The value of perseverance: Using Dakota culture to teach mathematics

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ABSTRACT

Cultural appropriation is a legitimate concern of indigenous people. In the United States, non-natives have copied native culture in everything from Native American themed parties to celebrities in costume to lingerie ads. The backlash from indigenous communities to this mimicry is understandable.

Video games offer a more functional application of Native American culture, specifically, Dakota culture. While at first glance, traditional Dakota values and educational video games may be an unexpected combination, there is much more to being a Dakota than regalia, pow-wows and sweat lodges We advise other cultures that wish to copy the Dakota to copy these values – honesty, courage, generosity and perseverance. Both the National Council of Teachers of Mathematics and the Common Core standards emphasize the importance of perseverance in mathematics. The very first standard of mathematical practice is "Make sense of problems and persevere in solving them". Spirit Lake: The Game is an example of how the value of perseverance in the context of traditional Native American culture can be applied in contemporary society. We tested efficacy of the game in increasing mathematics achievement with a sample of fourth- and fifth-grade students from two reservation schools. Students playing the game showed significantly greater improvement in mathematics achievement from pre- to post-test.

What does it mean to be an Indian, Anishanaabe or a Dakota? McGlennen (2015) argues convincingly that native identity is not a connection to place, to a particular reservation. Legally, being the member of a native nation can be defined as tribal enrollment, regardless of residence (Spirit Lake Tribe, 2014). However, concerns over cultural appropriation seldom arise because another falsely claims residence or tribal enrollment. Being a Dakota or an Ojibwe means more than regalia. This is not the identity native people seek to protect. Rather, backlash from native communities is against the exploitative use of culture, including dress, dance, music, etc. often for financial or other personal gain and taken out of context (Scafidi, 2005). As a Dakota who fought a decade-long battle to abolish the hated Fighting Sioux nickname, this is the type of cultural exploitation that is our concern (Longie, 2015).

Members of native nations are connected through a shared history and values, but by whose definition? Blaeser (2015, p. 168) noted that the history of native people is most often presented in romantic stereotypes "…unconnected to the every day lives and survival of contemporary Native people…"

There is diversity among the 500 American Indian groups in degree of preservation of tribal language and in tribally specific religious and social activities (Red Horse, Lewis, Feit, & Decker, 1978; Weibel-Orlando, 1991). Yet, many social scientists feel it is possible to identify certain core indigenous values (e.g., Sue & Sue, 1990); generosity, courage, honesty, harmony with nature, non-interference; patience; circular time; and a broad view of the family. Blaeser cites endurance, relatedness, survival, spirituality and time as important cultural ideas. Vizenor (1998) also emphasizes survival, resistance and relation with nature as important contexts of native culture.

In the United States, despite hundreds of years of oppression and campaigns of extermination, the Native Americans have survived and persevered (Longie, 2006). When our youth wear clothing emblazoned with "Native Pride" whence comes the source of that pride? It's not the poverty or the plethora of other problems endemic to most reservations– it's our character, those values that people should emulate that have enabled use to endure and survive as a people despite those challenges.

Perseverance in the face of hardship may be the unifying characteristic of native peoples. The present study applies perseverance and fortitude, two major values of the Dakota to game development, with the objective of improving academic achievement of Native American children.

Perseverance is defined as a steady and continued effort, usually over a long period, and especially in spite of difficulties or setbacks.

The Dakota cultivated perseverance. Traditionally, rules were rules of survival and if they weren't followed, the whole tribe was at risk. Those who enforced the rules persevered in their chastisements until individuals conformed to the law. Without perseverance, the Dakota would not have survived the world they lived in. Their perseverance is one of the main reasons why their descendants are here today. Fear is the greatest enemy of perseverance. There is the physical fear of being killed or injured by an enemy or wild animal. Another type of fear that persists today and relates to education is fear of failure, of not being able to measure up to expectations.

We were born during what many American Indians call the greatest generation, those in the 1940s and early 50s who overcame poverty, racism, alcoholism, lack of transportation to get an education, fight for a job within the system and bring jobs and self-governance to the reservations. This generation because of their perseverance brought much of the development we see on the reservations today - housing, manufacturing, tribal colleges -that overcame many barriers that benefit the reservation today. Prior to this generation, there was nothing on the reservation - no running water, no housing. This generation, in turn, opened the opportunities available to Indians now. We overcame the prejudice of the border towns, even the bad treatment of us when we went into the stores and restaurants in towns adjacent to the reservations.
Why was our generation able to do that? Maybe because we were the first generation exposed to technology. We were exposed to television, gas stoves, etc. during our adolescence. As Edmunds (2001) noted, rural reservations were "inundated by a cultural invasion" that began with radio and television and has continued through videogames, the internet and social media.

