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ABSTRACT

The Jasper Challenge Series of Vanderbilt University (Tennessee) has been used in conjunction with the university's videodisk problem-solving series, "The Adventures of Jasper Woodbury," to provide a teleconference-based performance arena that allows students and teachers to assess the degree to which they are learning to solve the kinds of problems that the Jasper series emphasizes. Students from a number of sites using the Jasper program jointly participate in teleconference challenges that allow them to choose the characters in the teleconference who do the best job of solving problems. They receive feedback and compare their ideas with peers from other cities and states. Pilot Satellite Challenges have been uplinked to over 30 sites across seven states. These Special Multimedia Arenas for Refining Thinking (SMART) challenges are described, and the challenge-based assessment model that has developed is explored. The first SMART challenge involved over 500 fifth and sixth graders in a game show called "Pick the Expert." A subsequent challenge involved a large group of students in a more difficult game show. A third challenge involved a single local classroom in a developmental exploration of teaching and learning before the challenge. Future plans for the SMART program are discussed, and the model that is being developed is reviewed. (Contains 15 references.) (SLD)

Extending the Impact of Classroom-Based Technology: The Satellite Challenge Series

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EXTENDING THE IMPACT OF CLASSROOM-BASED TECHNOLOGY: THE SATELLITE CHALLENGE SERIES

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ABSTRACT

The impact of classsroom-based technology on learning can be extended through the innovative use of distance learning technologies. Vanderbilt University's Jasper Challenge Series is one example of the possibilities that exist. The Challenge Series has been used in conjunction with Vanderbilt's Jasper Woodbury Problem Solving Series. It provides a teleconference-based performance arena that allows students and teachers to assess the degree to which they are learning to solve the kinds of problems that the Jasper series emphasizes.

In the Challenges, students from a number of different Jasper sites jointly participate in teleconference-based challenges that allow them to "test their mettle" by choosing the characters on the teleconference who do the best job of solving some difficult problems. Students need to be expert problem solvers in the domain being investigated in order to make the appropriate choices. Students call in their votes at the end of the challenge and have the opportunity to compare their ideas with those of peers from other cities and states. They then receive feedback about the strengths and weaknesses of each choice. Later, they get a chance to participate in new, video-based challenge. The Challenge Series also provides a forum for displaying student-generated projects that are relevant to the theme of each challenge.

Discussion will focus on the lessons learned from our first four Challenge Series pilots. Teachers' reactions to the challenges will be discussed as well. It will be argued that the general approach of the challenge-based assessment model we have developed can be used to enhance formative assessment and subsequent learning in any problem or project-based curriculum. Design principles for successful Challenges will be enumerated and discussed.

INTRODUCTION

The Jasper Satellite Challenge Series is a prototype for a new form of interactive, challenge based assessment which is designed to be applicable to any project based curriculum. Initially developed within the context of Vanderbilt University's The Adventures of Jasper Woodbury problem solving series, a series of videodisc based adventures designed to develop mathematical problem solving and critical thinking skills in middle school students through collaborative learning, the Challenges provide motivating public performance arenas that allows students to "test their mettle" with respect to the Jasper adventures and extensions.

Students and teachers in multiple classrooms at remote sites form a community of learners linked together by teleconferencing technology. These students participate in a specially prepared, interactive television show. During the show students' answers are relayed to our studios by phone and these data are then graphically presented to students so they can see how their answers compare to those of their peers in other cities and states. The challenges provide an opportunity for students and teachers to engage in formative self assessment.

Over the past two years the Cognition and Technology Group at Vanderbilt has conducted three pilot Satellite Challenges that have been uplinked to over 30 sites across seven states (Cognition and Technology Group at Vanderbilt (CTGV), 1992a). Variations on the satellite events are continuing to be developed and studied. We eventually named these events SMART

Challenges, where SMART stands for "Special Multimedia Arenas for Refining Thinking." In this article we describe the evolution of the SMART challenges and discuss the challenge based assessment model that has developed.

