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ABSTRACT

Problem-based learning (PBL) has great potential for inspiring K-12 learning. KaAMS, a NASA funded project and an example of PBL, was designed to help teachers inspire middle school students to learn science. The students participate as scientists investigating environmental problems using NASA airborne remote sensing data. Two PBL modules were developed that address two different environmental issues: active lava flows and coral reefs in Hawaii. The modules consisted of new lesson plans that could be used flexibly by many teachers, and that use existing NASA and other Web resources. The goal was to harness those resources that exist rather than create totally new ones. This paper provides an overview of the instructional design challenges in creating Web-based PBL teacher support materials, the PBL model selected for use, the activities embedded in the PBL, and initial results of classroom trials. (Contains 10 references.) (Author/AEF)

Kids as Airborne Mission Scientists: Designing PBL to Inspire Kids

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Problem-based learning (PBL) has great potential for inspiring K-12 learning. KaAMS, an example of PBL, was designed to help teachers inspire middle school students to learn science. The kids participate as scientists investigating environmental problems using NASA airborne remote sensing data. This paper provides an overview of the instructional design challenges in creating web-based PBL teacher support materials, the PBL model we selected, the activities embedded in the PBL, and initial results of classroom trials.

Introduction

Kids can be motivated and inspired by making direct contributions to solving real scientific issues. Can teachers be inspired too? Through a PBL approach, KaAMS, a NASA funded project guides teachers to take middle school children on live and past NASA airborne missions to collect data to study two environmental issues. The ultimate mission of the project was to inspire kids to learn and develop a career interest in science, math, technology and geography by their participating as scientists in activities punctuated by "bursts" of interactive events culminating in the analysis of data from NASA airborne missions. The mission is accomplished by providing resources to teachers to use with middle school children. To do this, we developed two problem based learning modules addressing two different environmental issues—active lava flows and coral reefs in Hawaii. The modules consisted of new *lesson plans* that could be used flexibly by many teachers, and that use *existing* NASA and other web resources. The goal was to harness those resources that exist rather than create totally new ones.

Problem-Based Learning Literature—the basis for KaAMS

The conceptual framework of problem-based learning model for KaAMS is based on the perspectives and implications of problem-based learning literature. Problem-based learning as an instructional model associated with the new learning paradigm (e.g., Reigeluth, 1999) has been implemented in diverse content domains such as medical education, business education, social education, and science education. Problem-based learning, in general, encourages students to engage in learning activities to solve a real world problem (Duffy & Cunningham, 1996). According to problem-based learning researchers (Barrows, 1986, 1992; Savery & Duffy, 1995; Schwartz, et al, 1999), key characteristics of problem-based learning include the following;

- Real-world problems with a motivational context to drive learning. A real world problem is used as a stimulus for authentic activity.
- Given a problem space, students generate their own learning goals in terms of what they will attain.
- Multiple learning resources including print, electronic and humans are provided for the student to develop a deep understanding about content knowledge related to the problem and apply that knowledge into the problem solving activities.
- Students as active problem solvers work with their peers, teachers, and experts to share their different perspectives and develop deeper knowledge on a subject area.
- By placing students in learning by doing situations, students develop a disciplinary knowledge base, problem solving skills, reflective thinking skills, and collaboration and communication skills.
- Teachers play a role as coach or facilitator that supports students' learning and problem solving activity, rather than directly teaching what students should know and how students should solve a problem.

In general problem based learning (e.g., Barrows, 1986, 1992; Savery & Duffy, 1995; Schwartz, et al, 1999), students engage in the following five stages of a learning process:

- *Present a problem*—Students start with a presentation of a real world problem.

- *Generate what students know and what they need to know*—Students actively define problems and generate what they know and what they need to know based on their prior knowledge and experience. They are encouraged to identify learning issues or knowledge necessary to construct an understanding about how to solve problems.
- *List possible actions*—Based on the previous activity, students discuss and come up with strategies and activities for solving the problem.
- *Collect and analyze information*—All students engage in gathering information from available learning resources ranging from print-based materials, electronic and human resources and from the designated facilitator. After gathering the information, they analyze and evaluate information in terms of what is most useful or what is not useful to solve the problem. They discuss and negotiate their perspectives about alternative solutions with peers, their teacher, and experts.
- *Present and share solutions*—They finally propose their solutions, share them with their peers and experts who might provide different perspectives to the solutions, and revise their solution based on feedback from their peers or experts.