A lot of us went to non-Indian schools off the reservation. We were put in the "slow" class with the poor white students. They never expected us to join the extra-curricular activities because they didn't think we were worth it. Yet, these same people were the ones who came back and started many of those improvements on the reservation. They didn't let the racism deter them.

Today reservations are a much better place to live than they were 150 years ago, 100 years and even 50 years ago when the author was a boy on the Spirit Lake Dakota Nation. There are better schools, there are jobs, and hardly anyone suffers from malnourishment. Yet, schools have a huge drop out rate. We propose a simple answer to the problem of academic achievement– return to the traditional value of perseverance. When the job becomes difficult some workers simply quit or do not attempt to look for work. The problem has become so severe on reservations that some casinos mandate an employee orientation for tribal members who have been fired or quit jobs at the organizations three or more times. When adults no longer practice

perseverance, we do not pass this virtue down to our children. As a result, when attending school becomes difficult or uninteresting, they simply do not attend. Research on one reservation found that the average student in elementary school missed an entire month of school (Longie,1995). A return to traditional values of perseverance and fortitude was hypothesized as a solution to this problem. Spirit Lake: The Game was developed by Dakota elders and tested with Dakota children in an effort to channel the new technology to benefit the next generation by integrating their traditional values, culture and history. In this manner, we follow in the footsteps of such Native American leaders as Yellowtail (Moxie & Bernardis, 2001) and Deer (Kidwell, 2001) who applied the education they learned in the white man's schools to defend and maintain the culture and sovereignty of their tribes.

Historically, the Dakota were the ultimate survivors. In spite of a war of annihilation by the Europeans, they survived. In spite of being put on reservations and living in poverty, they survived. In spite of the numerous social ills that plagued reservations they survived. Now in the twenty-first century, Dakota are one of the fastest growing populations in the country. How did people manage to survive in spite of tremendous odds? Simple, it was in their character to persevere. They were taught this virtue from childhood.

In his book, Dakota Life in the Upper Midwest, Samuel Pond writes this about the Dakota before the coming of the white man,

> *"...if they would have accompanied them through one year, in 1834 they would have learned that they did not contrive to live without hard labor, also that they did not shrink from hard work, but acted like men who were determined to take care of themselves and their families. If they had been as indolent and inefficient as many think they were, we should have never heard of them, for they would have perished long ago. (p. 23)"*

Years later, (1900) John Fire Lame Deer, who was born in a twelve-by-twelve foot cabin gives an account his life on a South Dakota reservation. John Fire Lame Deer persevered despite extreme hardships and became a noted medicine man. Here is the first paragraph of his story, Hard Times In Sioux Country:

> *"There were twelve of us, but they are all dead now, except one sister. Most of them didn't even grow up. My big brother Tom, and his wife were killed by the flue (sp) in 1917. I lost my own little boy thirty-five years ago. I was a hundred miles away, caught in a blizzard. A doctor couldn't be found for him soon enough. I was told it was the measles. Last year I lost another baby boy, a foster child. This time they told me it was due to some intestinal trouble. So in a lifetime we haven't made much progress. We medicine men try to doctor our sick but we suffer from many new white man's diseases, which comes from the white man's food and white man's living, and we have no herbs for that (p. 311, 1999)."*

Today's reservations continue to provide role models who have faced enormous difficulties in their lives yet they persevered. Research on academic success at the community college level found integration of Native American culture, from accommodation of intergenerational responsibilities to incorporation of Native American history throughout the curriculum, to be

