Appendix 1
Literature Review

Audience	Program Description	Eval/Research Goals & Methods	Findings/Results	Source
5-18 year old students in 58 participating countries on 5 continents	• Global Learning and Observations to Benefit the Environment (GLOBE) is an international environmental education program designed to increase student scientific understanding of the Earth, increase environmental awareness, and help students reach higher standards in science and math by doing real science using a collaborative inquiry based learning experience. • The study focused on determining if student collected data are accurate enough to support rigorous scientific investigations.	• The Education Team on Data Validation and Accuracy Assessment collaborated with teachers and students to 1) design and test pre-protocol learning activities, 2) test the protocols designed to guide the collection and analysis of data and 3) implement the learning activities and protocols to determine the relative accuracy of student verses scientist collected land cover data. • They developed an error matrix to determine the accuracy of land cover maps generated by students compared to professionals.	• Student-scientist research collaborations are feasible and can produce results reliable enough for professional quality data (The study found overall accuracy was 67% when comparing student data to reference data). • To obtain good results in the field extensive pre-protocol training is needed. This requires significant time investment and training. • Scheduling field sampling can be challenging given the school academic calendar.	Becker et al., 1998
High school students and teachers	• Ten schools (100 students) in Georgia, U.S.A and Russia participated in an exchange program where they participated in environmental research activities in Russian and American communities and lived in the context of each others culture. • Students participated in the Global Thinking Project where they 1) worked with their teachers to construct ideas about environmental topics, 2) got involved in two episodes of	• Case study/documentation of the project of the network science approach where students are allowed to construct meaning from their experiences and participate in activities that closely resemble those of real scientists (including investigating real science problems, collaborating between individuals within classrooms, and among geographically remote classrooms, shared goals, data, and knowledge through questioning, data analysis, and	• The authors report that both students and teachers achieved greater understanding of the environment and of a different culture. • Constructivist learning environments are conducive to student understanding by the open/self directed nature of the learning experience.	Dunkerly-Colb & Hassard, 1997

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	problem identification, data collection and analysis and 3) participated in two "Global Environmental Summits in Moscow and Atlanta. • Development of a "citizen scientists" among teachers and students who participated.	discussion of results and finally technology enhanced projects that are unique and compelling – i.e. Beyond word processing and telecommunication but constructing graphs, tables, and maps.)		
High School students and teachers	• This paper is a review of projects that engages the use of technology to facilitate authentic scientific practice in classrooms. • The author most notably focuses on the CoVis project funded by NSF in 1993.	• Case Study/documentation of the best practices associated with achieving science learning through the adaptation of scientific practice • The author lists a series of characteristics of authentic practice based on the evaluation results of numerous authentic projects.	• Learning occurs when students investigate open questions about which they are genuinely concerned using methods that parallel those of scientists. • The CoVis project successfully focused on two types of technology tools for students: 1) scientific visualization tools and 2) communication and collaboration tools. • CoVis and other data vis projects presented teachers with a set of resources and technologies as opposed to a fixed curriculum. Teachers were encouraged to set a project cycle (anywhere from 2 days to a half a year) based on their needs and student needs. • Teachers are the richest source of expertise – focus teacher development activities around the establishment of a community of teachers for the exchange of ideas, experiences, and strategies. • Two important themes among projects that use technology to facilitate authentic science practices in the classroom – 1) focus on local phenomena and 2) encourage conduct of activities in multi-school communities (becoming a part of a larger community of science practitioners)	Edelson, 1997

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The CoVis development team	• Learning through Collaborative Visualization, or CoVis, a project which engages students with real world scientific visualization tools, and collaborations with real world scientists, in order to develop scientific knowledge	• Case study/documentation of the history (since 1992) of the development of CoVis, the problems that arose, and the subsequent handling of those problems by the CoVis development team • Lessons learned and best practices	• Tacit expert knowledge should be embedded into the tool's interface (i.e. geographical visualizations and graphical interfaces to link students to data, as opposed to text) • Keep only the most important and useful functions of the scientific tool, so as not to overwhelm students with too much complexity • Automate or make unnecessary tasks which will have little pedagogical value (i.e. the time researchers spend reformatting data) • Add "bridging functions" where necessary to help students grasp concepts that are more than one step away from their usual frame of reference (i.e. first presenting colors on a map as numbers to get students to understand that the colors represent amounts and not just ink) • To avoid being too open-ended, include inquiry-support software tools that facilitate structure and planning, recording and monitoring • Supply data libraries that support investigations into students' topic of choice (to help motivate them) • The "Learning-for-Use" design framework includes three steps that must be met (which must go in order but can be cycled through numerous times and/or in various ways for each learning objective): 1) *motivation*, which can be achieved through the creation of task demand or eliciting curiosity, 2) *knowledge construction*, which can be achieved through direct experiences,	Edelson, 2005

