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Instructional Strategies Utilized During the Implementation of a Hypermedia, Problem-Based Learning Environment: A Case Study

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This article reports on a case study conducted to examine the instructional strategies utilized, teacher and student attitudes, and student achievement when a sixth-grade teacher and her 19 students implemented a hypermedia, problem-based learning unit. Results revealed that the teacher used questioning, peer support, group and individual feedback, and structured management as primary instructional strategies. Overall the teacher's attitudes were positive, although she expressed frustration at not having enough time to complete every activity. While the teacher was not completely satisfied with students' performance, student achievement was generally average, and their attitudes were generally positive. Findings suggest it may possible for designers of problem-based environments to support teachers' efforts through overt integration of questioning, collaboration, feedback, and management strategies within the instructor materials. These strategies represent effective instructional practice, and using them within the context of problem-based environments may potentially lead to greater teacher satisfaction and student achievement.

Engaging learners in problem solving represents one means for achieving the goal of promoting understanding and retention of concepts, facts, and skills (Gallagher, 1997; Rabinowitz & Glaser, 1985). Problem-Based Learning (PBL) combines learning theories about problem solving with the case study approach (Gallagher, 1997) in which students are presented with problems embedded in relevant, resource-rich contexts (Hoffman & Ritchie, 1997). Students assume the role of primary researchers as they analyze the problem, consider possible solutions, develop a plan, and evaluate the outcome (Kaufman & Mann, 1997). One main goal within this context is to encourage high level thinking as students address complex problems reflecting real world practice where multiple problem solving approaches are possible (Finkel & Torp, 1995). In this way, the PBL environment serves as an "apprenticeship for real-life problem solving." (Stepien & Gallagher, 1993, p.25).

PBL has been implemented in a variety of settings, from higher education – such as medical, education, and business schools – to elementary, middle, and secondary schools. The *Center for Problem-Based Learning at the Illinois Mathematics and Science Academy* was one of the early K-12 promoters of problem-based learning. Early curriculum efforts focused on gifted education; however expansion of its initiatives led to encompassing learners of varying ability (Illinois Mathematics and Science Academy, 2002). This PBL model involves placing students in an ill-structured domain that mirrors real-world instances. Students proceed through a variety of activities to frame their understanding of the problem, access resources, gain understanding, and recommend solutions. Teachers act as guides to limit the confines of the problem, provide assistance, monitor students' progress, and give feedback (Illinois Mathematics and Science Academy, 2002).

Researchers of problem-solving environments indicate that students tend to develop more positive attitudes toward learning than students in more traditional environments (Sobral, 1995; Kaufman & Mann, 1997), and achieve essentially the same knowledge level as those receiving traditional instruction (Gallagher & Stepien, 1996; Brush & Saye, 2000). Norman and Schmidt (1992) in their review of PBL research suggest that students seem to be intrinsically motivated when these studies summarized effects on goal orientations. Results from a meta-analysis of PBL medical school models reported that medical students enrolled in traditional programs tended to score higher on standardized measures of basic science knowledge than those in problem-based programs; however, PBL students seemed to have superior long-term recall, since they purportedly held a deeper understanding of the content (Albanese & Mitchell, 1993).

However, implementation of problem-based learning is not without drawbacks, both for students and teachers. For students, one drawback is the difficulty they have with regard to assuming a different, more active role. Researchers have reported students often refrain from initiating interaction in the form of questioning their peers when confused about a concept, and instead seek to solicit "correct answers" from the teacher (Herrenkohl & Guerra, 1998). Schmidt, Boshuize, and de Vries (1992) reported medical students needed at least six months to adjust to the new, self-directed learning environment when immersed in a problem-based curriculum.

For teachers, the drawbacks center on the lack of experience many teachers have with more open-ended domains (Brush & Saye, 2000; Land, 2000). Teachers must assume a primarily guiding role (Brush & Saye, 2000; Herrenkohl, Palincsar, DeWater, & Kawasaki, 1999), which requires them to attend to many different aspects of the learning environment at one time. Additionally, they must continue to engage in sound teaching practice: maintaining student interest, providing access to a variety of resources, monitoring student progress, gauging the type of feedback to give learners, and continually facilitating the learning process (Brush & Saye, 2000; Bednar, Cunningham, Duffy, & Perry, 1995; Gallagher, 1997).

Furthermore, many researchers have found that teachers express frustration with the amount of time it takes to implement problem-based experiences (Maor & Fraser, 1996; Rhodes, 1999; Pierce & Jones, 2002). In addition, teachers have reported difficulty transitioning students into their more active roles (Mammen, 1996; Gallagher, 1997). Other researchers have described teachers' difficulty in knowing how to assess students (Glazewski & Brinkerhoff, 2001).