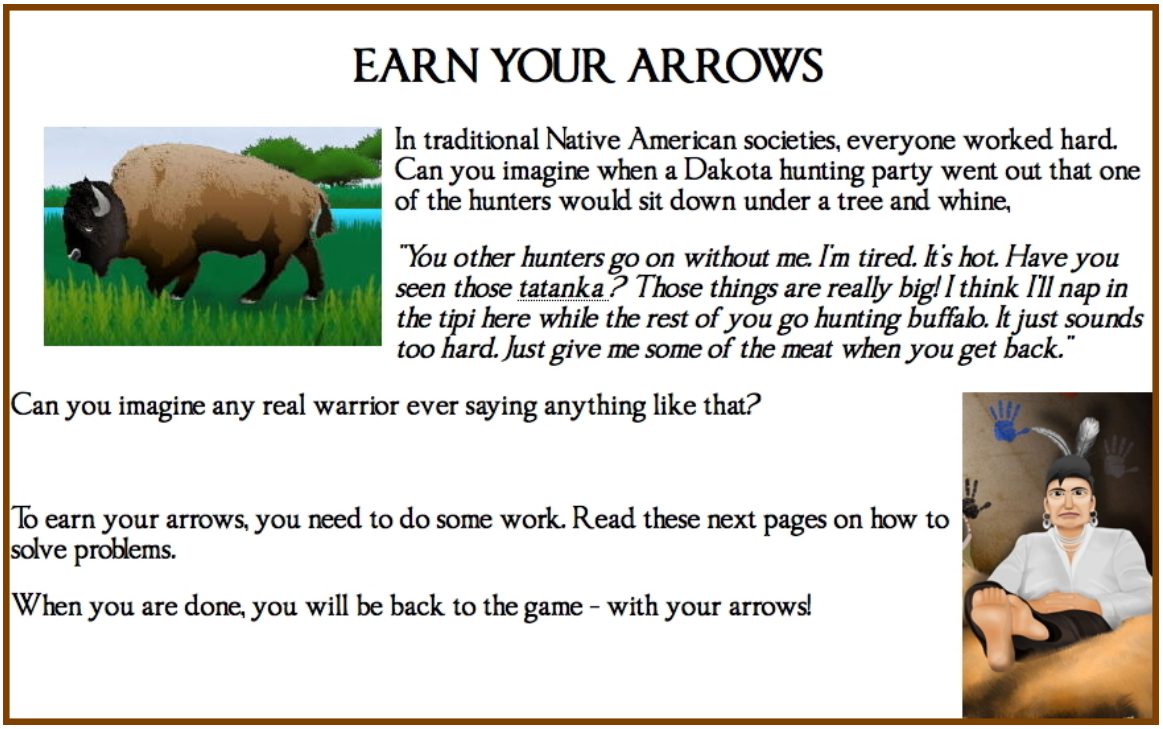
related to significantly higher retention of at-risk students (Rousey & Longie, 2001).

In contrast to the types of cultural appropriation seen in mainstream films, video games offer a more functional application of Native American culture, specifically, Dakota culture. While at first glance, traditional Dakota values and educational video games may be an unexpected combination, there is much more to being a Dakota than regalia, pow-wows and sweat lodges. Other cultures that wish to copy the Dakota are advised to copy these values – honesty, courage, generosity and perseverance. Both the National Council of Teachers of Mathematics and the Common Core standards emphasize the importance of perseverance in mathematics (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). The very first standard of mathematical practice is "Make sense of problems and persevere in solving them". Spirit Lake: The Game is an example of how the value of perseverance in the context of traditional Native American culture can be applied in contemporary society.

In the United States, Native Americans are both the fastest growing minority group and the lowest performing in mathematics (DeVoe, Darling-Churchill & Snyder, 2008). Over 1,000,000 Native Americans live on federally-designated reservations; students from these sites perform even lower than the mean for all Native Americans (De Mars & Longie, 2011).

Many variables correlate with academic outcomes for Native American students, as well as the general population. Numerous studies have found time to be a factor predictive of achievement in mathematics (Hersh and John-Steiner, 2011). The time factor includes time devoted to solving a problem, the perseverance shown, time spent on homework and instructional time. As one of the barriers to effective instruction in classrooms of predominantly disadvantaged children is behavioral, i.e., lack of sustained attention (Laffey et al., 2003), we hypothesized that increased attention would translate into higher mathematics achievement. Spirit Lake: The Game was created to test this hypothesis.

To heighten attention, we incorporated Native American culture in an educational video game in two ways. First, in the general story line we based everything from clothing to the landscape to daily activities on authentic tribal history, given research showing that student



EARN YOUR ARROWS

In traditional Native American societies, everyone worked hard. Can you imagine when a Dakota hunting party went out that one of the hunters would sit down under a tree and whine,

"You other hunters go on without me. I'm tired. It's hot. Have you seen those tatanka? Those things are really big! I think I'll nap in the tipi here while the rest of you go hunting buffalo. It just sounds too hard. Just give me some of the meat when you get back."