BACKGROUND

There have been two major forces behind the development of the SMART Challenges. One is the recognition of a need for learning communities in which students, teachers, school administrators and community members can engage in continual processes of inquiry and knowledge building. The other is a need for alternative assessment that can help to inform and reform the curriculum as it is currently practised. Systemic assessments (Fredericksen & Collins, 1989) can provide immediate and ongoing feedback to teachers and students, helping them to improve the quality of their teaching and learning within a complex problem solving curriculum. They can also be used to help collect data that can be analyzed and function as a means to evaluate the program and its effectiveness. The first SMART Challenge emerged as a response to our experience implementing the Jasper series in nine states (CTGV, in press). Since then the Challenges have been piloted three times and refined as a result of our research experiences.

SMART CHALLENGES

Leading to SMART Challenge I

The importance of the community of learners model was recognized in the design of the nine state *Jasper* implementation project conducted in 1990-91 and use of this model was found to be increasingly more important as the project progressed. In the planning of the implementation project it seemed clear to us that the teachers who were going to teach Jasper needed to feel part of a community that was larger than themselves. This was why we had attempted to have a minimum of two Jasper teachers per school, and why we had paired each Jasper site with someone from a local corporation who could offer technical and motivational support.

Based on the research literature on the development of skilled performance and expertise (e.g. Chase & Simon, 1972), it also seemed clear that even the two weeks of intensive professional development that we were able to offer our teachers and corporate representatives would need to be supplemented with ongoing opportunities for learning. We assumed that our corporate representatives would be particularly helpful in answering questions about the technology the teachers were using, but we also anticipated questions about pedagogy. This was why we provided all our teachers with an electronic account to American Online. Our thought was that teachers would use this to contact our center; we had people on staff whose job was to monitor their messages and respond. As we discuss below, there were reasons why this resource was underutilized.

As the first year of our Jasper implementation unfolded, we began to discover additional reasons for focusing attention on a learning communities model. One involved the importance of support from within the school. Nearly every one of our teachers commented that their ability to implement the new ideas associated with the Jasper curriculum was affected strongly by the strength of support from their school principal. There is a research literature that emphasizes the importance of support from the principal (e.g. Hallinger & Murphy, 1993; Murphy, 1991;) but we had been only dimly aware of it at that time. Therefore, we did not systematically help teachers focus on plans for developing school wide and community support.

Luckily, many of our teachers implemented their own plans for developing support from school and community members. For example, they invented ways to help parents and other community members understand the value of Jasper and the experiences related to it Several of our teachers invited parents and other adults to solve a Jasper adventure, and they used the students as "experts" to keep the adults from getting too far off track. This idea proved to be a very powerful approach to community building. We have used it many times in our own community--always with extremely favorable results.

An additional positive outcome that often accompanies opportunities for community members to solve the Jasper problems is that they often volunteer to help students learn more about topics featured in the Jasper adventures--topics such a boats, airplanes, principles of flight, eagles and other endangered species, recycling, and ideas for viable business plans. And teachers often got community members to help when students created and implemented their own projects such as their own trips to interesting locations, funded by their own business plans.

Another reason for building learning communities emerged several months into the year, when we saw that only a subset of the teachers were making regular use of America Online to communicate with us and with one another. A major reason (which was obvious in retrospect but not in prospect) was that they had almost no free time during school hours for doing this, and since they did not have computers and modems at home they could not communicate from there. In addition, there was usually no compelling reason for them to communicate with one another and with us. We began to think about the possibility of developing high stakes events that would stimulate a greater exchange of ideas and information.

In addition to our observations of how busy our teachers were during the school day, we noticed how many types of local events took precedence over Jasper-related activities, even though teachers and students wanted more time to work on Jasper. Events such as state mandated testing represent cases in point. We began to see that attempts to change (and hopefully improve) the nature of teaching and learning in classrooms will always compete with other priorities and that a major factor for change might be to create new priorities that are viewed by the community as even more important than the competing ones. Again we were led to including high stakes events within the Jasper curriculum.

