWorks project. She has a Masters in Genetic Counseling from Sarah Lawrence College. She has an interest in secondary science education and curriculum development.

Phil Brookhouse provides professional development based on integrating technology for Maine's teachers through Maine Learning Technology Initiative (MLTI.) He taught middle school science for 30 years and has been affiliated with Bates College and University of Southern Maine at Lewiston/Auburn.

Judith L. Johnson, the project evaluator, is President of JohnSilver Associates, Consultants in Research, Evaluation, and Assessment. She has a Ph.D. from Boston College in Educational Research, Measurement, and Evaluation and was director of Testing and Institutional Research at a state university in Maine for 20 years before starting her own consulting business.

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