Enhancing Native American Mathematics Learning: The Use of Smartboardâ -generated Virtual Manipulatives for Conceptual Understanding

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Abstract. This paper reports the results of a study to compare learning effects from two groups of Navajo elementary students participating in the TECHShare project. Students were 3rd and 4th grade Navajo children participating in a multimedia-enhanced geometry lesson on the topic of three-dimensional cubes. The comparison group in this study received instruction using the lesson at desktop computers, while the experimental group received the identical lesson with their teacher using a Smartboard® in lieu of individual computers. A Smartboard® is a multi-feature whiteboard connected to a computer that allows users to physically manipulate items that are projected on the screen. The results of a pre-post assessment of cube knowledge achievement suggest that using the Smartboard technology was more effective for this group of students than desktop computer workstations. Observational data and post-experimental interviews with teachers suggest that students in the Smartboard condition also demonstrated more "spontaneous" group interaction and collaborative behaviors.

Introduction

The TECHShare project is a distance education initiative of the Navajo Education Technology Consortium (NETC). The NETC is a partnership of thirteen school districts and ten individual schools (as of June 2002) that joined forces in 1997 to leverage funding for technology in their schools. Located in New Mexico, Arizona and Utah within or near the Navajo Nation, NETC member districts and schools serve student populations that are predominantly Navajo (roughly 85%). In June 1999, the NETC was awarded funding for a five-year Star Schools project, known as TECHShare. The NETC anticipates that the TECHShare project will help to ameliorate the negative effects of isolation, mobility and scarce resources on Navajo students' academic achievement through the development and distribution of standards-based multimedia online lessons. The Center for Educational Evaluation & Research (CEER) is serving as the external evaluator to the project.

Background of the Problem.

The Navajo Nation covers an area of approximately 25,000 square miles and crosses three states. The area is sparsely populated and many NETC schools are in small communities, where teacher turnover is high and qualified substitutes are scarce. Many Navajos utilize extended families in raising their children, with the result that it is not uncommon for students to change schools – even districts – once a year or more. These conditions result in students being exposed to multiple standards and curricula within a given year so that articulation of instruction is lacking and academic progress is slow. Native Americans also have one of the highest dropout rates in the country, with about 36% not finishing high school – almost twice the national average (Swisher and Tippeconic III, 2000). And contrary to expectations, research indicates that in the case of Navajo students, those who dropout perform no worse academically than those who stay in school: 45% of Navajo dropouts were 'B' or better students (Platero et al. 1986 as cited in Hale, 2002). Hale (2002) lists several *school*-related deficits that have been suggested in the literature as critical factors in of the apparent Native American achievement gap; the list includes:

- Passive teaching methods
- Irrelevant curriculum
- Inappropriate testing
- Uncaring teachers
- Large schools
- Tracked classes
- Lack of parent involvement

When considering mathematics instruction specifically within a Navajo framework, *passive teaching methods*, *irrelevant curriculum*, and *inappropriate testing* consistently emerge as likely contributors to low performance. While many teacher preparation programs have improved in their provision of training in active student-centered instructional strategies, many teachers tend to fall back on the passive teaching methods and strategies that they experienced earlier in their own schooling. This passivity is reinforced by the trend of curricula selection consideration that are based on preparation for standardized state and district tests and you have arrived at decontextualized instruction without cultural considerations or meaningful learning. A related problem is that few teacher preparation programs adequately prepare teachers for teaching in classrooms that include large numbers of minority and English language learners (ELL), in spite of the fact that enrollments of both minority and ELL students continue to rise rapidly nationwide. Traditional transmission methods of teaching based on teachers lecturing and students sitting passively and memorizing information are in marked contrast to the experiential learning that Native American students are accustomed to at home and in their communities (Nelson-Barber & Estrin, 1995), and are not supportive of ELL students. There exists a vast body of knowledge that points to *relevant* teaching and learning as the bridge that crosses the knowledge gap (see Bransford,). The problem is how to effectively employ methodologies to address the critical issue of context for native learners, while not sacrificing the declarative knowledge often demanded by achievement tests. There is growing evidence that technology, when properly applied, can ameliorate the passivity of many relevancy and contextual problems with instruction by involving students in direct manipulation of abstract mathematical concepts.

Manipulating the Abstract

As Fouts (2000) states in his report on computers and education for the Gates Foundation, one of the central components of school reform – as evidenced in the No Child Left Behind legislation – is the goal of higher academic standards and a stronger focus on higher order thinking, problem solving skills and real world applications. These ends can only be accomplished in a learning environment that is substantially different from the traditional classroom, and technology proponents are confident that new technologies provide the means to this end. Classroom use of computer applications was demonstrated to be more effective than lab use for teaching mathematics. A set of fifth grade students had access to computers with standards-based software in their classrooms, along with teacher-led standards-based instruction (Basic Skills/Computer Education). These students had higher gains overall and in math on achievement tests than did students who experienced the same curricula and technology in lab settings (Mann et al., 1999).

Other studies have demonstrated the advantages of technology suggest that technology applications that enable student collaboration tend to result in improved achievement. In one study, upper-grade elementary students used a software collaboration tool called Computer Supported Intentional Learning Environment (CSILE) that enables students and teachers to create and post text and graphics to ask questions, search for other students' answers, give feedback on student responses and work and then reformulate their initial answers and questions. These students performed better on standardized tests in reading, language and vocabulary and on measures of depth of understanding, multiple perspectives and independent thought than students who did not use the software (Scardamalia & Bereiter, 1996).