The way in which teachers manage these environments has implications for learners, educational researchers, and instructional designers alike. A deeper examination into what teachers do when implementing a new and different environment such as PBL can provide greater understanding regarding what they need for success. In light of this, we conducted a case study to examine the instructional strategies utilized by one teacher during the implementation of a hypermedia, PBL unit. Our purpose was to examine the following research questions:

1) What instructional strategies were utilized during the implementation of a hypermedia, problem-based learning unit?
2) What was the impact of the PBL unit on teacher attitudes regarding problem-based learning?
3) How effective was the PBL unit with regard to student learning and attitudes?

METHOD

Participants and Setting

Participants in this case study were a sixth-grade teacher and 19 students enrolled in an enrichment course entitled "Global Connections." The teacher was in her seventh year of teaching, and had previously taught a variety of subjects and grades. Although the teacher described herself as using "different forms of student-centered learning" in her approach, she had never taught using a problem-based method.

Twelve of the students were female and seven male. Students were selected to be in this course on the basis of recommendations from their fifth grade teachers. Recommendation criteria included an interest in technology and a willingness to learn about diversity and other cultures. Students ranged in ability from high-achieving to special education, but most of the students were described by the teacher as "in the middle."

Materials

Student Materials. The unit used in this study was *Up, Up, & Away!*, an interdisciplinary hypermedia, problem-based learning unit developed in accordance with the guidelines provided by the Center for Problem-Based Learning operated by the Illinois Mathematics and Science Academy (2002). *Up, Up & Away!* integrates learning goals specifically relating to meteorological concepts, math, geography, and language arts. At the center of this unit is a challenging problem that guides and directs the learning activities. At the opening screen (see Figure 1), students are given the task of planning a global circumnavigation via balloon, a feat attempted by a host of teams and accomplished for the first time in 1999. The hypermedia database contains linked informational multimedia Web pages about ballooning.

The opening screen also holds links to three options: Project, Resources, and Hints (see Figure 1). The Project button takes students to a screen detailing the three components expected for the completed project. The components include a description of requirements for Balloon Design, Travel Plan, and Supply List. The Balloon Design directs students to submit a cut-away drawing or model of their balloon, informs them on what criteria to include, and solicits a rationale for their design. The Travel Plan describes criteria for a well-designed launch site and route. The Supply List prompts students to include a list of supplies along with a rationale statement for each item.

The Resources button links to informational Web sites related to global ballooning. The informational sites are organized under four topic headings: (1) Prior Attempts, (2) Weather & Geography, (3) News Articles, and (4) Balloon Design. Beneath these headings are links to Web sites containing information relevant to completing the *Up, Up & Away!* challenge. For example, links under Prior Attempts allow students to access Web pages of eight different teams attempting to circumnavigate the earth via balloon.

Selecting the Hints button takes students to another screen that provides access to a variety of student materials including a glossary of ballooning-related terms, an information log for recording where relevant facts are located, and three guiding questions, each matching the three main problem