Can you imagine any real warrior ever saying anything like that?

To earn your arrows, you need to do some work. Read these next pages on how to solve problems.

When you are done, you will be back to the game - with your arrows!

Figure 1: Introduction to Problem-solving lesson

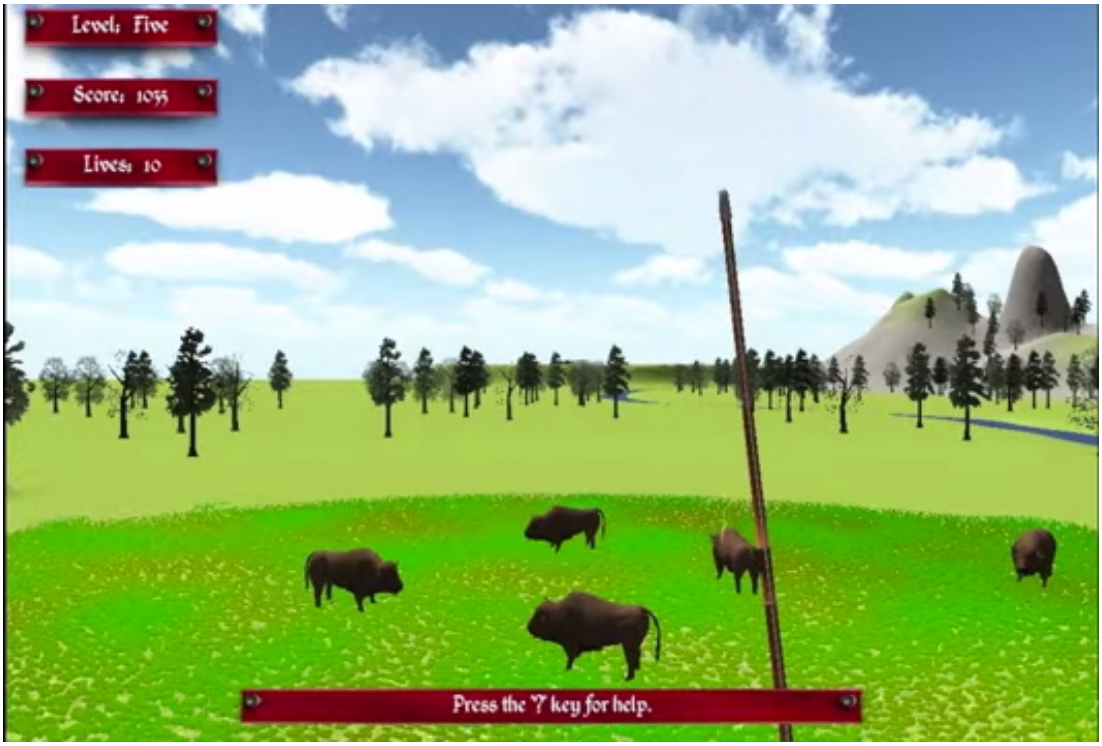


Figure 2: Buffalo hunt scene in Spirit Lake

engagement, as evidenced by physiological and behavioral responses, is enhanced when users perceive features of a learning environment to be visually realistic (Sibuma, 2012). Second, we emphasized traditional cultural values of perseverance and fortitude as applying to achievement today.

Figure 1 below shows the introductory screen of a unit on problem-solving that begins by encouraging students to follow in the footsteps of their ancestors who did not shirk difficult tasks. After earning their arrows through completing math problems that helped the tribe - such as dividing the 48 hunters into hunting parties of 8 hunters each, and determining if any would be left out – the player has earned the right to join the buffalo hunt. As reinforcement, the player is actually able to hunt buffalo in a 3-D world, as shown in Figure 2 below.

Each game level follows this same pattern that includes subject matter instruction with culture rather than in place of instruction in the content area. After instruction, students are presented with math challenges. Correct answers lead to game play that is integrated with the problems, just as the problem of dividing into hunting parties is followed by hunting virtual buffalo. Incorrect answers route students to corrective instruction that must be completed before returning to the game.

EVALUATION

Sample

To test the efficacy of the game, we selected a sample of 62 fourth and fifth-grade students from two schools located on an American Indian reservation in central North Dakota. The schools are located approximately twenty miles apart on the same reservation. The schools are demographically similar. Both have student bodies over 95% Native American, both have 20-25% of students proficient in mathematics in grades three through five. Neither of the schools met state targets for Annual Yearly Progress in mathematics or reading. Both are high-poverty schools located in the same rural persistent poverty county. As the program is designed to be implemented within a school, random selection of individuals is not possible. One school was randomly selected as the control group and a second as the intervention. Games were played by all of the students in fourth- and fifth-grade at the intervention school.

