Project Title: Dakota Learning: Computer-Assisted Mathematics Instruction In A Cultural Context

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Final Report

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EXECUTIVE SUMMARY

Mathematics achievement of Native American students is the lowest of all racial and ethnic groups, a disadvantage that is evident by the fourth grade. Students living on American Indian reservations, which are located in rural persistent poverty counties, perform even below the national average for Native Americans. Dakota Learning Project (DLP) applies research in mathematics education and computer gaming to bring to commercialization a product that addresses this performance gap. In Phase I we developed and tested an educational program that integrates mathematics with the teaching of Dakota culture for students in fourth and fifth grades. DLP is centered on a computer game interface where Native American avatars guide the student through collection of assessment data and completion of increasingly difficult problems in computation, data analysis and geometry concepts. Immediate feedback is provided, with reinforcement in the form of prizes earned for correct answers. The program analyzes incorrect answers and routes the student to appropriate instructional content based on the type of error identified. Instructional methods offer options of on-line games, quizzes, videos, animation and virtual manipulatives. Teachers have access to regular reports on individual student and class performance, with links to recommended on-line examples, class handouts and PowerPoint presentations.

We compared the pre- and post-test scores of students from two reservation schools on a test of elementary mathematics. Students at one school had the mathematics curriculum supplemented with DLP. The two schools are located less than 25 miles apart and are closely matched on ethnicity, class size, average achievement and income. Other than DLP both schools used the same mathematics curriculum. All fourth and fifth-grade students were assessed prior to the intervention on a test of mathematics knowledge aligned with state standards. No significant differences were found on the pretest. All students in the fourth grade at the experimental school were a part of the DLP, as were 15 students randomly selected from the fifth grade. All three fourth-grade teachers accessed the supplemental resources on-line and extended time teaching mathematics using these resources while none of the three fifth-grade teachers elected to do so. On the post-test, DLP students in both fourth and fifth grades scored significantly higher than the control groups at the same grade level. Fourth grade students showed substantially more progress than fifth-graders. Whether this was due to the greater teacher support, the whole-class method of instruction or developmental issues could not be determined. Phase II will extend this research to levels covering all state mathematics standards for number operations and geometry for fourth through sixth grades, include groups with varied levels of teacher participation and track student progress longitudinally to document a long-term effect.

Reading a draft of the final report, the site coordinator wrote, “You’ve left out how much the kids loved the game.” No student ever declined the opportunity to play. Behavior problems decreased to almost zero during the game sessions. Teachers reported students’ motivation and effort in mathematics increased. Phase II will include an added measure of student engagement to test for the significance of difference in time on-task, perseverance on difficult problems and attitudes toward mathematics.

A Kickstarter crowd-funding campaign exceeded its target, receiving over $21,000 from 255 backers. Applications have been submitted to the Pearson EdTech accelerator program and NYC Schools Gap App challenge. These commercialization activities offer both bridge funding from Phase I to Phase II and increased market visibility.

Technical Objectives

1. Create prototype of an on-line application that integrates instruction in Dakota culture with instruction in mathematics standards for grades three, four and five.
2. Write a program to collect on-line assessment data for evaluation of students' progress in mathematics and usage of DLP resources.
3. Create supplemental materials for instructors including PowerPoint presentations and printable study guides.
4. Write a program to collect on-line data on teachers' usage of DLP resources.
5. Write programs that will serve as a basis for extension of the levels for additional lessons in Phase II and to additional tribal groups in Phase III.
6. Conduct an analysis of impact on student performance that will serve as a guide for Phase II design.

Background

Problem Addressed

There are 4.6 million Native Americans in the United States, of whom approximately 700,000 are enrolled in public or Bureau of Indian Education Schools (U.S. Census Bureau, 2008, Faircloth & Tippeconnic,2010). Over one-third of the Native American population lives on federally-designated reservations, overwhelmingly located in rural persistent poverty counties. Native Americans are disproportionally rural residents, and not just in any rural counties. Although Native Americans make up less than 2% of the national population, they are the predominant minority in 10% of persistent poverty counties (Farrigan, 2010).