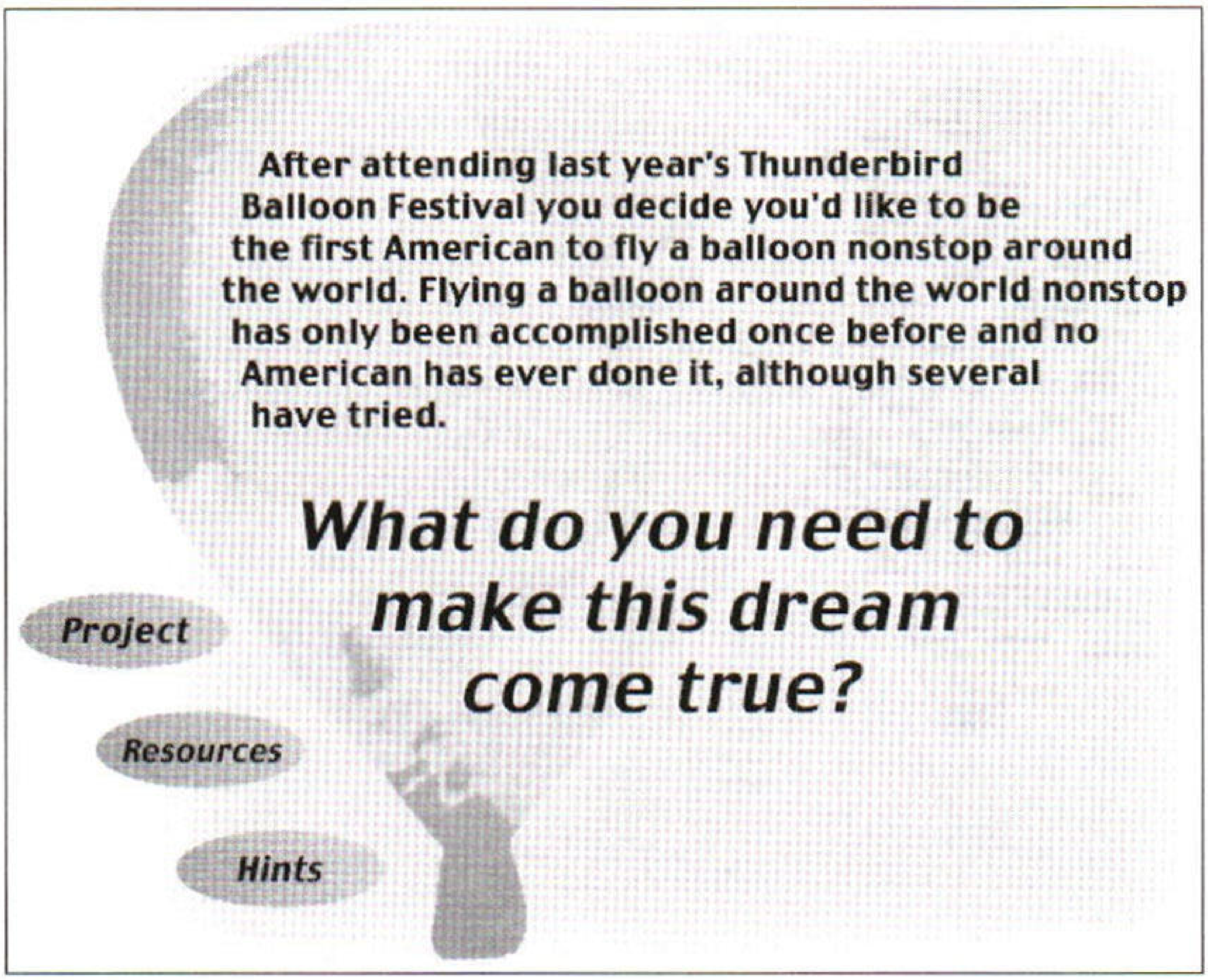

Figure 1. Up, Up & Away! Opening screen

components described above. These guiding questions are designed to support the initiation of their resource gathering (e.g., "If I've never designed a balloon before, where do I start?").

The Hints section also includes several organizing aids for students needing guidance in how to analyze and solve the problem. From the anticipated questions and responses described above, students can link to one of several forms designed to cue their thinking for the purposes of enabling them to discriminate between essential and non-essential information. For example, one form will lead learners to the knowledge that there are three different types of balloons, each with different components, and each with advantages and disadvantages when it comes to flight. Students are clued to look for these balloons, their components, and the pros and cons of each. This form also has students search for which type of balloon was used in prior attempts to circumnavigate the earth.

Teacher Materials. *Up, Up, & Away!* features a detailed teacher's guide designed to enable effective and efficient implementation of the learning unit. The guide was initially written by the developers, and teacher input from two prior implementations of the program was subsequently incorporated

(Glazewski & Brinkerhoff, 2001). The teacher is provided with lesson plans intended to introduce the unit and its central problem, support the students as they gather resources, and recommend alternative enrichment activities. Embedded within the lesson plans are mini-lectures which the teacher can opt to deliver; these cover a variety of topics, such as a lecture describing the Jet Stream and its importance to balloonists. The guide also includes science demonstration ideas related to the learning goals, such as "Hot Air Rises." The majority of the guide contains content related to covering instructional objectives, but suggestions are also made for implementing cooperative learning, creating bulletin boards to spark interest, and collecting additional books and magazines as resources. Teachers are also advised to give feedback for each strand of the project, and a form is included for this.

Project Assessment Checklist. A set of checklists for the three strands of the project (Balloon Design, Travel Plan, and Supply List) is included for final project assessment. Each checklist consists of 13 to 16 condition descriptions which delineate the criteria to be included in an exemplary project rated on a zero or one basis. For example, an exemplary balloon design needs to include a pressurized capsule and needs to identify such essential components as the ballast, burners, and rip valve. The Pearson correlation coefficient for the interrater reliability among two independent raters was .94.

Posttest. A 10-item, short answer, paper and pencil criterion-referenced posttest measured the specific learning goals and objectives. The total number of point possible for the posttest was 27. Test items were developed from the information included in the database and the mini-lectures as they related to solving the problem, such as calculating distance given rate and time. The KR-20 reliability coefficient for the posttest was .58.

Student Attitude Surveys. Student attitudes were measured through a 10-item attitude survey. Seven Likert-scaled items, arranged on a four-point scale from *strongly agree* to *strongly disagree*, asked about such things as the ease of using the student interface, student effort in completing the unit, ease of finding information and feelings toward *Up, Up & Away!*. The attitude survey also included three open-ended response items soliciting student opinions on what they liked best about the unit, what would have helped them do a better job of completing the unit, and what they felt should be changed about the unit. The KR-20 reliability coefficient for the attitude survey was .74.

Procedures

The teacher implemented *Up, Up & Away!* during six 50-minute class sessions. Implementation of the PBL unit occurred in the school computer lab which contained 36 computers. The primary researcher (the first author) attended each class period to collect observation notes and conducted a debriefing with the teacher following each day of instruction. On the first day of instruction, the teacher introduced the unit, and students self-selected partners or triads. The teacher provided each student with folders that included forms to record information and clips for students to place handouts. Folders were collected at the end of each session. The teacher examined each folder and recorded feedback before the next session. All instruction, with the exception of the last day of implementation, occurred in a computer lab. Each cooperative pair worked on one computer.