We implemented the program in the fall semester. All fourth-grade students at both schools and all fifth-graders at the control group school were administered the pre-test and post-test with the exception of students with learning disabilities too severe to be tested. The children who were excluded were essentially non-readers. According to teacher report and our own observations, their reading and mathematics skills were second-grade level or below. In the intervention school, five fifth-grade students from each of the three classrooms were selected by their teachers to participate. Demographic statistics for the sample, by group, can be seen in Table 1. There were no significant differences between experimental and control group schools in gender distribution, or in age within grade.

Table 1
Sample Demographics

	Intervention (N =39)		**Control (N=23)**	
Gender % female	51%		48%	
Grade • Fourth grade • Fifth grade	70% 30%		51% 49%	
	Mean	**SD**	**Mean**	**SD**
Age (All students) Grade • Fourth grade • Fifth grade	9.7 9.5 10.4	0.8 0.6 0.9	10.1 9.9 10.3	0.6 0.7 0.5

Instrumentation

We created a 24-item test, matched with North Dakota state standards for grades two through six. We initially planned to use released items from the state standards test. However, North Dakota is one of the few states that does not release test items. Thus, we used released items from the California state standards test. The published California standards addressed by these items matched verbatim with North Dakota standards. While research with a substantially larger, more diverse sample found a Cronbach alpha of .84 for this test (De Mars, 2014), internal consistency reliability coefficient we computed for the current sample for the same test = .57. This relatively low value is likely a result of the high ceiling of the test, with many students simply guessing at the upper-grade items, as discussed below.

Data Collection

All fourth- and fifth-grade students from the two schools took the pre-test in their respective school's computer labs using the same on-line test created with Surveymonkey software. All students in the intervention group and all students from the control group school who were still enrolled in the school took the post-test, with the exception of students in special education, as noted above. At post-test, approximately 25% of the students at each school were no longer available. Some were absent or suspended but in most cases the school staff remarked, the students were merely "gone". We administered tests at the beginning of the fall semester, and again, eight weeks later, after students had played the games two to three times per week in their classrooms for 25-30 minutes per day. We collected usage data to estimate total time on task during the hours allotted for the intervention group. To progress in the game, students are required to answer a challenge question or form approximately every two minutes. Each answer records the number of attempts, response and a date-time stamp. The total minutes the class spent on task during a session was computed automatically by subtracting the time of first input

from a student in the class from the time the last student in class answered a question.

DATA ANALYSIS

We performed all analyses using SAS/STAT software, version 9.4 for Windows. We computed descriptive statistics computed for demographics, pretest items, pre-test and post-test total scores, by grade level and by school. We performed two repeated measures analysis of variance (ANOVA) was to test for statistical significance. One analysis was conducted with only school and time as the predictor variables. A second analysis included school, time and grade. As both analyses yielded essentially identical results, only the latter is presented here.

Four outliers, two from the intervention group and two from the control group, were deleted from the final analysis. Three of these had low scores (less than five) due to having left the remainder of the problems blank. In one case, the student had been called out of class after beginning the test. Analyses were run with and without the outliers. The effect was minor, and resulted in slightly smaller, but still significant, effect in favor of the intervention group.

RESULTS

The percentage correct for each item on the pre-test can be seen in Figure 3 for fourth-grade students and in Figure 4 for fifth-graders. Some evidence for validity can be seen in the higher scores for fifth graders and the pattern of progressively lower percentage correct as the items move from the second- to the fifth-grade level. Also, consistent with published state reports showing the majority of students at these two schools to be below grade level, it was only at the second-grade level that all of the fourth-grade students' percentage correct was higher than the