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			indirect experiences, modeling, instruction, explanation, or sense-making and 3) *knowledge organization*, which can be achieved through practice (using components of understanding in another context), application (applying understanding in context), or reflection • Units should be scenario-based and inquiry • Teacher preparedness, achieved through professional development, is necessary • Professional development should teach specific curriculum in context, and extend over the course of the time that the curriculum is being implemented • Development teams should be diverse, including expertise in science, technology, cognitive science, classroom teaching methods, and teacher professional development, and partnerships should last long-term • Developers from one area (i.e. scientist, classroom teachers) should observe the work environments of the other areas for extended periods of time	
Learners in grades 8-16	• The application of a developed framework for the adaptation of scientific investigation tools for inquiry based classroom learning, to a data visualization tool called ClimateWatcher, which is used in educational settings to facilitate investigations into climate.	• Case study/ documentation of the process by which a scientific data visualization tool is adapted for optimal use in the classroom, • To use a three-step process, which follows understanding the expert tacit knowledge required to use the tool, re-designing the tool to convey that tacit knowledge, and developing activities to engage students	• Scientific tools adapted for educational use provide students with more authentic experiences, • when bridging strategies are employed to provide learners with the knowledge that is already tacit for the experts using the tool	Edelson & Gordin, 1998

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		with the tool, • To utilize five identified bridges: motivating context, activities, data selection, interface, and support for learning		
A 5th grade class of students	• Planetary Forecaster, an earth systems science unit developed for middle school students using the "Learning-for-Use" design framework, developed by Edelson, which is based on a learning model for developing useful knowledge	• Data collected from pre- and post- assessments, student work, and classroom observations of a class of 27 students at a public high school in Chicago, using Planetary Forecaster • An in-depth case study conducted through pre- and post- interviews of three of these students, of varying academic abilities (determined by the teacher)	• Significant misconceptions that existed prior to engagement with the unit were no longer apparent after • Students understood the "that" and "how" of the concept introduced in the unit, but were missing the "why." A recommendation is made to redesign the curriculum to better explain the "why," but it is also suggested that there may simply be too many knowledge demands of the task in this unit • It may be that some of the students misconceptions are due to images and accounts offered in popular media • New misconceptions not anticipated were identified • The activities that students engage with in Planetary Forecaster helps students to better understand scientific concepts, but did not address all misconceptions	Edelson et al., 2002
Nine to twelve year old students at a Montessori school	• Explorations on GLOBE (Global Learning and Observations to Benefit the Environment), an international environmental education program, and develop criteria for training material for STSP programs.	• Observations made in a classroom of 9 to 12 year old students using the GLOBE explorations at a Montessori school in Boulder, CO	• A simple model of content consistent with the Web is developed. This model begins with the main elements of pictures and descriptions, arranges those elements into groups, which also have descriptions, and using technology that enables the creation of a number of presentations, allowing those presentations to be shared, as well as other forms of communication, between scientists, teachers and students (this	Haberman et al., 1998