The KaAMS Model

From these perspectives and implications of the problem-based learning literature, we developed the KaAMS problem based learning model with four learning stages in which middle school students engage: 1) problem scenario, 2) propose ideas/search information, 3) conduct mission/collect and analyze data, and 4) propose solution. Each learning stage of the KaAMS problem based learning model includes the following key attributes:

- Authentic, ill-structured problem situation
- Assumption of roles by the students
- Reflections about what they know, what they need to know
- Planning the investigation procedure
- Access to rich NASA web resources
- Active investigation
- Learning activities situated within real NASA missions
- Reflective thinking exercises
- Peer and expert collaboration
- Learner activities/tools in interpreting data gathered
- NASA scientist support
- Shared solutions with peers and experts

Conceptual Framework for KaAMS

Foundation of KaAMS

Conceptually, the KaAMS framework, as shown in Figure 1, is built upon the premise and foundation that among all NASA web resources from all aspects of the agency, a multitude of resources can be used in the classroom. These resources are filtered through a second-level premise, which is the Web-Enhanced Learning Strategies (WELES) interface. This interface helps to sift through the available resources for elements and composite sites that are appropriate for use by middle school teachers and students. These resources are then used in four parts of a lesson plan—frame/inform/explore/try. The third premise is that teachers can use real web resources from real NASA missions in a problem based lesson format. Finally, these three levels of resources are harvested as part of the KaAMS PBL lesson plans.

Students are presented with an environmental problem that is of concern of to a NASA mission. They begin a series of problem-solving lessons from which they develop content and applied knowledge by participating in problem solving activities. Through a series of framing and informing activities, students search for additional information on the problem, develop an understanding of the science of the problem, and propose a solutions for conducting a mission that will provide remote sensing data to solve the problem. Students become involved in "bursts" of activities to conduct a mission, collect and analyze data. Finally, students summarize their findings in several different ways and go public to share what they have learned with classmate and/or other outside their classroom. One important note is that the students participate in reflective activities throughout the entire process.

Developmentally Appropriate Lessons

Also evident in the design were the following key characteristics we found about middle school students (From: This We Believe).

- Moving from concrete to abstract thinking
- Curious on a wide range of topics, few of which are sustained
- Prefer active over passive learning
- Respond positively to participating in real life learning situations
- Are inquisitive and challenge adults
- Desire recognition