Finally, we began to see the importance of mechanisms for creating a dynamic curriculum. For example, individual teachers frequently generated new ideas for teaching Jasper concepts and for linking them to other areas of knowledge; we wanted to be able to communicate these ideas to other teachers. At the same time, our observational and interview studies (e.g. CTGV, in press; Goldman et al, 1991) were helping us find ways to improve the learning of students. For example, by using "what if" questions after solving particular Jasper adventures, we were able to help students deepen their understanding and make transfer more flexible (e.g., CTGV, 1993). Similarly, we discovered ways of constructing visual representations of situations that made especially difficult concepts easier to comprehend and communicate. And as we worked with local teachers to use these insights to improve the learning experiences of their students, we began to see that middle school students could reach higher levels of performance than we had anticipated initially. We wanted to find ways to communicate these possibilities to other members of our collaborative team. So we began to consider design principles for building a learning community that was capable of continual evolution and change.

Other lessons we learned from the nine state Jasper implementation not only emphasized the importance of fostering learning communities, but they also pointed to a need for alternative forms of assessment to provide feedback to students, teachers, and outside evaluators, including our research team.

During the year of the nine state implementation we received data from the sites about performance on our assessment instruments. There were clear indications of effective learning and transfer in all sites (see especially CTGV, 1992a; Pellegrino et al, 1991). Nevertheless, we also noted that many students' scores were far from perfect and that there was often considerable variability in performance across different schools and classes within schools--even in cases where pretest scores on standardized math achievement tests would suggest that students should perform relatively similarly. This led to the conjecture that different teachers were probably teaching the Jasper adventures differently and that this affected the quality of their students' learning. Observations of classrooms within our local area reinforced this belief. So we began to think about ways to help the teachers, as well as our research team, continually re-assess the quality of teaching as well as the standards of achievement that were reasonable for students. In many classes, we felt that the standards were too low.

From the nine state project we also discovered that teachers and especially students had grown to hate the paper-and-pencil assessment instruments that we had developed and administered (e.g., CTGV, 1992b). This prompted us to think about ways to preserve the value of assessment for learning (especially formative assessment) without making the students and teachers feel "tested." The metaphor we preferred was to give students a sense of being mentored by people who were on their side and wanted to help them achieve remarkable levels of performance. Clearly new models of assessment were needed.

Together these experiences led to our first design of a challenge based assessment model, which incorporated the development of a community of learners located in several states. This challenge based assessment experiment, SMART Challenge I, made use of teleconferencing technology.

SMART Challenge I: Pick the Expert

Our initial SMART Challenge involved one special event, a satellite teleconference focused around a game show called "Pick the Expert." Over 500 fifth and sixth grade students in 7 states prepared for and participated in the Challenge through the following stages:

1. Complete an adventure.

Students began to prepare for the "Pick the Expert" challenge by working with the Jasper adventure "Rescue at Boone's Meadow". In this adventure, Jasper finds a wounded eagle while on a fishing trip in the wilderness. By radio, he is able to communicate his location. Students help Emily, one of the characters in the video, as she plans to rescue the eagle. Solving this adventure, the students must evaluate a number of options such as the use of a car, an ultralight, or walking, while a considering numerous constraints such as speed of travel, distance, weight of cargo, and so forth. There are a number of possible options for saving the eagle; students discuss the strengths and weaknesses of each plan that they generate.

2. Solve relevant analog and extension problems.

After solving the rescue problem and discussing alternative plans, the students further prepared for the Jasper Challenge by solving related video-based analog and extension problems that engaged students in "what if" thinking such as: (a) What if the gas tank on the ultralight held 4 rather than 5 gallons?; (b) What if the ultralight faced a 4 mile per hour headwind on this (shown on video) part of its flight? Students also worked with extension problems such as considering the issues that Charles Lindbergh had to consider when planning his flight from Paris to New York (he would have run out of fuel had he not had a tailwind of at least 10 miles per hour).

3. Participate in a Teleconference Based Uplink Event.

The SMART Challenge involved a game show, "Pick the Expert," that featured three college students as contestants. Each claimed to be an expert on flight and on the Jasper adventure "Rescue at Boone's Meadow." Each "expert" was asked a series of questions about flight, including information about the effects of headwinds and tailwinds and whether, on a round-trip flight, a 10 mph headwind (on the way) and tailwind (on the way back) would cancel one another out (they wouldn't). Students knew that their task was to listen to the experts' answers and judge for themselves who was the true expert. A representative from each class would call in their votes during the live teleconference.