At the beginning of each class period, the teacher began by providing verbal feedback. She reminded students of the project challenge and presented a mini-lecture to set daily expectations. Some days, this lecture included specific content information the teacher chose to relate, and other days she simply described the tasks to complete before the end of the session.

After each day's instruction, the teacher related her impression of the day's activities, what her plan was for next time, and her perception of the students' progress. Additionally, she participated in an interview before and after the implementation. On day six, the final day of instruction, all students completed a posttest and an attitude survey in the teacher's classroom. Five students were randomly selected for brief semi-structured interviews, each lasting approximately 10 minutes.

Research Design and Role of Researcher

Guided by the qualitative inquiry framework, in an attempt to understand the students' and teacher's experiences learning environment, the research design is an evaluative case study (Merriam, 2001). The type of case study involves description, explanation, and judgment. Within this context, multiple data sources are used to examine the effectiveness of an intervention. In the current study, we examined the teacher's strategies, the participants' attitudes, and the unit's effectives through multiple data sources. Observations and interactions with the participants were overt, and each visit focused on defining the various teacher strategies and subsequent student responses, and on eliciting teacher perspectives following each observation.

Data Sources and Analysis

Interviews. The teacher participated in interviews before and after implementation of the unit. Interviews followed a semi-structured protocol. The pre-implementation interview elicited information regarding the teacher's background, the class characteristics, her beliefs regarding teaching and learning, and her pre-implementation preparation. In addition, the teacher and researcher conducted debriefing sessions after each day of the unit. Daily debriefing interviews centered on the teacher's perceptions of the unit and her student's progress. Post-implementation information regarding the experience, teacher attitudes, and perceptions of student achievement was also obtained.

Five students were selected at random and interviewed following completion of the unit using a semi-structured protocol. Students were asked to describe their experience with *Up, Up & Away!*, recommendations regarding what could make it better, and overall attitudes toward the unit. Teacher and student interviews were transcribed. We first analyzed for the purposes of identifying themes (Emerson, Fretz, & Shaw, 1995). A coding scheme was then developed according to the emerging themes, and the interviews were analyzed a second time and classified according to the codes to achieve data integrity.

Observations. All class sessions were observed with the primary intent to record instructional strategies, process, and participant interactions, which included teacher-group, teacher-student, and student-student. All observation notes were transcribed and analyzed to produce a coding scheme based on the emerging themes. The observation notes were then analyzed a second time and all classroom events were classified according to the codes.

Teacher Guide. Because the teacher chose to annotate the teacher guide, we considered this a valuable post hoc data source. Specifically examined for emerging patterns were her personal teaching notes and outlines, the components she selected to use, the components she did not select for use, and the handouts she created to supplement the original guide.

All observation, interview, and teacher guide codes related to strategies (i.e., the teacher giving feedback), events (i.e., a student asking a question), or attitudes (i.e., "PBL takes a lot of time") (Emerson, Fretz, & Shaw, 1995). Codes from the observations and interviews were examined for overlap, and collapsed into larger categories. Data were then analyzed a final time based on the revised scheme.

Student Achievement Measures. One achievement measure was student projects, which were assessed by two independent raters according to one of the three grading checklists: Balloon Design, Supply List, and Travel Plan. Student posttests provided a second measure of achievement. These were scored by the researcher and assigned a percentage grade. Descriptive statistics of the results were calculated.

Student Attitude Surveys. Descriptive statistics for each of the seven Likert-style items were calculated. Student responses to the three open-ended items were examined for consistent themes relating to their experiences within *Up, Up & Away!*.

RESULTS

Our primary focus in this study was to investigate the instructional strategies utilized by a teacher when implementing a hypermedia, problem-based learning unit. A secondary focus examined teacher attitudes, student attitudes, and student achievement. Results reported below represent the observations, interviews, the annotated teacher's guide, student project performance, student posttest performance, and student attitudes.

Teacher Interviews

The teacher interview data was used to inform research question one regarding teacher strategies and question two regarding teacher attitudes toward PBL. Overall interview results demonstrate the teacher prepared extensively as revealed through the description of her handout and lesson creation; however, she indicated feeling as if she misjudged the amount of time the unit would take. The teacher felt that the students enjoyed the unit and performed well. In general, the teacher's attitudes toward the unit were positive, but if teaching it again, she would allow more time for the activities.

Information solicited in the pre-implementation interview focused on background information, her beliefs concerning the nature of teaching and learning, and the manner in which she prepared for the implementation. She characterized her teaching style as diverse, stating:

> "I have a variety of approaches. I like to get kids involved in discovering things, rather than me telling them...I use a lot of questioning. In history, I like to ask, 'Why do you think this or that happened?" In math, I like to ask, "What do you notice about this pattern?" ...I like it if they are involved and active."