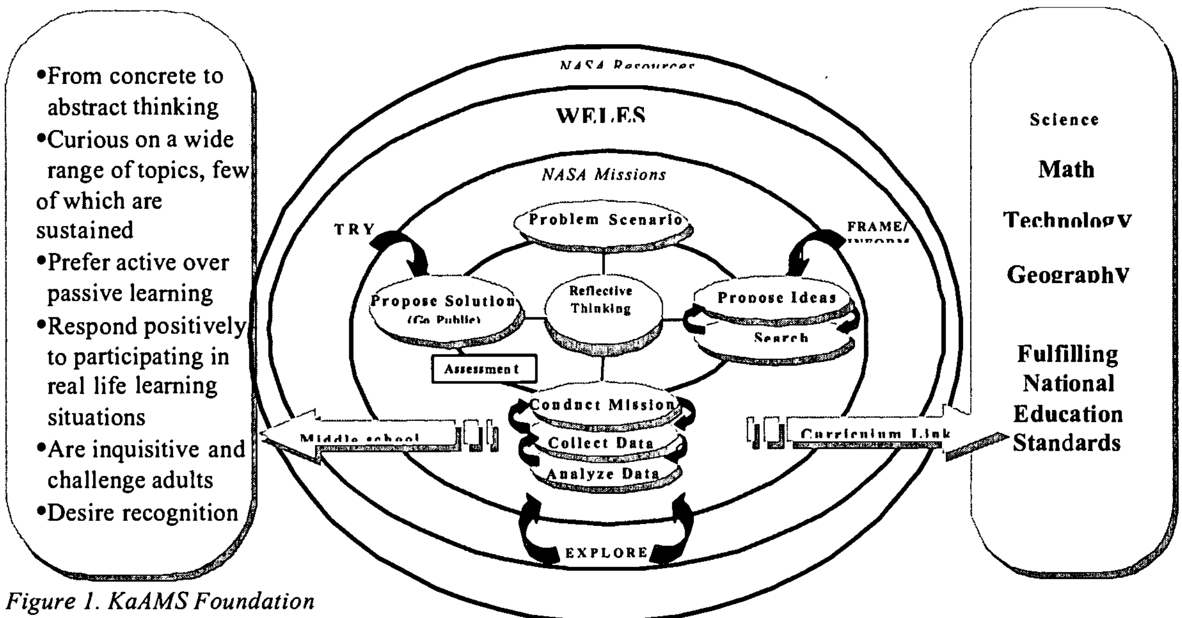

Figure 1. KaAMS Foundation

Links to National Standards

To maintain the link to the National Standards, we have completed an analysis of the NSTA/NRC standards and the AAAS Project 2061 Benchmarks to target in the KaAMS Project. Each lesson plan links to the specific national education standards that might be satisfied by completing the lesson activities

Flexibility

Since flexibility is very important to maximize the usability of this site, we have designed the site for the teacher. The framework is constructed so that the teacher is in control of how much and what types of the available activities that his or her students actually see. He or she can start from Phase 1 and proceed to Phase 4, or he or she can just go the activities of Phase 3, for example.

Mapping Design Attributes of KaAMs onto PBL and the Scientific Process

Problem-based learning and the scientific process follow similar steps. This cross over made explaining the learning process to content experts very easy. See Table 1. Some examples of how the design attributes were built into the KaAMs is shown in the last column.

Table 1. Mapping KaAMS onto the PBL Process

PBL Process	Scientific Process	KaAMS	Design Examples
Problem Clarification	Identify Problem	Problem Scenario	• Two problems— finding lava flows for the Pacific Disaster Center, and determining if the coral reef need protection for a real Congressional Executive Order
Plan Development	Research ideas and	Propose Ideas/Search for	• Activity Sheets as

	Develop plan for investigation	Information	Who, What, When, Where, Why and How questions to determine what the students know • Students complete reflection journals • Find information using existing NASA web resources • Participate in activity bursts to explore new concepts
Collect Information	Collect Data	Conduct Mission and Collect Data	• Students think critically about which aircraft can run their mission and select from several possibilities • Students plan the actual mission and compare it to the actual NASA mission
Analyze Information	Analyze Data	Analyze Data	• Students use actual data from the live missions to draw conclusions • Students use guidelines from NASA scientists for interpretation of their data
Present Solutions	Report Findings	Propose Solution: (Go Public)	• Write a report to the Pacific Disaster Center, • Make recommendations to the President in response to his executive order

Alpha Testing Phase

The assessment strategy for the entire KaAMS project was divided into three major phases designed to capture data that would support initial product development (alpha testing), on-going resources development and implementation planning (beta testing), and analysis of impact on the stakeholders in the learning environment (research-impact analysis). See Figure 2. The diagram below illustrates the flow of alpha, beta, and research processes used for each of the two major products being developed; (1) volcano mission and (2) coral reef mission. This report summarizes overall data collection methods and procedures as well as the findings from the alpha development cycle for Products 1 and 2 - Mission: Studying active lava flows.