The answers given by the expert contestants were scripted. All contestants were correct on the first round of questioning. By the fourth round everyone except the true expert had made some erroneous arguments. It was at this point in the teleconference that the students were to call in their votes.

Reactions to SMART Challenge I

The teleconference turned out to be an extremely popular event for our Jasper sites. First, students enjoyed the preparation phase for the challenge. We knew from previous data that students liked solving "Rescue at Boone's Meadow" (stage 1, above). Our new data indicated that, in contrast to earlier reactions to our paper and pencil assessment instruments, students enjoyed working on the video-based analog and extension problems (stage 2, above). Teachers indicated that students felt they were learning something new (about headwinds and tailwinds) rather than simply going through the motion of practicing a specific set of "old" skills.

On the day of the teleconference (stage 3, above), videotaped and oral reports from teachers revealed groups of students actively discussing the strengths and weaknesses of each contestant's answers. At voting time, 85% of the students picked the real expert. To do so required them to understand that a trip of 65 miles with a headwind, followed by a return trip of 65 miles with a tailwind, did not mean that the headwind and tailwinds canceled each other out.

Lessons Learned from SMART Challenge I

In addition to the enthusiasm of teachers and students, we learned two more lessons from our initial SMART challenge that seem particularly noteworthy. First, the event was indeed high stakes for teachers and schools, and that had several advantages. Cables that were supposed to be run to a school "sometime soon" were run in time for the Challenge; uplinks that were slated "for the near future" became available in time for the Challenge; school events that might otherwise have interfered with working on Jasper and its extensions became second priority to the Challenge. In general, the Challenge seemed to help a number of things get accomplished that otherwise might have slipped by the wayside.

A second lesson SMART Challenge I was that it was less challenging than students had anticipated and wanted. A number of students wrote us that they associated Jasper with tough challenges, and that the Challenge had not been tough enough. Actually, the information that students had to understand (about the headwind and tailwind on a round trip not canceling each other out) was quite sophisticated. But it seemed easy to the students because their preparation activities were very close to the events that they had to judge on the game show. We had worried about too many students being wrong during our first Challenge, so we had created a close link between the preparation during phases 1 and 2 and the actual information needed for the Challenge. The students' comments suggested that we had erred on the side of making things too easy.

SMART Challenge II: Rate that Plan

Our second SMART Challenge also involved one special event, again a satellite teleconference. However, this time the challenge focused on a more difficult game show called "Rate that Plan." Students prepared for and participated in the Challenge through the following stages.

1. Complete an adventure.

Students began to prepare for "Rate that Plan" by working with the Jasper adventure "The Big Splash." In this adventure, Jasper's young friend, Chris, wants to help his school raise money to help buy a new camera for the school TV station. His idea is to have a dunking booth in which teachers could be dunked when students accurately hit a target. He must develop a business plan for the school principal in order to obtain a loan for his project. The overall problem centers around developing this business plan including the use of a statistical survey to help him decide if his idea would be a money maker. The problem posed at the end of the video is to prepare the business plan that Chris should present to the Principal. The problem can be approached from multiple perspectives and requires the evaluation of multiple elements and options to construct an acceptable alternative that meets the constraints originally set by the principal.

2. Solve relevant analog and extension problems.
Students next worked on "what if" extensions of "The Big Splash." For example, in "The Big Splash", Chris sampled every sixth person in the lunch line. What if he had sampled every fifth person who entered the school on Monday morning; 1/2 of all the students in his homeroom; or 70% of all the students at baseball practice? Similarly, Chris decided not to fill the dunking booth pool with water from a firetruck even though the water would be free because there was too much risk that the fire department would be called out on a fire. Students discussed the levels of risk that would be acceptable to them. The "what if" problems also included pitches by "hucksters" about their plans for the fun fair and why the plans were superior to Chris'. Many of the plans were flawed (e.g., some were based on nonrepresentative samples). Students learned to detect the flaws and explain how the hucksters' arguments could be improved.