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			forms a community of learners, and traditional roles are blurred) • Barriers to the fully successful implementation of this model will dissipate as technologies improve	
Middle and high school teachers	• The Gulf Stream Voyage, a CIESE product, in which students investigate the Gulf Stream through various real-time data sources.	• Teachers interacted with the Gulf Stream Voyage Web Site and used it with their students, recording a journal of their experiences. Face-to-face and phone interviews were conducted.	• Teachers were generally able to use the site as intended, keep students on track, access the real-time data, and solve the problems presented in the lessons • Real-time data can be successfully implemented in classroom settings, and it provides authentic, engaging, and meaningful learning experiences	Hotaling, 2005
Elementary, middle and high school students	• The *Earth Day: Forest Watch* program, in which students collect and assess data about the health of white pine forest stands, and then compare their results to data given by the Landsat Thematic Mapper (TM) for their local area. Students use mathematics to investigate their research questions, and learn the connection between mathematics and other disciplines.	• A description of the project, as a student would go through it	• Argue that environmental data analysis can be successfully implemented in middle school and early high school classroom to meet mathematics content standards (algebra and geometry)	Lauten & Lauten, 1998
The WISE development team	• Web-based Inquiry Science Environment (WISE), which is a library of inquiry-based science learning lessons for grade 5-12, incorporating real-time data and current real world science, on the internet • Teachers can customize the site and lessons to their liking • Four major categories of lessons: investigation, controversy,	• A description of the many projects on WISE • Lessons learned and best practices of the WISE development team, culminating from research and evaluations of this program	• Steps of lessons must be open enough to engage students in inquiry without being so broad that students can easily get lost • The science doesn't necessarily need to be "simplified." WISE developers often offer very detailed steps for the first inquiry investigation, and then less detailed steps for subsequent investigations • Each lesson regularly incorporates	Linn et al., 2003

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	critique, and design • great example of a project model: students build an initial model, test it in the local environment, revise their model, compare results to findings from prior years, and record the difference		"prompts," or questions, asking students to reflect on a concept or their own learning, or make connections between learned concepts or ideas • Having students work in groups of two is more effective than larger groups • Having the teacher initiate a class discussion about the students' findings and then encouraging them to post them to a discussion board involved much more student participation (90%) than a classroom discussion alone typically does (15%) • Criteria for technology projects that support knowledge integration: 1) works with science in the existing school curriculum, 2) is locally adaptable, 3) allows teachers and students to post revisions and suggestions, and 4) addresses student misconceptions • Make science and scientific evidence accessible by including evidence pages, pivotal cases, an inquiry map, and the inquiry question itself • "make thinking visible" by asking students to report their ideas, test them against identifiable criteria, and holding them up to recognized standards	
Results of a meeting of 60 data visualization experts associated with the CILT (Center for Innovative Learning	• The Center for Innovative Learning Technologies (CILT) was founded in October 1997 with a grant from the National Science Foundation (NSF) to stimulate the development and study of important, technology-enabled solutions to critical problems in K-14 science, technology, engineering, and	• The paper includes a general review of a variety of visualization and modeling (VISMOD).	• Visualization and modeling tools are used in a curricular context. • The CILT is building a database of design principles which will provide a framework for the development of new learning environments (http://cilt.org).	Kali, 2002

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Technologies) University CA/Berkeley, Stamford and the Concord Consortia	mathematics (STEM) learning. • CILT has engaged the collaborative efforts of a wide range of people, institutions, and organizations including cognitive scientists, computer scientists, natural scientists, engineers, classroom teachers, educational researchers, learning technology industry leaders, and policy analysts.			
Classroom teachers – general review and recommendations	• Teachers are presented with many choices of selecting and using data collection technology. • Teachers are encouraged to not consider one choice (such as microcomputer based laboratories MBL vs. calculator based laboratories CBL)superior to another, but rather select carefully based on the educational needs of the student.	• This paper is a general review and series of recommendations regarding the teacher decision making about student data-collection technology. • There are a series of questions the authors encourage teachers to ask themselves in technology selection: 1) why should my students use this technology? 2) is the use of this technology appropriate both pedagogically and developmentally? 3) Is the use of the technology justifiable (time, money to prepare for its use), 4) How do I choose the type of data-collection technology to use with my students?	• The NSES refer to technology as exciting tools which allow students to conduct inquiry and understand science. The appropriate use of technology is recommended: • Grades K-4 "Employ simple equipment and tools to gather data and extend the senses • Grades 5-8 Use appropriate tools and techniques to gather, analyze, and interpret data • Grades 9-12 Use technology and mathematics to improve investigations and communications. • Author claims that research has shown that use of data-collection technologies can strengthen students' graphing skills. These tools help students understand information on a graph by linking the concrete experience of data gathering with a symbolic representation in real time (no specific ref stated to support this statement).	Krueger & Rawls, 1998
Elementary and secondary school students	• GLOBE (Global Learning and Observations to Benefit the Environment), an international	• Evaluations from years 1-9 of the program, with successive testing and revisions of the various	• An estimated 85,000 students participated in GLOBE in the United States during its first year.	Means et al., 1996; Means et al, 1997;