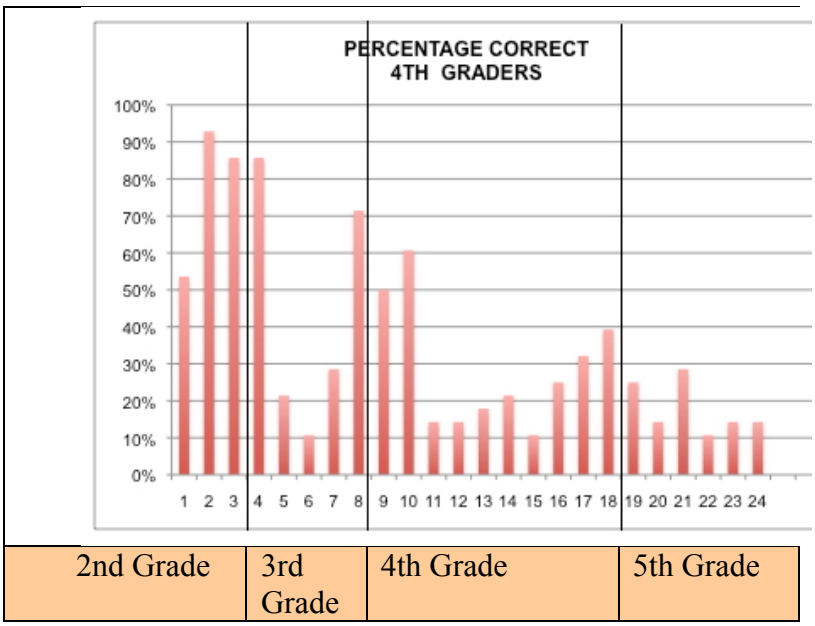


Figure 3: Grade Four Pre-Test Scores, All students

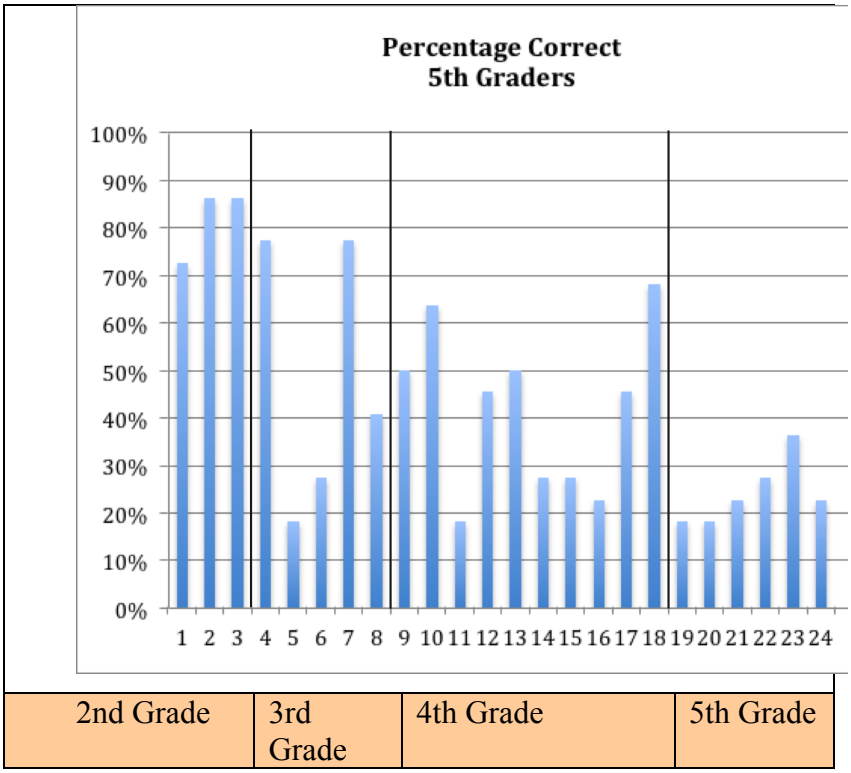


Figure 4: Grade Five Pre-Test Scores, All students

25% predicted by chance, with multiple choice items with four options. On only two of the five third-grade level items were fourth-grade students' scores above the chance level.

Similarly, with the fifth-grade students, as can be seen in Figure 4, on only one of the five fifth-grade level questions did more than 25% of the students respond correctly. Clearly, students were performing significantly below grade level.

Means, standard deviations and number of subjects, by grade, are shown in Table 2 for the intervention group and Table 3 for the control group. As would be predicted based on the low performance on individual items, mean pretest scores were very low for both groups. Out of 24 questions, the average student answered less than ten correctly.

While both groups increased from pre-test to post-test, it can be seen that the improvement of the two intervention groups substantially surpassed the two control groups. The effect is best illustrated graphically, as in Figure 5. The control groups increased only slightly in mathematics achievement, as would normally be expected after only eight weeks of mathematics instruction of 45 minutes or less per day. In contrast, the fourth-grade intervention group improved the mean test score 64% while the fifth-grade intervention group improved 29%.