3. Participate in a Teleconference-Based Uplink Event.
On the day of the teleconference students were asked to rate individual business plans on the basis of their effectiveness. These plans were proposed by contestants, each of whom was trying to sell a plan to the class as a way the class might work together to raise money for an imaginary school "Fun Fair." Embedded in the contestants' proposals were all the data students would need to assess the merits of an individual plan. Two of the three plans contained flaws such as the use of non-representative samples or inaccurate estimates of expenses. Students had 45 seconds to rate each plan and explain any flaws. They then had the opportunity to watch three college panelists who asked questions of the contestants and thereby provided additional information students could use for their ratings. Students were then given a second chance to rate each plan and explain what was good and bad. At the end of the show, students were asked to choose the plan they thought would be most effective for them at their school's imaginary Fun Fair. As in the previous challenge, students from all over the country called in their ratings for the best plan and were then shown the ratings of their peers, as well as the ratings of the college panelists who appeared on the show. Students also knew that they were to mail in their answer sheets which asked them to explain the reasons for their ratings.

Reactions to SMART Challenge II

As was true of the first challenge, teachers and students were highly enthusiastic. During the show, teachers reported that the discussions following the uplink were spirited and were motivated by the opportunity students had to compare their answers to those of peers across the country and to the college panelists who appeared in the uplink. A number of the teachers felt that the discussions were especially helpful to students who had originally overlooked flaws in various plans because it helped them improve their understanding of key aspects of statistics (e.g. random sampling) that were necessary in order to create effective business plans.

Some representative comments made by teachers on our survey forms include the following:

> *The Challenge broadcast is a much needed aspect of the project. It proved a great reinforcement of skills and allows many extensions to existing projects.*

The Challenge series aids in the continuity of the whole Jasper concept. Students consider themselves "experts" after solving each Jasper episode. They need opportunities to extend and expand their new found knowledge. Their skills need to be fine tuned so they (students) will continue to use these skills in everyday math situations.

I think the children enjoyed the culminating event.

Lessons Learned from SMART Challenge II

As with the previous challenge, we observed that a high stakes event such as a SMART challenge made things happen that otherwise might have taken a long time to accomplish. We learned three new lessons as well. The first was that our format was now too hard because students did not have enough time to evaluate the strengths and weaknesses of each business plan. We had been aware of this possible difficulty when planning the challenge, but had little choice because we had only one 45 minute time slot when all our classes could participate in the challenge, and we could not afford to go on the air for a second time slot. We had hoped that our use of the college panel to ask questions about each plan, coupled with the opportunity to rate each plan twice, would overcome the severe time crunch imposed by the constraints of linear television. But students remarked quite adamantly that they wanted the time to actually work through each business plan.

A second lesson we learned was that we needed information about students' reasons for choosing the best business plan rather than only the call-in-data we received about their choice for the best plan. As it turned out, the vast majority of the students choose a plan that was actually flawed--a plan to sell ice cream at the fun fair. Did this mean that they had not learned well while preparing for the challenge, or that their votes were based on something else?

It was not until we received the students' answer sheets with reasons for choices, plus had the chance to interview some students, that we were able to decide whether they had learned or not. As it turned out, many classes had learned well whereas other had not. Those who seemed to have learned were ones who explained that (a) the plan they chose was flawed (it was based on data from a very biased sample of respondents), but (b) it would probably have been the best plan even if the sample had been representative, In contrast, other students seemed to have voted for the ice cream plan without realizing that it was based on biased data.

We tried to understand why a number of students had not noticed flaws in several of the business plan. Was this because the concepts were too difficult for them or because the teachers had not prepared them for the challenge, (either because of a lack of time, lack of interest, or perhaps because of an inadequate understanding of the concepts required for the preparation)? In order to answer these questions, we decided that the next step in our research needed to be to keep a better eye on what happened in the classroom. This became the goal of our next SMART Challenges, IIIA & IIIB.