Additionally, she expressed her reliance on group work as a strategy. "I encourage them to help each other rather than come to me. The things I ask of them almost require it because some things can be fairly complex." She described students as often working together on projects or assignments, reiterating, "They get a lot of value out of working together, and sometimes students know better how to help each other..."

In response to questions regarding her preparation for the implementation, the teacher stated she went through each activity, added notes to herself, and then proceeded to prepare outlines for each day of implementation. She then separated the components and created daily plans.

> "I planned for a different idea or topic each day. I had to read a lot, and I checked out all the resources on the CD, including doing research on my own about the jet stream...I also thought about my own ideas. Where could I add from my own teaching ideas to this unit?"

After planning for each day, the teacher reported she examined what was required of each student for completing the tasks, and subsequently determined the handouts they would need. To help the students stay organized, she explained creating folders into which the students would place the handouts. She used several handouts from the unit materials and also created her own. "The handouts," she explained, "will let students know what to finish for each day." For example, on the second day of instruction, the teacher intended for students to research the three different types of balloons, components of each type, and the pros and cons of each. She provided each student with a form from the teacher's guide that provided students with places to record the three balloon types, information, and pros and cons about each.

The teacher participated in daily debriefing sessions after the instruction. Each day, the teacher verbalized feeling a sense of stress resulting from time constraints. On the first day, she reported, "We need more days. We didn't get through what I wanted. I don't know how it will go. I wanted to get through the information log and talk about brainstorming…I planned for too much… [For next session] I might have to change the plan." Each subsequent day of implementation was marked with similar statements: "we don't have time to finish everything."

However, as students proceeded through the implementation, she also conveyed a sense of satisfaction concerning their progress. On day two, she expressed, "They were confused at first, and that was actually good because I want them to see that this is difficult. They seem to be getting it, the idea of how balloons work. I feel good about where they are." By day four of instruction, she sensed the students had worked through most of their confusion, and stated "They are enjoying it more now that they're all close to the same place [of progress]; some will have homework, but we'll be on track for next time. At least they're understanding it for the most part." On the final instructional day (day five), she summarized her thoughts regarding student progress, saying "I don't feel that good as a whole, and it's hard because of time. Some of the students didn't finish, and now they'll have to [finish their projects] for homework…those who did finish, I think, really learned a lot, but the time just got away."

Following the implementation, the teacher again expressed frustration in lacking ample time to complete all the work. In fact, there was a post-unit review and reflection activity from the teacher's guide she wanted to use with her students, but did not have time to use, saying "I wanted to make a little game out of the review, but we didn't have time for it."

Despite the time pressures, she was generally satisfied with students' experience. "I think they really got a lot out of this, and it was very different for them. They liked the project. I know some of them felt rushed, but that's just how it worked out." However, after showing her the students' posttest and project scores, the teacher expressed surprise at students' performance.

She had anticipated they would have higher achievement, and stated most students usually performed at the A or B grade level in her course. She attributed this mostly to lack of time, saying "Well, we just had so little time."

Her overall attitude toward problem-based learning reflected a positive experience. She stated, "Though I never taught that type of problem-based project before and I wasn't familiar with the content, the structure gave me everything I needed…but, I couldn't have done this without the teacher's guide. I really needed that material, and it helped me to think about where to add in my own ideas."

Observations

The primary researcher observed each session to determine what instructional strategies the teacher implemented during the PBL unit. Overall observations of instructional strategies revealed the teacher structured each session in a similar manner each day: introduction with feedback from the previous session (if applicable) and guiding questions; mini-lecture or demonstration related to new concepts; statement of expectations regarding what students should accomplish during the current day; student research with guidance from the teacher; and lesson closure. During student inquiry, the teacher constantly circulated, probed for student understanding, and provided feedback. At the end of each class session, she collected student folders, examined them, and returned them to students with written feedback. While feedback was suggested in the teacher's guide, it is important to note that she devised her own folder scheme and feedback method, rather than using the available form from the teacher's guide.

On the first day of instruction, the teacher asked students to select a partner and provided each student with a color-coded folder – each student in the pair had either a red or yellow folder. She used the color-coding as a means of assigning roles and responsibilities throughout the implementation, such as who would be responsible for the CD-ROM. Before each class session, the teacher would also place informational handouts or checklists for students to consult which supported their research efforts or detailed the day's expectations.

The teacher began each daily activity with a set of written goals, and structured the plans accordingly. Each day began with an orienting question or set of questions, such as "Who can describe what we know?" The teacher then solicited responses from students and asked follow-up questions. Next, she tended to provide feedback to the class as a whole. For example, after reviewing students' research as it related to the jet stream and why winds blow, the teacher found that many students were having difficulty distinguishing between the three different types of balloons. She began the subsequent class session by saying, "Let's review the three types of balloons because I'm not sure everyone understands the differences between all three." She then proceeded to elicit information from the students, providing them with feedback and instruction where necessary to address any misconceptions.