Table 2
Descriptive Statistics, By Grade Level, Intervention Group

	Pre-Test			Post-test		
	Mean	S.D	N	Mean	S.D	N
All	9.3	2.3	37	14.3	5.2	40
Grade						
4	9.2	2.5	25	15.1	5.3	28
5	9.5	1.9	12	12.3	4.6	12

Table 3
Descriptive Statistics, By Grade Level, Control Group

	Pre-Test			Post-test		
	Mean	S.D	N	Mean	S.D	N
All	9.0	2.1	21	9.7	2.6	22
Grade						
4	9.3	2.5	10	9.9	1.9	11
5	8.6	1.7	11	9.5	3.3	11

Results of the repeated measures ANOVA are summarized in Table 4. Consistent with the results portrayed in Figure 3, it can be seen that there was a significant effect of time, with scores improving from pre-test to post-test. There was also a significant interaction effect of time by school, with students from the experimental group improving significantly more from pre-test to post-test than did the control group.

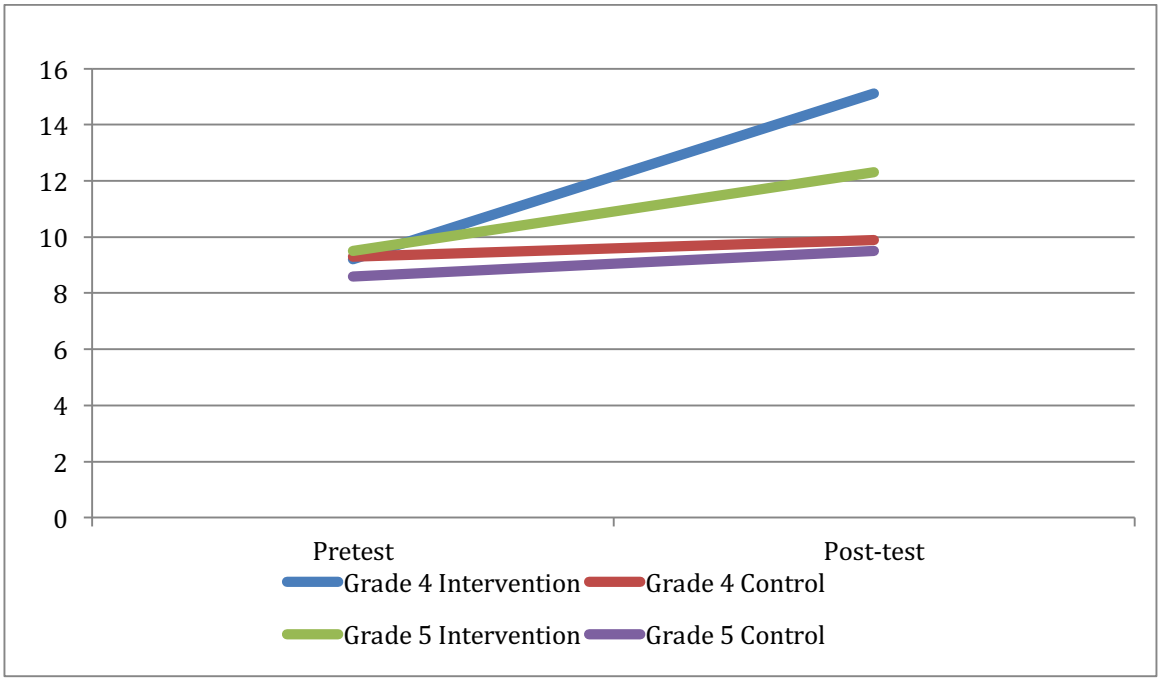


Figure 5: Pre-test and Post-test mean scores by grade and school

Although the fourth grade increased more than fifth graders, this difference was not statistically significant. It should be noted, for reasons discussed below, that the fifth-grade class spent significantly fewer minutes using the program. While the fourth-grade classrooms spent an average of 24-28 minutes per session using the program, or 48- 56 minutes per week, the fifth-graders had less than half of this amount of time on task, approximately 17 minutes per session, due to conflicts in availability of the computer lab and early school dismissal due to weather.