SMART Challenge III A: Local Presentations

In our third attempt to explore SMART challenges we decided to work with only a single local classroom so that we could carefully observe the teaching and learning sessions prior to the challenge and see how they related to the performance of students during the challenge itself. We upped the stakes of the challenge and the preparation for it, while dropping the teleconference format this time. After solving "The Big Splash" and its analogs and extensions, students were to work in groups to invent their own business plans and collect data to support their arguments about the viability of the plans (i.e., to estimate projected income and profit). For the culminating event each group of students would present its own business plan to a panel of experts and answer questions asked by these experts. These experts included local business, university, and educational leaders. If the plans were sound, the school principal would lend each group the money to actually carry out its plan.

The teacher with whom we worked on this project was an experienced Jasper teacher who has become an invaluable colleague. We observed his classroom daily for the 8 weeks of instruction that it took to complete this unit, and we worked with him to introduce some new instructional tools that we felt would facilitate student learning, including self-assessment devices. (reference this chapter) At the end of each day we were able to discuss ideas with the teacher through a computer-based two-way videoconferencing system that connected his classroom with the LTC.[1]

We were able to observe the effects of the students' self-assessment on classroom discussion and also the nature of classroom discussions about key mathematical concepts such as representative sampling, optimal sample sizes and so forth. In addition, we encouraged the teacher to give students multiple experiences for making presentations and we videotaped the progress of the students as they made their presentations--first about the income portion of the solution to "The Big Splash", then about their thoughts on expenses, later about their thought on the entire plan (income, expenses and degree of anticipated profit). Later presentations were about each group of students' own business plans and the data gathered to assess its feasibility. These were all in preparation for the culminating event, the presentations of the students' own business plans to the panel of community leaders.

Reactions to SMART Challenge III A

Our experienced teacher was extremely pleased by his students' progress. He had taught Jasper for three years and felt that, without a doubt, his students had reached levels of understanding and skill (including presentation skill) that he never before imagined possible for students of this age. Our panel of experts who interviewed the students about their own ideas for business plans was also extremely impressed by the high level of performance of the groups--including their abilities to think on their feet while answering questions asked by panel members.

Lessons Learned from SMART Challenge III A

Our classroom observations convinced us of the importance of helping teachers make the thoughts, feelings and skills of their students visible. One way that helped accomplish this was a simple device that provided frequent opportunities for anonymous self-assessment by the students. Our teacher felt that these assessments provided an excellent opportunity for him to better understand what the class was thinking or feeling and to then take appropriate action.

Probably the most important lesson learned from our classroom observations involved issues of professional development. A number of issues arose during class discussions that pushed all of us--the teacher plus members of our research team--to the edges of our knowledge. For example, what was a way to clarify the reasoning underlying the mathematical procedure used to estimate the best ticket price in "The Big Splash"? At a more general level, what are the general principles for deciding on sample size? This became important for students developing their own business plans. If their school population size was twice as large as the one in the Jasper adventure (Chris's population size was 360), should the sample size be 120, remain at 60 or what? Many members of our research group were not sure about the answers to these questions, and the same is true of teachers because they did not have the benefit of in-depth preparation in statistics when they attended school. In addition, most teachers with whom we have worked are not familiar with how visual diagrams can be used to help students understand complex concepts--diagrams that members of our research team found themselves using in order to communicate with one another.

These experiences helped us realize how much we as a research team rely on one another to continually learn new information that we need to know, and how difficult it is in most classrooms for teachers to have similar advantages. So we began to think about another important function for our SMART Challenges: To provide new information to teachers as well as students, and to structure situations so that we as a research team could also learn from the teachers and students. These goals shaped our work for SMART Challenge IV, which is discussed below. First, however, we discuss SMART Challenge III B.