After orienting students and providing group feedback, the teacher focused on the new concepts for the day, usually in the form of a mini-lecture or demonstration. For example, on day two she wanted to show that hot air rises, but did not have the materials available for the demonstration suggested in the teacher's guide. Rather, she planned her own illustration with a half-inflated helium mylar balloon tied with paper clips on the string for use as weights, and a hair dryer. Before heating the balloon with the hair dryer, she planned questions to ask students such as, "What will happen when I heat the balloon with the dryer?" After soliciting several responses, she demonstrated that the balloon will rise when heated. Following this, she asked students to explain the motion of the balloon, inquiring, "How was it able to rise if we did not remove any weight?"

Following the mini-lecture or demonstration, the teacher set the expectations for the focus of students' research efforts. Students then worked collaboratively with their partners to complete the day's tasks. The teacher subsequently circulated to gauge students' progress, continually prompting them to describe their understanding. As students worked to complete their research and create a solution to the problem, they posed many questions. The teacher would often recommend that students ask their partner or consult with a specific peer.

The teacher closed most of the sessions with a short review, allowing students to report their progress. For example, at the end of day two, the teacher gathered the students together and asked, "What did you find? Raise your hand and tell." Students reported the different balloon types they had found. The teacher followed with, "What is the Roziere? What are the parts? Jason, you found that out. Tell us what you know." She then proceeded to have students summarize what they had learned about the other two types, and presented students with a homework assignment to be turned in the following class session.

Annotated Teachers' Guide

The instructor's annotated version of the teacher's guide and her lesson plans were also used to determine what types of strategies were utilized. Her notes within the guide itself tended to relate mostly to familiarizing her with the content, and organizing her understanding of it. For example, the information related to winds and jet stream instruction contained summary notes, such as "jet stream = 300 mph," and clarification regarding jet stream directions in each hemisphere. Her written lesson plan for this content contained information directly quoted from the teacher's guide, such as "[Jet streams] are caused by differences in the earth's surface temperature and are found where the biggest contrast occurs, usually where cold polar air meets warm tropical air."

Additionally, her lesson plan contained an extension of the previous day's plan related to the thermodynamic processes of heat and density. The teacher directly planned a connection between density as it relates to balloon flight, and density as it relates to jet stream winds. It is important to note that this connection was not made within the teacher's guide; rather, the teacher furnished this information independently.

Outlines the teacher created for each class session all consisted of an introduction, a list of questions to ask students in the inquiry, a mini-lecture or demonstration, directions for modeling use of the day's handout, and a summary of expectations she hoped the students would meet for the day. The elements from the *Up, Up & Away!* guide incorporated most consistently by the teacher were the questions relating to various concepts. For example, she used such questions as "What prevents us from climbing into the jet stream and just letting it take us wherever it's blowing?" and "What pushes a balloon through the air?" Additionally, the teacher's daily lesson plans contained significantly more detail than was provided in the teacher's guide.

Student Achievement and Attitudes

The third research question examined student attitudes and achievement. Mean scores and standard deviations for project achievement are reported in Table 1. On average, students achieved a higher percentage of points possible for the Supply List, while scoring the lowest on the Balloon Design. Mean scores and standard deviation coefficients for posttest results are reported in Table 1. Students performed within the average range, ($M = 17.5$ out of 27 points possible).

Means and standard deviations for responses to the attitude survey items are reported in Table 2. Results represent Likert-scale responses ranging

Table 1

Mean Scores and Standard Deviations for Student Project and Posttest Scores

	Points Possible	Mean	Standard Deviation
Balloon Design	13	8.2	4.4
Supply List	14	9.8	2.1
Travel Plan	16	13.4	2.3
Posttest	27	17.5	4.2

Note: 19 students completed the project and posttest.

from 1 (*strongly agree*) to 4 (*strongly disagree*). These data suggest that most students would enjoy completing a project like *Up, Up & Away!* again (M = 1.8), and that using the Web site was easy (M = 1.6). However, most disagreed they had enough time to complete the project (M = 2.6), or that the project was fun (M = 2.6).

Student responses to the open-ended question regarding what they liked suggest overall that they liked working with the *Up, Up & Away!* Web site and working on the project, namely finding out about balloons, balloon flight, and designing the balloon. Several expressed they liked the sense of "being in control," and doing something "new and different."

Students were also asked what would have helped them do a better job on the project and what would make *Up, Up & Away!* better. Almost all stated they needed more time to research and complete the project. Along with that, several also stated they wanted to be given more information. A few suggested they would have preferred to make an actual balloon model rather than just a drawing of their balloons.

Of the five students who participated in brief, post-implementation interviews, three mentioned a need for more time in the process. They all thought the CD was easy to use, and three students mentioned the project was "cool" or a "cool idea." When asked to provide ideas for improvement, one suggested a need for more "multimedia – videos on what could happen when you are flying." Another suggested he would prefer to actually build a model, not just draw the balloon.