Despite decades of research and billions of dollars in program funding to address this problem, significant racial discrepancies persist in mathematics achievement, with Native Americans performing the lowest of all minority groups. These deficits are evident at the earliest National Assessment of Educational Progress, in the fourth grade. Poor educational outcomes and their social and economic consequences continue to be a disadvantage throughout the lifespan. The percentage of Native American students who are below basic in mathematics by eighth grade (47%) is much higher than the 29% for all students. The national figure (6%) of students who are advanced in mathematics is three times that of the proportion of American Indian/ Native Alaskan students who score in the advanced range (DeVoe & Darling-Churchill, 2008). In the rural areas where Native American students comprise a high proportion of the student body, mathematics achievement is even lower than the poor national average for Native American students.

Related Research

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. Time devoted to a subject is linked to an affective factor, values, both the value of mathematics specifically and the value of perseverance. (Dehaene, 1997; Phan et al. , 2010).

Specific school types relate to achievement. The high poverty, predominantly minority schools where low-performing students caught up in mathematics achievement focused on good teaching, successful instructional strategies, increased effort, better attendance and self-confidence in mathematics (Balfanz & Byrnes, 2006).

Given the relationship between mathematics achievement and poverty status, both at the school and individual level (Chatterji, 2005; Klein et al., 2000; U.S. Department of Education, 2001) control for the percentage of students in poverty between treatment and comparison schools is essential for any credible research design. All of the relationships discussed above have been found to persist after controlling for socioeconomic status (SES) variables.

The Dakota Learning Project (DLP) is a computer-based application designed to simultaneously strengthen all these characteristics within low-performing schools while it extends the time spent on mathematics. DLP incorporates teaching the values of perseverance in the context of traditional Native American culture and the importance of mathematics. Time is extended by integrating mathematics and culture within the social studies curriculum, by providing homework problems linked to the Hoksina game, and other online activities and through development of intrinsically motivating activities that will encourage students to increase their time outside of school hours.

DLP design applies the lessons learned in the studies of effective teachers to computer-assisted mathematics education, beginning with the incorporation of basic math facts in early levels and continuing through the levels on probability. If a student gives the area as an answer to a question when the perimeter is the correct answer, the program will provide the definition of area and perimeter, show how to compute each one and then ask the student again to give his or her answer. We are programming the guiding and prompting activities seen by our best teachers.

The most successful on-line learners are “task- and detail-oriented people who are focused in their study habits” (Brown, 2000). The population to be served by DLP does <u>not</u> fit Brown’s (2000) profile of successful learners in computer-based on-line programs. On the contrary, the student body of most schools serving a high proportion of minority students is low in education, achievement and interest in mathematics (Werf, Creemers, Jong & Klaver, 2000). *DLP addresses this barrier head-on by incorporation of cultural education that emphasizes valuing, applying and persisting in academic endeavors, particularly mathematics.*

Research is limited in how certain groups use educational technology, in particular, those who do not fit the standard profile of self-motivated, academically well-prepared, critical thinkers willing to commit substantial hours to learning (Illinois On-Line Network, 2006). While students in upper elementary cannot “vote with their feet” by dropping a course that does not meet their needs, they can tune out and just not participate. Effective programs for disadvantaged learners need to bridge the gap between the competencies students bring with them and those they need for course success (Arendale, Higbee, & Lundell, 2005) a gap that is being identified and addressed in the DLP design as detailed in the work plan below.

In addition to a mismatch with learner needs, many schools face teacher resistance to implementation of computer-assisted instruction. Teachers have both negative reasons for resistance, e.g., unmotivated to apply extra effort, and positive ones such as concerns that any new program will take time away from needed work toward meeting state standards. *DLP addresses these concerns both through professional development emphasizing values to teachers, and through extensive resources that integrate with state standards and minimize demands on teacher time.*

In summary, the Dakota Learning Project brings together research on causes and correlates of mathematics achievement, effective computer-based mathematics instruction and barriers to implementation. All of this research has been incorporated into the design of the DLP, as discussed above and in the following work plan. Beyond product development, this plan includes a well-controlled pre- and post-test design to determine the effectiveness of our product on increasing students' mathematics achievement.

Results and Accomplishments

All six of the project objectives were met. Technical progress and accomplishments are discussed by objective below.

> <u>Objective 1: Create prototype of an on-line application that integrates instruction in Dakota culture with instruction in mathematics standards for grades three, four and five.</u>

Topics for game challenges and instructional resources were based on a review of North Dakota mathematics standards for second through fifth grades in the areas of number sense, geometry and statistics.