Table 4
Repeated Measures Analysis of Variance, Tests of Hypotheses

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Time	1	164.97	164.97	12.91	0.0007
time*school	1	91.04	91.04	7.13	0.0100
time*grade	1	11.58	11.58	0.91	0.3454
time*school*grade	1	22.00	22.00	1.72	0.1953
Error(time)	54	690.00	12.78		

CONCLUSION

The goal of the Dakota Learning Project (DLP) was to integrate Dakota culture with research in mathematics education and computer gaming in order to raise the mathematics

achievement of Native American children. These pilot study results were extremely promising in both providing preliminary support for efficacy and providing guidance for future research. The game proved to be highly engaging to the students and related to significantly higher test scores. Teacher reports, the site coordinator observations and the time students were on task all support a high level of student engagement.

Time - including time devoted to solving a problem, the perseverance shown, time spent on homework and instructional time - is a much better predictor of mathematics achievement than measures of mathematical aptitude (Dehaene; 2011; Hersh & John-Steiner, 2011). Through educating students in the traditional values of perseverance, courage and survival against all obstacles, teachers used the game to encourage students to spend more time on the mathematics challenges in the game and not give up.

We applied research on the use of effective educational game design throughout development, combining feedback from the game regarding correctness of answers with elaborated instructions and meaningful incentives (Delacruz, 2011; Nelson, 2007; Van Eck & Dempsey, 2002). In Spirit Lake: The Game these incentives were the opportunity to experience culturally-based activities in a 3-D virtual world, such as gathering herbs to save the tribe from an epidemic or hunting deer.

Several changes are recommended in future research based on our experience of evaluation of educational video games in two reservation schools. Problems in organization and low-performance in these low-performing rural schools were greater than anticipated. Achievement was lower, resources scarcer and absenteeism higher even than the high level of challenge we had anticipated based on past experience in this and similar reservation communities. At post-test, approximately 25% of the students at each school were no longer available. Frequent scheduling conflicts occurred, both for individual students and facilities. While it was possible to teach fourth-graders as a whole class, this was not an option for the fifth grade as all classes desired to be involved and it was not possible to schedule six classes twice per week. Instead, the computer lab was scheduled and five students from each class were selected. The time required for students to travel from their classrooms and back again reduced time available for using the program. On some days, the computer lab had been double-booked and the site coordinator and students would spend another ten minutes or more looking for an available space.

We originally proposed to have third through fifth-grade students participate, as the game was targeted to teach mathematics at this level. However, pretest results for fourth- and fifth-grade students showed the majority to be achieving a year below grade level. Within these particular schools, it was determined that third-grade students were not performing at a high enough level to benefit from the program. Therefore, the pilot was conducted only with fourth- and fifth-grade students.

In the interest of creating a workable prototype within a short time frame, we used commercial solutions, SurveyMonkey for collecting pre-test and post-test and SAS software for data management and statistical analysis. Use of a multiple choice format allowed students to randomly guess at an answer and still have a 25% probability of getting the answer correct. This guessing, along with the generally low pretest scores resulted in low-test reliability. We have since re-written these tests using our own code to be all open-ended response.

These complications in the research should not discourage further work in the area of educational games based on indigenous culture. The gains in test scores were both substantial and significant. Perseverance in solving problems in mathematics is part of the Common Core

standards adopted by 37 states. Spirit Lake: The Game emphasizes perseverance, a core Dakota value, and although no quantitative measure was included for perseverance in the pilot, qualitative indicators suggest an improvement on this dimension.

Students in both of the schools researched showed little perseverance initially. If a problem was difficult, the student simply gave up. This same lack of perseverance was shown during the intervention. In the first weeks, if students could not answer a question, he or she immediately asked the teacher or site coordinator for the answer, or guessed at random. After three weeks, half-way through the intervention, many of the students were observed, unprompted to begin using a pencil and paper to try to work out problems in the game. On the post-test, 5% of the students simply quit well before finishing the test. All of these were from the control group.

One advantage of Spirit Lake: The Game and other video games is the capability of automated collection of student engagement. While observational measures of student time on task are more reliable than teacher or student self-report, their use is prohibitively expensive, requiring multiple on-site assessments of each classroom and specialized training (Fredricks et al., 2011). Games, in contrast, can monitor student activity by the number of minutes each student is interacting with the program.

The present study lends indirect support for the proposition that teaching traditional values, particularly perseverance, can impact Native American student achievement through increased effort. Future research will compare games with and without lessons in traditional values to directly test for effects on perseverance in instructional activities and resulting impact on achievement.

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