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and teachers	environmental education program, and develop criteria for training material for STSP programs.	components of the program • Teacher surveys, student surveys, site visits, which incorporated interviews with teachers and administrators, classroom observations, and in formal discussions with students, analysis of data submissions (added Year 5), case studies (added Year 6)	• There is strong teacher and student enthusiasm and support for this program, especially its adaptability to a variety of contexts, and its inquiry and collaborative learning aspects • Participation in GLOBE increases the likelihood that teachers will engage their students in actually doing science, and students gain a new understanding of science and how its conducted • The hands-on activities, use of technology, and involvement in real world science aspects of GLOBE appeal to students and give them a sense that what they are doing has value • GLOBE students developed the ability to apply more broadly principles of data collection and analysis • Science and math learning in GLOBE classes is enhanced, as well as student understanding of what it means to do science • A local "franchise" model of teacher training has proven very successful and greatly increased the number of GLOBE teachers trained • A significant investment of time, motivation and persistence is required by the teachers • Technology should be more "goof-proof" and easy to use • More mechanisms for teacher support and training are required • Student data collection must be more than just that; it must be integrated with a conceptual understanding of what they are doing (learning activities that meet	Means et al, 1998; Center for Technology in Learning, 1999; Center for Technology in Learning, 2000; Center for Technology in Learning, 2002; Center for Technology in Learning, 2003; Center for Technology in Learning, 2004; & Center for Technology in Learning, 2005

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			this goal should be developed) • Model classroom strategies for getting the entire class involved (not just small groups of students) should be provided to teachers • GLOBE is most successfully implemented as a whole-school program, and strong administrator support is integral • Implementation of the program should be supported for a variety of grade levels and contexts. These should be provided, but also the ultimate way the module is used should be left up to the educator • Classroom assessment materials should be provided to teachers • Datasets that appeal to teachers (and are used by teachers) most relate to concepts that are commonly found in curricula (such as weather) and are straightforward and easy to use • Materials should be well-integrated across investigation areas, highlighting the interdependencies of Earth Systems • Data collection and analysis skills should be emphasized throughout the curriculum and well-integrated with science concepts • “25% of teacher training time should be helping teachers to learn how to support their students in planning, executing, analyzing, and communicating research investigations” • Scientists should be actively involved in recruiting and supporting schools • Elementary teachers especially need support in the areas of science content	

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			• In 2000, there was a notable decrease in number of teachers reporting a lack of internet access or technological apprehension as a barrier to implementation • Curricula should be integrated with content standards • Partner institutions who act as mentors for their local school has proven to be a very successful strategy, although funding issues often led to challenges for the partners in sustaining their role • Teachers use the teachers guide (background information, directions, field guides and diagrams) in planning their lessons, but not in their teaching • Teacher did not use the provided standards alignment charts (instead, they just used their own knowledge of their local standards) • Teachers rarely used the web site for anything besides reporting data (the preferred the paper guide for activities) • Teachers never used GLOBE materials alone for their lesson; rather they supplemented them with materials from textbooks and other sources	
4th grade students in a self-contained classroom	• The JASON project is a international, multimedia hands-on science education program designed to expose students and educators to state-of-the-art science and technology. .	• Qualitative case study approach (Lincoln and Guba 1985). Primary source of data were derived from semistructured one-on-one student interviews (4 students of 18 in class selected on basis of gender, achievement history, and willingness to participate) interviewed 4 times (30-45 minutes each) over the	• Overall, results indicate that the JASON project had a notable impact on short-term attainment of science content for participants, however little change was seen in their conceptions of the nature of science over the 6 month time frame of the study. • Interestingly – most of student prior knowledge about the topic area (rainforests) in the study was derived	Moss, 2003