Six game levels were created, centered on a 3-D virtual world created with the Unity 3-D Integrated Development Environment (IDE). Each level includes mathematics challenges, e.g., how many pits must Hoksinato jump over to get to the lake. Students provide input using an HTML form. JavaScript is used to provide prompts and hints, determine whether the answer is correct and the number of attempts. Student answers and the number of attempts are passed via PHP to an SQL server at the corporate site. Answering a challenge correctly enables the student to continue in game play, e.g. jumping over the pits. Incorrect answers route students to a page where they can choose to answer practice problems, watch a video on the topic, or read a web page.

Game development and testing occurred in three stages.

STAGE ONE: Three levels were created, tested and revised. During development, two days of user-testing on-site were held to identify issues with integration with the school system and other usability problems. One unexpected problem identified was that due to the need to run a particular mandated assessment program, the Bureau of Indian Education schools in the area used Windows XP. Rather than develop for an operating system quickly becoming obsolete, the project purchased 15 laptop computers to be used in development.

While the first three levels were being used in the schools, a fourth level was created. User input was collected both electronically and by our site coordinator. Based on this feedback, the levels were revised. For example, wooden arrows were added to the path to make the correct direction more obvious, as students frequently lost their way in the 3-D world. As students seldom selected the longer Khan Academy videos as instructional choices, a larger number or short videos (2-3 minutes) were added.

STAGE TWO: After three weeks of user testing, all four levels were revised again. For example, we found that some students deliberately wandered around to explore the virtual world. To maximize the proportion of time spent on the challenge problems and related mathematics, barriers were added. It became apparent that many students required instruction in basic keyboarding and some students were further behind in grade level than had been anticipated. Thus, the introductory level was expanded to include both second-grade level material and detailed instructions on using the keyboard and browser, e.g., to click on tabs at the top of a page to see a new page.

STAGE THREE: After this second revision, an additional three weeks of testing of the prototype occurred using all six levels. Instructional content for each level is shown in Table 1 below.

Table 1
Content by Game Level

Level	Content
Finding your way to the camp	Introductory level collects student demographic data, provides game background, game instructions and problems at the second-grade level.
Herb hunt	Multiplication of one- and two-digit numbers
Warn the tribe	Review of multiplication, division of two-digit numbers by single-digit numbers
Buffalo hunt	Multiplication of two-digit numbers. Division of three-digit numbers
Berries in the woods	Multiplication of two-digit numbers. Computation of perimeter
Stealing ponies	Use of a number line. Computation of probability.

The game levels are organized hierarchically, by grade level, with problems from standards for second grade at level 1, third- and fourth-grade at levels 2 and 3, problems from fourth-grade standards at level 4, and fifth-grade at levels 5 and 6.

As North Dakota, along with 44 other states, will soon be making a change to the Common Core Standards, with a heavier emphasis on number sense and operations in elementary grades, this is the area of the standards where the greater emphasis was placed in Phase I.

The application installed on laptops included the following directories:

- Oyate: A 3-D virtual world under the name Spirit Lake Oyate: The Game
- Input: Pages that serve the in-game challenges
- Quizzes: I-framed pages that serve the quizzes from SurveyMonkey
- Framed Pages: I-framed pages that serve supplementary games, practice problems and virtual manipulatives from the Internet. These are framed rather than linked to keep the player within one window session and thus facilitate passing data in the form of a JSON object
- Extra Assets: Contains supplementary games, practice problems and virtual manipulatives written by the project and stored locally
- Movies: All video clips, whether part of the game instructions, challenges or mathematics instructional resources are stored here.
- Scenes: Artwork used in the 3-D game is stored here.

With six playable levels completed, objective one was met.

<u>Objective 2: Write a program to collect on-line assessment data for evaluation of students' progress in mathematics and usage of DLP resources.</u>

Data to address this objective were collected from three sources; in-game input forms, Surveymonkey quizzes and a browser cache file. Student answers to challenges were saved in an SQL database on the corporate server. Pre-test and post-test data and all quizzes to which students were routed following incorrect answers were created and stored in Surveymonkey. Student usage data were stored in a file on the laptop for monitoring use of local files and on the corporate server to record usage of on-line resources.