SMART Challenge III B: Mentoring with College Students

This challenge was a variant of SMART Challenge III A and involved a new class of sixth grade students. The major difference in Challenge III B was the addition of a "two way mentoring" program involving the thirty sixth graders and thirty college students who were taking a class in "Cognition and Instruction" at Peabody College at Vanderbilt. Each class was divided into 6 groups of students, and each pair of groups (one from the sixth grade and one from the Peabody class) first met face - to - face. Subsequent interactions were carried out via computer-based two-way videoconferencing facilities that connected Peabody College with the sixth grade classroom. Each group of sixth graders and their respective college counterparts "met" for half an hour once a week to discuss students' progress as they proceeded from solving "The Big Splash" to creating and presenting their own business plans.

Reactions to SMART Challenge III B

SMART Challenge III B is still ongoing as we write this paper. Nevertheless, we have already observed a number of reactions to it that seem very clear.

First, the experience for the college students has been valuable. It provided them with the opportunity to see a number of the issues discussed in class actually exemplified in the real world. For example, several of the college student groups were worried that their sixth grade students seemed to take no initiative in thinking through issues such as how to begin problem solving or to present their ideas in a coherent manner. Instead, they simply wanted the college students to tell them the answers. Experiences such as these brought to life a number of class readings and discussions that focused on the fact that many students have not learned to think for themselves in a wide variety of domains.(e.g., see Bransford, Goldman & Vye, 1991, Nickerson, 1988; Resnick, 1987). When the college students encountered these problems in the sixth graders, the issue of teaching thinking they became much more real to them. It was then possible to help the college students devise strategies that would help make the sixth graders more generative in their activities and to relate this to course readings and discussions.Overall, the introduction of the mentoring activities had an extremely positive effect on the college class.

Second, the sixth graders learned a great deal from the mentoring experiment. The teacher indicated that they looked forwarded to meeting with their college group and viewed them as mentors rather than as "testers". The sixth graders also began to discover that the college students were human; many of the sixth graders seemed to begin the project with the misconception that "smart" college students would have no trouble solving a problem like "The Big Splash." It was very helpful to them to hear that the college students had solved the problem in their class and had found it very challenging. In fact, the majority of the college students did not come up with optimal solutions on their own. In addition, it was helpful to the sixth graders to learn that a number of the college students were also quite nervous about making public presentations to groups.

Lessons Learned from SMART Challenge III B

An important lesson is that a number of logistics issues must ultimately be solved to make mentoring activities run more smoothly. Interruptions to the schedules of the middle school students were frequent and often sudden. Unfortunately, quick communication with the college students was usually difficult. In addition, substitute teachers often did not feel comfortable with the videoconferencing technology and did not want to use it. For projects of this kind, there is a need to ensure that teachers, substitute teachers, college professors and college students are more easily able to communicate. We are working on alternative telecommunications facilities that should facilitate this process.

Another important lesson is related to the "need for professional development" lesson learned in Challenge III A. Like many middle school teachers, most of the college students had not yet had courses in statistics and hence quickly found themselves on the edge of their knowledge when attempting to work with the sixth graders. This provided further motivation to increase our focus on the role of professional development in SMART challenges, as addressed in Challenge IV, below.

SMART Challenge IV: Toward More Frequent Opportunities for Mutual Learning

SMART Challenge IV is just beginning to be implemented as we write this paper. Based on lessons learned from the earlier SMART challenges, it is designed to assess the value added of increasing the opportunities for mutual learning by teachers, students and our research team. It culminates in a special live televised event called "The Big Challenge", which is a variant on SMART Challenge II's Rate that Plan game show. It involves a number of experimental and control classrooms, which differ in their preparation stages.

The control classrooms in SMART Challenge IV receive experiences similar to those discussed in SMART Challenge II, above. Students prepare for The Big Challenge by solving "The Big Splash", solving analog and extension problems relevant to it, and then spending several days generating their own business plans and deciding how they would collect data to estimate the projected income for their plans.

Students and teachers in the experimental classrooms are also preparing for the live TV show The Big Challenge by solving "The Big Splash", solving analog and extension problems relevant to it, and then spending several days generating their own business plans and deciding how they would collect data to estimate the projected income for their plans. In addition, students and teachers in the experimental classrooms are provided with more frequent opportunities for mutual learning. This occurs by way of four special video-based programs that occur prior to The Big Challenge. The first program provides an introduction to the series; the purpose of the three remaining programs is to help students and teachers focus on specific sub-challenges while also providing opportunities to (a) compare their answers to those of students in other experimental classrooms throughout the city and (b) see models of powerful ways to express ideas.