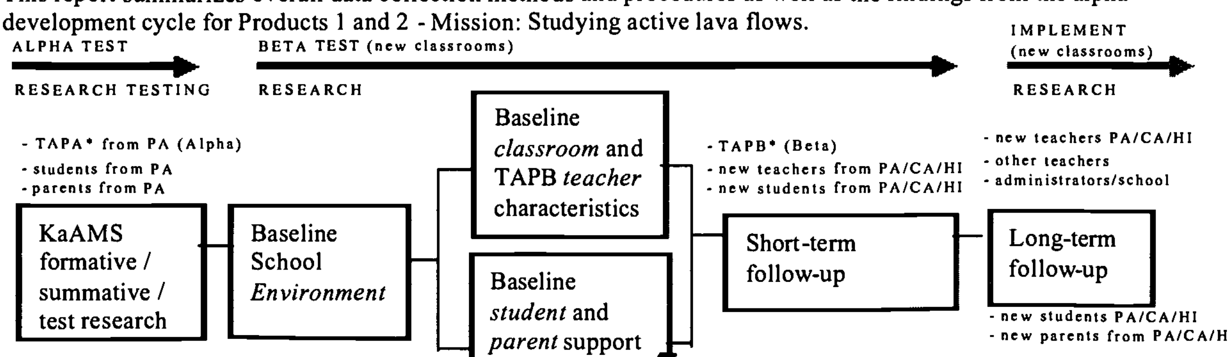

Figure 2. Overall Assessment and Research Strategy
Methods

During the Alpha testing formative and summative evaluation data were collected. With project enhancement in mind, data collected from key stakeholders during the alpha (initial formative development) testing phase included five levels of assessment: (1) reaction, (2) learning gains, (3) performance, (4) education system changes, and (5) impact on the greater society. Research protocols were also tested to assess their effectiveness in measuring the effects of KaAMS materials on teachers, students, and stakeholders in the surrounding community, namely parents. See Table 2.

Table 2: Research questions and assessment

Research Questions	Assessment
How are teachers using KaAMS and NASA resources?	Performance
How are teachers changing their teaching practices (e.g. teaching strategies, incorporation of NASA resources, etc.) over time as a result of using KaAMS and NASA resources?	Performance/ System Change
How are student levels of interest in pursuing science-related career changing over time as a result of using KaAMS and NASA resources?	Learning Gains
How does the use of KaAMS diffuse to the surrounding school system?	Impact on Greater Society

All formative evaluation instruments were administered throughout the alpha testing phases to gather feedback from teachers while preparing for and using the KaAMS materials. Interviews, observations, and focus groups were also conducted at least once per week with teachers and students during the 6-month alpha classroom trials. The summative instruments were administered to teachers at the end of the KaAMS classroom trials and final interviews and focus groups were conducted with teachers and students. The research instruments were administered to teachers and students for pre- and post-test data collection and at and additional 1-month follow-up period for students. Parents were surveyed at the beginning and end of the school year.

Subjects

Three middle schools in a rural Pennsylvania school district participated in the KaAMS alpha test classroom trials, East, West, and Distant. Six different classrooms from these schools were actively involved. Four were 6th grade, one was 7th grade, and one was an 8th grade honors class. The six teachers who participated provided data about themselves, their classrooms, and success of using KaAMS materials during the alpha testing cycle. Teaching experience ranged from 3 to 23 years; initial preferences for primary teaching strategies included hands-on activities, collaborative activities, role play, and problem-based learning; half of the teachers had moderate success using web resources in their classrooms the other half had not used such resources in their classrooms.

Data were collected from a total of 144 students, 82 were boys, 59 girls and 3 did not respond to the gender question. On average, the students had a moderate level of interest in pursuing science.

One hundred and fifty three parents of KaAMS students returned surveys indicating their initial perceptions of science in their school and child's success and interest in science as well as reporting their highest attained level of education. A majority of the parents did not have college degrees, worked in non-science related jobs, and had a neutral opinion of their child's school's science program.

Measures and Instruments

Formative and Summative evaluation: A series of instruments, observation protocols, and interview protocols were developed to collect formative and summative data from the teachers and students during the alpha testing development cycle.