Surveymonkey was used to expedite programming in Phase I. It allows for skip logic to send students to harder or easier test items based on the correctness of their answer and to route students back to the game if they meet a criterion, in this case, correctly answering five questions of increasing difficulty. While Surveymonkey proved adequate for the prototype phase and testing there were drawbacks. Using an outside source for production would leave the DLP application vulnerable if the Surveymonkey vendor were to go out of business or raise prices significantly, making a stand-alone solution preferable.

Coding our own quizzes will also allow for tighter integration within the game and customization to meet the needs. User testing, discussed under objective one, showed that students made fewer errors when links were large and highlighted. While manuals on best practices in web design decry flashing animation with comments such as, "Don't use animated gifs unless your target market is ten-year-olds", it so happens that our target market <u>is</u> ten-year-olds and large, flashing buttons that say "Click here to return" are effective. *As the quiz questions, multiple choice options and program logic have all been written rewriting these in HTML and JavaScript can be accomplished quickly in Phase II.*

Three separate types of SAS programs were written to read each data type. Both the SQL files and Surveymonkey data can be downloaded as Excel files and imported into SAS. Thus, switching from Surveymonkey to an in-house system will require no revision of the analysis programs. Each program reads the data into separate variable fields, checks for out-of-range values, computes frequency distributions and produces tables of items by difficulty level. Programs for quizzes and tests also compute internal consistency reliability statistics. All programs have been documented and can easily be converted into macros to be called as needed for analyses of Phase II game challenges, quizzes and usage data analyses.

Objective two was met.

<u>Objective 3: Create supplemental materials for instructors including PowerPoint presentations and printable study guides.</u>

This objective has been met.

A draft version of a printable teacher's manual was written and two on-line resources created, comprising of proprietary materials in teacher resource directory, and public resources, respectively.

The teacher resource directory includes five types of resources;

1. Practice problem presentations that show how to solve sample problems similar to those used in the game challenges,
2. Instructional presentations that teach topics tested in the game,
3. Game instructional resources, including one PowerPoint and several printable handouts,
4. Copies of the pre-test and post-test used,
5. Printable certificates to give to students as reinforcements for passing a level.

Based on observational data collected during the user tests completed under objective 1, each resource was designed to present a single topic in a 2-3 minute discussion. Tests were given to the teachers upon their requests. Although it was expected that teachers would teach similar problems, there was no guarantee that they did not use the identical problems. In Phase II, the problems on the pre-test and post-test will be modified to be similar but not identical to the problems on the test examples that the teachers received.

North Dakota is one of the states that does not release items on the tests administered to assess whether schools met their annual goals. This has caused significant friction at some schools, including those used as our experimental and control groups, with the assessment perceived as something of a "black box". In the interest of maintaining rapport with the schools, our site coordinator felt it best to provide teachers with copies of the tests used.

Teacher resources were maintained in a password-protected site, enabling us to monitor which teachers accessed these resources for classroom use and which did not. All three of the fourth grade teachers downloaded the supplemental materials, while none of the three fifth-grade teachers did.

Our on-site coordinator made extensive use of the public resources that we had curated, using at least one of these sites per day for every day of the last three weeks of testing. While the fourth-grade teachers were in the classroom when this usage occurred, and commented positively on the sites and the students' reactions, they did not initiate usage of these resources outside of the planned intervention time.

Objective 4: Write a program to collect on-line data on teachers' usage of DLP resources.

This objective was met. The program to collect data was written, however, the program was not used in Phase I. None of the fifth-grade teachers accessed the DLP resources. The students used the program outside of the regular classrooms, and although all of the teachers were offered a username and password for site access, none of the fifth-grade teachers requested one. Thus, for fifth-grade teachers, there was no usage to analyze.

In contrast, all three of the fourth-grade teachers requested, and received, usernames and passwords. In this situation, on-line usage data did not prove to be an indicator of teacher usage of DLP resources. The site coordinator noted that the fourth-grade teachers worked collaboratively. One teacher would, for example, download a "cheat sheet" for the game that gave keyboarding instructions, and then print copies for all of the classes.

Very little on-line usage was recorded of the teacher resources, or teacher usage of the game itself. Three, non-exclusive reasons for this lack of usage are postulated. First, the teacher resources were not available until mid-way through the pilot test. Second, due to the timing when resources were available, the teacher training that occurred at the beginning of the project did not emphasize teachers' usage of resources. Third, both teachers and the site coordinator experienced time constraints during the pilot testing, which occurred as a result of conducting the testing during the school day when school staff have many competing responsibilities.