At the end of the preparation stages, both experimental and control classrooms participate in the live interactive "Big Challenge" show that allows them to test their mettle with respect to a number of issues relevant to business plans and "The Big Splash." Data we are collecting both during and after this challenge will help us assess the value-added of the video-based programs made available to classes in the experimental condition. We expect to find advantages for student understanding, for students' abilities to give clear presentations (including their use of graphics to communicate effectively) and for teachers' understanding of statistics and how they can help students to better understand statistical concepts.

Future Plans

Our hope is that SMART Challenge IV will provide us with information and experience that will allow us to refine our ideas during the summer of 1993 and prepare to implement key learning community ideas in a larger number of schools in the Nashville Metropolitan School System during the 1993-1994 academic year. Our next SMART Challenge project will be extended to one year and will cover Jasper trip planning adventures as well as statistics and business planning adventures. The school system's educational TV studio has given us permission to use their facilities to deliver SMART challenges throughout the school year.

An extremely important issue is one of ensuring that students will not be hurt on state tests of accountability by spending so much time working on SMART challenges. Our current plan for dealing with this issue is to ask schools to agree to implement a year long, daily "project hour" that provides time for problem-based and problem or project-based activities such as Jasper without taking time away from ongoing instruction in mathematics, science, reading or other key activities. We then plan to gradually integrate the instruction in the mathematics classes by working backward from Jasper adventures to find relevant concepts and skills that students are covering in their math classes. And we plan to merge our Jasper-related instruction with a unique approach to skills-based assessment that has been developed by our colleagues Doug and Lynn Fuchs (1992). In this manner, we hope to show strong gains on standardized tests while also helping students develop the complex thinking and communication skills that the Jasper adventures are designed to afford. Furthermore, we plan to continue our work with two-way mentoring involving college students and extend the experience to other members of the community such as representatives of local businesses who want to make a contribution to the schools.

Needless to say, our plans for next year are still only a small part of what one needs in order to develop an effective learning community. But we want to make sure that we do not attempt to do more than we can manage--we are right on the edge as it is. In subsequent years we hope to extend our work to younger and older grades and to other curriculum areas. And we plan to continue to collect data to determine what works and what needs to be changed.

SUMMARY AND CONCLUSIONS

The general model of challenge-based assessment that is being developed is applicable to any problem-based curriculum, and in its current version, consists of the following six stages.

1. Complete a problem or project based unit of instruction (e.g., an episode of *Jasper*)
2. Review solutions and practice additional problems to deepen and broaden understanding of concepts, procedures, and computations in preparation for a new challenge.
3. Solve a new challenge problem similar to that of the original problem (stage 1). Work on class projects that are related to the theme being studied.
4. Participate with students in many other classrooms in video based performance events related to stages 1, 2, and 3. These events showcase the best student solutions, presentations, and projects; provide expert models for students and teachers; and provide students with immediate feedback on their performance and that of their peers.
5. Conclude with a culminating video-based event that is highly motivating for students and teachers.
6. Repeat with a new unit of instruction.

The impact of classroom-based technology on learning can be extended through the innovative use of distance learning technologies in conjunction with our theoretical model of challenge-based assessment. When high stakes, high visibility events like the "Big Challenge" or or the Jasper Challenge Series take place students and teachers in remote sites are supported by local school authorities and communities. However, we found that to ensure student preparation students and teachers need to be prepared in ways that go beyond a final high stakes event. Students and teachers are connected with one another across multiple classrooms to form a mediated community of learners that share goals performance and a common context. Our theoretical model for challenge-based assessment, as exemplified by the Jasper Challenge Series, is an example of how formative assessment can be used to highly motivate students and teachers and drive instruction. This is especially important for problem and project based curriculums which require alternatives to traditional assessment instruments. It is our hope that in the future we will be able to extend our theoretical model across the curriculum to include other domains in science, language arts and social studies.

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FOOTNOTE

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