Method

This report describes the evaluation activities conducted by CEER (the Center for Educational Evaluation and Research) in Year 4 of the Navajo Education Technology Consortium's (NETC) Star Schools project, known as TECHShare. The focus of the TECHShare project is to improve student learning through the distribution and use of standards-based multimedia lessons. Many of the lessons are developed from materials collected from teachers participating in major professional development initiatives, such as two Technology Innovation Challenge grants in New Mexico and Arizona, and the National Teacher Training Institute in Arizona. Teams at four universities, Dine College and NITI (National Indian Telecommunications Institute) then fine tune the materials and add multimedia to create lessons for electronic delivery. Once the lessons are completed, they are placed in an online database where they are available for teachers and students to download from the NETC's website, known as NETtrain (http://nettrain.unm.edu). The participating universities are Arizona State University/ASSET, Northern Arizona University (NAU), New Mexico State University (NMSU), and the University of New Mexico (UNM).

The primary target population for the project is the member schools of the Navajo Education Technology Consortium, which are located within or near the Navajo Nation. The majority of students at these schools are Navajo, and many are Limited English Proficient (LEP), low income, or both, and most perform well below the national average in academic achievement. In an effort to address these particular conditions, some lessons are being developed specifically for Navajo students.

To test the notion that students whose teachers used multimedia enhanced math instruction with the additional of a Smartboard® in the classroom would show grater gains from pre to post testing than students whose teachers used multimedia enhanced instruction on individual computers. A sample of 53 Elementary Mathematics students (from four different teachers and across an average of nine math lessons) whose teachers did not use a Smartboard®, were compared with 39 Elementary Mathematics students whose two teachers used the Smartboard® during math instruction.

Results

The resultant dataset, when comparing multiple pre-post math tests, emerged as 489 pre-post pair results in the No Smartboard condition and 276 pre-post pairs. The results of an one-way ANOVA ($F(1,763)= 27.06$, $p=.001$, $eta^2=.034$) are presented in the figure below**.** The finding supports the idea that students whose teachers used a Smartboard® with math instruction tended to show greater pretest to posttest gains ($M=20.76$, $SD=23.67$) than students whose teachers did not use the Smartboard® to facilitate instruction ($M=11.48$, $SD=23.68$).

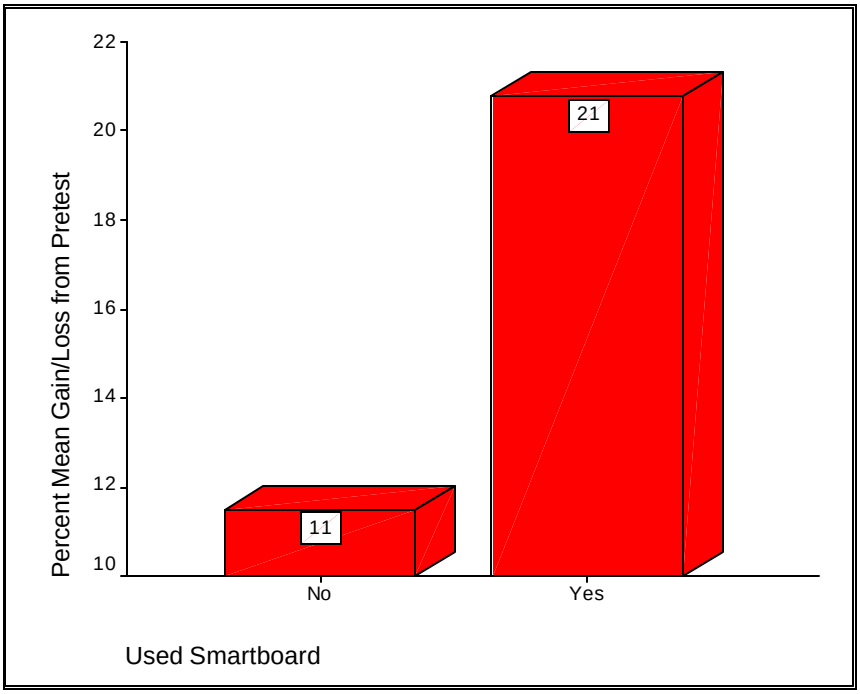

Figure 1. *The Comparison of Smartboard use vs. desktop computers in Navajo elementary mathematics classrooms*

Conclusion

Recall that one of the functions of the Smartboard® is the ability to allow the user(s) to actively manipulate content on the board. With this in mind, consider that much has been written regarding culture and the learners' preferred style of acquiring and using new information (i.e., Zhang and Sternberg, 2001). Native American learners, for example are generally thought be more collaborative and experiential learners who seem to perform better when facts and ideas are presented in a global and visual fashion. Contrast this to the verbal and analytical style preferred with Anglo-European learners. (i.e., Nelson-Barber, and Estrin, 1995). These types of finding may suggest that Native American learners might perform beneficially from a highly manipulative, visual environment that is offered

by the Smartboard ®; especially when the teacher encourages collaboration and reflection, and the lesson lends itself well to manipulations (e.g. *Drag and Drop*).

This finding suggests that instruction may be facilitated by matching student learning styles and cultural preferences with specific content and lesson design. This could have a significant impact on limited language learners and for learners whose cultural predisposition for learning necessitates a global, collaborative or experiential approach. For most publishers, the costs of producing culturally relevant materials for the relatively small native student market are too prohibitive. Furthermore, most teachers are not provided with adequate professional development on the home cultures of native students or their learning styles, outside of one general course on multiculturalism or an occasional inservice. In lieu of a massive and cost-prohibitive manufacture of cultural or even tribe-specific curricula, a well-reasoned blend of culture, technology and content may assist native learners of mathematics.

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