Teachers were asked to review the KaAMS lesson plans, prepare to use the lesson plans in their classrooms, and complete evaluation surveys after each lesson and at the end of the trial indicating ease of use; value of resources, instructions, and assessment guidelines provided; success of activities; amount of preparation time; descriptions of the classroom activity during KaAMS lessons; and general feelings about using KaAMS for teaching and learning. Teachers were also asked to share feedback during interviews and focus groups including responses to questions such as: What did you like/not like about the supporting website? What parts of the lesson plans did you use - why? What additional support materials did you need to use these materials? What additional materials did the students need? What would you change?

Periodically students were asked, during interviews and focus groups, to respond to questions such as: What did you like/not like about the KaAMS activities? How useful were the internet sites? What was happening in the classroom during KaAMS? What did you learn? and what would have made these activities more useful to you? Observational data were collected several times during the classroom trial that lasted between 3 and 6 months, depending on the classroom teacher. Observation data were collected on how the teachers used the materials, how the students participated in the activities, and artifacts developed by the teacher or students during the KaAMS lessons.

Research: The research questions were focused on the teachers, students, and parents. Teachers completed an on-line instrument eliciting background information, preferences for classroom activities, and attitudes toward the use of web resources in the classroom. The instrument was a combination of an attitude survey previously developed and validated for similar research (Koszalka, 2000), a series of questions related to perceptions of their school's ability to support the use of internet technology in the classroom (McCarthy, Grabowski, & Koszalka, 1998), and preferences for teaching styles (Grabowski, Koszalka, & McCarthy, 2000; Koszalka, Grabowski, & McCarthy, 2000). This instrument was administered at the beginning of the classroom trial period and the end (pre-post test).

Data were collected on student level of career interest in science, pre-, post, and 1-month after using KaAMS materials. Student career interest surveys were purchased from the APA. The survey also included a series of questions developed to assess reflective thinking (Koszalka, et al., 2001) and gather demographic data.

Parents were asked to complete surveys at the beginning and end of the school year to assess their perceptions of their child's school's science program. The questions were taken from previous research on measuring parents' perceptions of school programs.

Results

The initial formative feedback provided guidance in designing support structures for the KaAMS website that helped the alpha teachers connect NASA science to their curriculum and prompt active student involvement, as scientists, during science class. The results from the formative and summative evaluation resulted in: development of enhanced lesson plan structures for the KaAMS website, new content support for teachers that strengthened the relationship between the overall problem scenario and learning activities, further instructions to 'coach' teachers in using PBL, web technology, and activities that prompt student reflection, stronger ties between lesson plans and national education standards and curriculum requirements, and enhanced activities that will better meet kids' needs. The initial research findings from the pilot classrooms were very encouraging. Although caution is warranted in interpreting these results, analysis of the research data collected during the alpha testing cycle showed significant, yet minor changes in teachers, students, and parents after the use of KaAMS in the classroom. Table 3 summarizes research findings in accordance with the KaAMS project research questions:

Table 3. Research questions and Alpha Preliminary Findings

Research Questions	Alpha Preliminary Findings
How are teachers using KaAMS and NASA resources?	Teachers noted the flexibility of KaAMS resources and used them in a variety of ways to enhance or change the way they teach.
How are teachers changing their teaching practices over time as a result of using KaAMS and NASA resources?	Several of the teachers tried new ways of integrating the web and collaborative activities into their teaching; changed their preferred method of teaching and the types of resources they used regularly in their classrooms, and their attitudes toward using web resources in the classroom.
How are student levels of interest in pursuing science-related career changing over time as a result of using KaAMS?	Significant increases in student level of science career interest
How does the use of the KaAMS products diffuse to the surrounding school system?	Parent perceptions of their child's school's emphasis on science, school's ability to provide good science experiences, and use of appropriate science resources were higher at the end of the school year than in the beginning.

We believe that we are providing teachers with a venue and structure for using NASA web-based materials in their classroom in meaningful and contextualized ways that will support student knowledge development in the content and processes of science. Through their high quality materials, NASA can make an impact on science in the classroom, which in combination with KaAMS strategies can change teaching practice, impress middle school kids with the importance of and strategies for conducting good science—the ultimate goal being to influence career aspirations of these kids toward science.

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