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		course of the school year. Core interview questions included: What science are you doing in class right now? How is it different from other subjects in school? How do you know when you are doing science? How would you define science? What do scientists do? • The study set out to describe how the JASON project was implemented in a self-contained 4th grade classroom and examine the international curriculum initiative within the overall context of a student-scientist partnership model (where students partner with scientists to collect actual data which is used to investigate real-world environmental questions) of science education reform. • A secondary goal was to examine changes in student perceptions of the nature of science as a result of participating in JASONTeacher was interviewed twice over the course of the school year. Regular class visits and on-going discussions with the teacher also occurred. • All student interviews were coded using an open coding strategy to form specific data categories (cross interpreted by two coders).	from experiences outside of formal school (Discovery channel, museums, etc). • Professional development implications – teacher did not stray from what was modeled/presented in professional development training. The teacher cited lack of time as the discouraging factor in determining what/how to teach JASON materials. • Student –Scientist partnership model if successful must be viewed as complementary and even beneficial to testing initiatives which are driving the choice of curricular programs. • Must encourage students' conceptions of science to include scientists engaging in experiments and natural observation – go beyond content focus and embrace science teaching and learning as portrayed in NSES and AAAS benchmarks.	
High school	• This project was a partnership	• Seven students from one project	• Results indicate that students' conceptual	Moss et al.,

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students in an innovative conservation biology class	between Valley High School (pseudonym) and the University of New Hampshire designed to examine the conceptual development of high school students understanding of scientific research over an entire school year. • Students participated in 4 science projects over the course of the school year including a local watershed water quality monitoring project, a computer based populations dynamics modeling project, a land cover/land use mapping project using Landsat Thematic Mappers satellite data, and the Forest Watch project (monitoring white pine).	based class. Students were selected based on their willingness to participate, gender, achievement history. • Students were purposefully selected and data consisted of audio recorded semi structured student interviews which were transcribed verbatim. • Students were interviewed individually for 30 minutes 6X over the course of the school year. • Data was coded and interpreted by a pair of researchers. These coded snapshots allowed the researchers to determine if any conceptual change occurred for each student regarding his/her understanding of scientific research.	understanding of scientific research including development of researchable questions, data collection, data analysis, drawing of conclusions, and communication of results rarely evolved over the course of the school year, remaining rudimentary. • Students had uniformed notions of scientific questioning, viewed data collection as only following prescribed steps and ultimately repetitive, and had little experience with data analysis or the communication of scientific findings. • Critical factors contributing to these student perceptions included insufficient exposure (to posing questions, data analysis, and communication of results) and a lack of sense of partnership (not communicating with UNH scientists directly – not involved in generation of research questions). • The design of the student-scientist partnership should be reexamined.	1998
Secondary School Teachers and scientists involved in the collaboration in Ireland	• a pilot project, devised by research scientists, conducted in Ireland in 1982, in which students collected air quality data and reported their findings back to the scientists	• a case study of this project • reporting of the air quality improvements over time as a result of this project • reporting of the overall success of the project	• report entitled, "An Air Quality Survey of the Greater Dublin Area carried out by Second Level Students" was published in 1988 • the sale of bituminous coal was banned in Dublin the same year that this report came out. This was a move that had previously been opposed by residents of the city, eventually resulting in improved air quality in the area • visits from the research team to the schools emphasized for the students and teachers the importance of what they were doing	Murphy, 1998

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The CoVis development team	• A CoVis project called WorldWatcher, which allows pre-college students to create dynamic color visualizations of datasets from various scientific research organizations, in order to support their scientific investigations • WorldWatcher makes data visualizations used by the scientific community more accessible for students in one of two ways: 1) supplying an interactive schematic diagram, graphically depicting relationships among variables and linking students to data, and 2) an online notebook that allows students to write text as well as embed multimedia objects, that students can use to record their progress and save their visualizations, and teachers can use to create projects • WorldWatcher offers both customizable, well-defined map displays for visualization and embedded calculators to perform mathematical operations on the visualized data	• A description of CoVis and WorldWatcher • Lessons learned and best practices of the CoVis development team, culminating from research and evaluations of this program • Reporting of the overall success, and successful outcomes, of the project	• Middle school and high school curricula have been developed and used for middle and high school students, which integrates inquiry-based learning, hands-on science, and student teamwork • The CoVis vision of a scientific "collaboratory," in which university researchers, schools/teachers and/or science museums and learning centers, and students work together using CoVis supplied products, has been successfully integrated into the day-to-day learning of many challenging learning environments	Pea, 2002
Secondary School physics teachers in Italy who were interested in using real-time experiments	• RTEI, or real-time experiments and images, in which computers are used in a classroom setting to acquire data and display it for the purposes of science teaching • The RTEI rationale is to have teachers work with their student	• Observations of, interviews with and questionnaires given to 17 teachers using RTEI in their classrooms, students' tasks and assessments, and informal interviews with students • Short case studies, or "stories,"	• 6 of the 17 teachers implemented, and often enriched, the RTEI rationale • 11 of the 17 teachers partially adopted the RTEI rationale • in order to better meet the rationale, teachers must 1) feel comfortable that students understand the tool and how it	Sassi et al., 2004