Table 2

Means and Standard Deviations of the Student Attitude Survey

Item	***N***	***M***	***SD***
Working on the *Up, Up & Away!* project was fun.	19	2.6	.76
Using the *Up, Up & Away!* Web site was easy.	18	1.6	.51
It was easy to find the information I needed to complete the project.	19	2.1	.74
I had enough time to complete the *Up, Up & Away!* project.	19	2.6	.82
I learned a lot while completing the project.	19	2.1	.76
I worked hard on the assignment.	19	2.3	1.01
I would enjoy working on another project like this again.	19	1.8	.55

Note: Responses ranged from 1 (*strongly agree*) to 4 (*strongly disagree*).

DISCUSSION

The purpose in this case study was to examine the instructional strategies utilized by a classroom teacher as she implemented a hypermedia, problem-based unit. In addition, the unit effectiveness was examined with regard to student achievement and attitudes, as were teacher attitudes toward the implementation.

Instructional Strategies

Our first research question focused on examining instructional strategies employed by the teacher. Results revealed the teacher prepared extensively for the implementation through creating lesson outlines, which included demonstrations, mini-lectures, and expectations of what the students were to finish each class session. Each class session was structured similarly: she began with feedback and guiding questions, delivered a demonstration or mini-lecture, and told students what was expected for that day. Guided by a handout to help support the task, students then worked with a partner to meet the expectations. The teacher proceeded to circulate, ask questions, and provide guidance during this time.

Four consistent instructional strategies emerged from the analysis of observations, interviews, and instructional materials: questioning, reliance on peer support, feedback, and management. Each of these is discussed in more detail below.

Determined and Extemporaneous Questioning. Throughout her pre-implementation interview, the teacher expressed intentional use of questioning to promote student thinking, which she also planed for in this lesson. Use of questioning as a strategy supports what Hand and Vance (1995) view as essential in inquiry-oriented science classrooms. They state, "In adopting questioning approaches which seek to determine students' knowledge, teachers now have to interpret students' responses to questions, and determine how closely these responses fit the essential concepts defined for the unit" (p. 42). In doing so, teachers can continually gauge students' progress in relation to the learning goals, as was the case with the *Up, Up & Away!* teacher.

Questioning in PBL contexts has also been identified by Hmelo and Ferrari (1997) as an important strategy. Use of questions can highlight key aspects of the content domain and demonstrate how students should be thinking about the problem-solving process. This is especially important for students who may lack the cognitive tools required to ask such questions of themselves. Teachers who prompt students' thinking in this manner are modeling an essential strategy (Hmelo & Ferrari, 1997).

Substantive Reliance on Peer-to-Peer Support. Another strategy articulated by the teacher throughout the interview process was intentional reliance on having students depend on their peers. Effective use of peer support has been identified by Salomon (1993), who employs the term "distributed cognition." Rather than placing an equal and separate cognitive load on each student, peer support can distribute the load. Some students have the ability to assume more of the load; thus, their understanding becomes highlighted, while others benefit from the shared knowledge.

Because the *Up, Up & Away!* teacher spent significant time monitoring individual progress through analysis of their folders and continual circulation, she may have been more aware of each student's understanding. Thus, when students came to her with general knowledge questions, she may have been better able to direct them to peers she knew could help. This strategy appears to have enabled her to spend time with the students most in need of her attention, while also helping ensure all students received answers to their questions. She was then free to continue monitoring and helping students with more complex questions as they related to the process for solving the problem. As Hand and Vance (1995) denote, effective use of peer support and questioning relies upon the fact that the teacher employs techniques that will provide an accurate mental checklist of individual students' understanding and manage students' questions efficiently.

Individual and Group Feedback. The teacher established a systematic means of providing feedback to each student through the folder system. This system allowed the teacher to track students' progress each day and provide them with individual written feedback as needed. The instructor's understanding of the role of feedback corresponds with other researchers who describe iterative forms of feedback to deepen understanding and product quality (Barron et al., 1998; Gallagher, 1997). Wood, Bruner, and Ross (1974), who studied the tutoring process of experts working with novices in a problem-solving environment, suggest that feedback represents a key element, as the tutor can narrow the domain and mark critical features for the learner.

In order for feedback to be most effective, experts should possess two theoretical models: one that encompasses a deep understanding of the task or process and another which specifies the desired performance characteristics (Wood, Bruner, & Ross, 1974). In the context of *Up, Up & Away!*, the teacher appeared to consistently hold a model of desired performance criterion in her mind, and provided feedback in relation to those criterion. As students progressed, she continually monitored their progress, and expressed more satisfaction with their work.

Structured Management of the Environment. The teacher ensured students were on track through establishing clear, attainable goals and communicating daily expectations. Other researchers have found teachers employ similar structuring techniques. In early *Jasper Woodbury* experiments, researchers found that some teachers tended to structure the problem solving process as a strategy for implementation (CTGV, 1992). Wood et al. (1974) found expert tutors "reduce the degrees of freedom" to make complex tasks more manageable. Salomon (1993) has defined this as "off-loading," a term describing the process of reducing opportunities for the purposes of minimizing unnecessary complexity, thus allowing people to better focus in higher-level cognitive demands.