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and images (RTEI) in their classroom and their students	to: 1) demonstrate otherwise unobservable phenomena, 2) compare RTEI results with other measurements, 3) be able to distinguish system fluctuation from real data anomalies, 4) engage in game-like or challenge-oriented tasks, and 5) understand mathematical functions in data and how they relate to theory	written up • The creation of training materials for a two-session teacher training workshop for the use of RTEI in the classroom	works, 2) focus more on the conceptual understanding of a "real" instance versus an "ideal" instance, or model, and 3) place more emphasis on helping students in decoding graph images • teachers should be trained to reconsider their entire classroom approach, from the way they structure their material, to the way they understand the learning process • classroom activities using RTEI must do more than guide students through a step-by-step process or simple processing of collected data through pre-defined algorithms • training materials should include putting the teacher in the place of the students, so that they better understand student difficulties	
Middle school students and teachers	• Sea Maven is a web-based learning tool that has been developed to enable middle school students to actively engage in collaborative learning in environmental sciences (using a network of platform sensors for monitoring oceanographic and meteorological processes.	• Formative assessment of the Sea Maven web product. • The Author used a combination of teacher focus groups and student assessment surveys to evaluate the success of the Sea Maven product.	• Backend relational database designed to allow teachers to monitor their students' performance was not used by the educators in the study. They preferred to monitor their student's activities in the classroom. • There were significant connectivity issues including slow load times and screen freeze ups were more common then expected. This was due in part to local LAN networks at the schools were slowed by the numerous behind the scene checks that verify the users computer has the appropriate plug ins (Flash and Quick time) and potentially poor network configurations. • Materials should have multiple levels of intellectual engagement to encourage synthesis and analysis of information.	SeaMaven

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High school students and teachers	• An authentic science experience for students designed to introduce real science topics and methods to students and teachers through hands-on field based programs. The program is called Boreal Forest Watch and involves the collection, analysis, and interpretation of forestry data. • To use student-collected information to build a long-term database for future global change studies in the boreal region	• Case study/documentation of the pilot year of the BFW program highlighting the importance of student-scientist partnerships and joint participation in research linked to global change studies of the BOREAS and to local ecological monitoring efforts of the Prince Albert National Park. • Students select/set-up a permanent study plot on a semi-annual basis, conduct a series of core science protocols/measurement activities, collect data and analysis on yearly basis, submitted to scientists for archive and additional analysis.	• Program offers unique learning opportunities and fulfills the Parks Canada's responsibility to conduct ecosystem management programs. • Complements the parks' regular interpretive programs providing a more quantitative scientific approach to learning about the boreal forest. • Designed in partnership with the Saskatchewan Education CORE curriculum. This made it possible appealing for the teachers and functional in the classroom. • Equal value on the educational value of the content and the scientific validity of student collected data.	Spencer et al., 1998
K-16 educators	• The Adopt-A-Drifter program, which partners one US school and one international school to adopt a data-collecting buoy which is deployed into the ocean. A teacher from each school is on board the ship when they deploy the buoy, and they can bring that experience back to their classroom, along with the students' access to the buoy's data and apply it to their learning	• A description of the program and how the 5 E's model of education (engagement, exploration, explanation, elaboration and evaluation) is applied to the lesson plans that have been developed for it	• Student investigations made with this program provide students with new knowledge about ocean currents, processes, modeling, and using and analyzing data. • Students develop reasoning skills by practicing science in a way that is more akin to real world science. • The data provided by the buoy can be used in open-ended and guided classroom investigations.	Tweedie et al., 2005
Middle school math teachers and students`	• SkyMath, an online curricula that teaches mathematics concepts incorporating real-time weather data	• Three-year long evaluation, in which the module was revised and re-evaluated a number of times • Exploratory methods were employed - classroom	• Students are effectively learning mathematics and science concepts using this module • Overall, students and teachers enjoy using this module	University Corporation for Atmospheric Research, 1997

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		observations and interviews (in-person and phone) with students, teachers, administrators, college faculty, and parents	• SkyMath is flexible enough to fit into a variety of ways, adapting to grade levels, learning styles, and class formats • Teacher resources such as teaching instructions, background information, and teacher stories make SkyMath easier for teachers to use • It is difficult for teachers to complete the SkyMath module in the six-week time frame suggested because of scheduling constraints • Technical difficulties were frustrating and slowed progress • The impact of the module is reduced when it is not connected to the curriculum taught in the rest of the year • Partnerships with other schools and students must have teacher support and involvement in order to be effective and meaningful • This type of module is more appealing to teachers who have a hands-on teaching approach	
5th grade students and their teacher, who was a co-developer of the curriculum	• A WISE project called *Plants in Space*, in which students collect data on plant growth, and use WISE software to graph and analyze their data	• A 2 year case study of 46 5th grade students (23 each year), their teacher, and their experiences implementing the Plants in Space curriculum • The curriculum was modified based on results from the first year and the modified version was tested in the second year	• The curriculum successfully promoted knowledge integration in year one. • Modifications were made to make the curriculum more visual representations of photosynthesis, a concept which students were not getting with the original design	Williams & Linn, 2002
An urban 5th grade teacher	• A WISE project called *Plants in Space*, in which students collect data on plant growth, and use WISE software to graph and analyze their data	• 2 year case study of a teacher as she integrated the WISE program into her 5th grade classroom • data obtained from videotapes	• over time, the teacher focused more on conducting real inquiry and less on logistics, as a result of repeated opportunities to teach a WISE unit • support form the development team	Williams et al., 2004

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		and transcripts of instruction, audiotapes and transcripts of interviews conducted with the teacher, and retrospective interviews	helped the teacher reflect on her teaching and her students' learning	
K-12 teachers	• This study evaluates the student-teacher-scientist partnership (STSP) aspect of GLOBE (Global Learning and Observations to Benefit the Environment), an international environmental education program, and develop criteria for training material for STSP programs.	• Conducted phone interviews with GLOBE teachers about their experiences with the program • Developed "Draft Training Material Design Criteria" • Requested feedback on the draft criteria from GLOBE teachers and teachers participating in other STSP programs • Revised the draft criteria based on that feedback	• Students should be involved in the full scientific process, from forming questions to analysis • Introductory-level background information should be provided but kept separate from data collection information • Include a student-centered section • Organize materials in a clear, easy-to-follow, graphical layout • Provide consistent formats for lessons, in a step-by-step format • Start lessons with basic concepts and build up from there • include hands-on and inquiry-based lessons whenever possible (include outdoor lessons whenever relevant) • provide strong support for teachers, including follow-up workshops • consider time and resource constraints	Wormstead et al., 2002
Community college and middle school educators	• The Alliance + project is a national training program funded by the Department of Education designed to provide hands on training for K12 teachers to integrate the Internet resources in the classroom curricula and improve science and math education. The project is lead by the Center for Improved Engineering and Science Education CISE at	• Logic model that links outputs to outcome-- trained teachers with the capacity to integrate technology in the classroom that are supported by the school's administration to take full advantage of real time date bases, collaborative projects, and other resources uniquely available on the web to improve teaching and learning • This report was a formative	• Continue to develop methods to overcome obstacles to connectivity and access to computers. Encourage teachers to use computer at home to enhance familiarity and expertise • Support teacher training—Alliance + is encouraged to redesign their course to a 10 week format with time for reflection and integration into school curriculum. Develop a pretest for the teacher training that would screen teachers in need of basic computer skills training.	Yepes-Baraya, 2000

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	Stevens Institute of Technology.	assessment of the first year of the Alliance+ project	• Increase use of collaborative projects (seen as painless way to introduce more teachers to the use of technology in the classroom) • Strengthen mentoring and support among trained teachers and their turnkey mentees. Involve school administration and technology staff as much as possible – fully integrate them into training models.	

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