Because the teacher in the current study knew her students well and because she had not used problem-based learning previously, it is not surprising she applied a more didactic approach in the implementation. Time constraints often disallow a more open, investigative process, and the pressure teachers feel to "get through the content" is often palpable (Hmelo & Ferrari, 1997).

Teacher Attitudes

Our second question in this investigation concerned teacher attitudes toward problem-based learning as a result of her experience. Overall, her attitudes were positive. Initially, she was pleased with students' performance, but when presented with the achievement results, she expressed disappointment that students had not performed better, attributing their performance to lack of time. In fact, "lack of time" consistently reflected the teacher's attitude throughout the implementation. The teacher's frustration expressed in regards to time is consistent with other findings of problem-based learning contexts (Maor & Fraser, 1996; Rhodes, 1999; Pierce & Jones, 2002). While teachers tend to value the problem-solving process, researchers suggest there is an on-going tension between "covering the content" and engaging students in the problem (Hmelo & Ferrari, 1997).

This tension was evidenced in the context of *Up, Up & Away!* to the degree that an important component of the unit was omitted altogether in the interest of time: the post-unit review and reflection. The teacher had initially planned for this, and stated they would present projects and play some type of game before the test. Other researchers have noted teachers abandoning post-unit reflections. Hmelo and Ferrari (1997) described this as more typical than not, but stated, "[This] is unfortunate because [reflection] provides an opportunity for students to consolidate and abstract what they have learned" (p. 416). In the case of *Up, Up & Away!*, time constraints prevented students from participating in post-reflection and review.

Student Achievement and Attitudes

Our final focus in this study examined student achievement and attitudes regarding the implementation. Student achievement was average overall. However, the teacher was not completely satisfied with students' performance, expressing she normally expects higher achievement from this group. Lack of higher achievement may have resulted from the inability to complete the post-reflection and review associated with time constraints noted above. Additionally, other researchers have noted students' difficulty in negotiating new roles with more open-ended environments, which can contribute to lower achievement (Brush & Saye, 2000).

It is important to note that students displayed differential performance for the various strands: Balloon Design, Supply List, and Travel Plan. On average, students received the highest percentage of points on the Supply List, while receiving the lowest percentage of points on the Balloon Design. It is likely this resulted from the Supply List task reflecting an easier process. For one thing, the task of designing the Supply List involved reading what other teams took in real life, and accounting for food, water, and safety needs. This is more of an informational problem-solving task (Wolf, 2000), rather than a complex problem-solving task. In short, a good Supply List could be devised from active reading and logical rationale to support students' choices. In contrast, the Balloon Design consisted of providing a more complex and technical response to be considered high quality. Students needed to evaluate the various types, select a balloon, include the design features, and provide a rationale for their choice, making it a more difficult task.

Overall, *Up, Up & Away!* was effective with regard to attitudes, which were generally positive. However, almost all students expressed frustration at not having enough time to research thoroughly and complete the project. Despite this frustration, almost all the students agreed they would like to work on another project similar to *Up, Up & Away!* in the future.

It is not surprising the students in the current study expressed frustration with regards to lack of time. Other researchers have found that transitioning students to PBL environments can be frustrating (Schmidt et al., 1992). Additional time may have allowed all students to complete the unit activities and may have allowed the teacher to implement the full plan, which included a post-unit reflection and review.

SUMMARY

The investigation of strategies employed within a problem-based learning unit revealed the teacher used questioning, peer support, group and individual feedback, and structured management. Certainly, most instructional designers view these strategies as integral components of any learning environment (Sullivan & Higgins, 1983; Johnson, Johnson & Holubec, 1994; CTGV, 1992), not just those problem-based in nature. One interesting outcome of this investigation is that the teacher was able to effectively activate and bring these strategies to bear within an unfamiliar teaching context. In this way, the process for the students narrowed and it seemed their efforts became more efficient, striking a more comfortable balance for the teacher.

This study has implications both for the design and implementation of PBL environments. As teachers are increasingly expected to teach larger classes and meet objective state standards, it may be difficult for them to invest a significant portion of their time and effort in order to effectively implement PBL units. It is possible that instructional designers of problem-based environments can support teachers' efforts through overt integration of questioning, collaboration, feedback, and management strategies within the instructor materials. These strategies represent effective instructional practice, and means for using them within the context of problem-based environments may potentially lead to greater teacher satisfaction and student achievement (Saye & Brush, in press).

Future research should examine additional strategies for supporting teachers as they implement inquiry-based units. Brush and Saye (2000) have discussed the need for additional means of support, one of which is to facilitate the teacher's efforts to provide immediate and spontaneous assistance to students throughout the inquiry process. Further research in this area may provide valuable insight into effective strategies for implementing problem-based activities in traditional classroom contexts.

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