Objective 5: Write programs that will serve as a basis for extension of the levels for additional lessons in Phase II and to additional tribal groups in Phase III.

This objective was met. Extensibility was a consideration throughout the program design.

All input forms for answers to the games math challenges call the same JavaScript file where the problem, correct answer, prompts and hints are all variables. All game input uses the same JSON object and PHP script. Thus, a new HTML file can be written, with artwork to reflect another reservation's geography and a problem on a different mathematical topic, re-using the same scripts from Phase I for checking the correct answer, providing prompts and hints for student guidance.

Game customization is simplified by having relative links to artwork, sound and video files in separate folders. To change the game from Dakota to another language, the sound directory can be replaced. Hundreds of game links to files that speak Dakota words will automatically link to files with the new language. Similarly, to change artwork, the appropriate directory can be replaced. Automatically, the links in the game to characters with dress and features representing one tribe will be replaced with characters for a new tribe.

As noted above, quizzes use data collected and stored using Surveymonkey, a commercial service. These will be rewritten in Phase II using JavaScript, HTML and PHP to collect data and write to the same database as the in-game problems.

SAS programs were written to analyze the data. The analytic programs can be re-run to produce reports by school, grade or classroom for any site by simply adding one statement to filter the relevant criteria. It is probable that SAS will be used in the final commercial solution, with cost estimates and licensing terms are currently being negotiated with the vendor. If the decision is made to write an in-house solution, the logic used in these programs can still be used to re-code in a combination of JavaScript, HTML and R.

Objective 6: Conduct an analysis of impact on student performance that will serve as a guide for Phase II design.

This objective was met.

A sample of fourth- and fifth-grade students was selected from two reservation schools. Pre-test and post-test data were collected to measure impact on mathematics achievement. Usage data were collected to enable comparison of students' time on task with improvement.

Sample

The sample with complete data consisted of 62 fourth and fifth-grade students in 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.

The program was implemented in Fall, 2012. 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 site coordinator observations, their reading and mathematics skills were second-grade level or below. In the experimental school, five fifth-grade students from each of the three classrooms were selected by their teachers to participate.

Table 2
Sample Demographics for Students with Complete Data

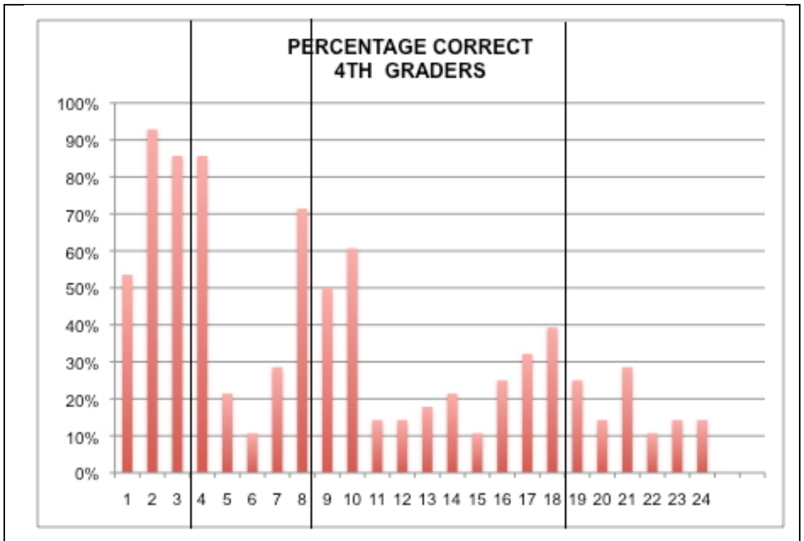
	Intervention (N =39)		**Control (N=23)**	
Gender % female	51%		48%	
Grade • Fourth grade • Fifth grade	 70% 30%		 51% 49%	
	Mean	**SD**	**Mean**	**SD**
Age (All students)	9.7	0.8	10.1	0.6
Grade • Fourth grade • Fifth grade	 9.5 10.4	 0.6 0.9	 9.9 10.3	 0.7 0.5

There were no significant differences between experimental and control group schools in gender distribution, or in age within grade.

Instrumentation

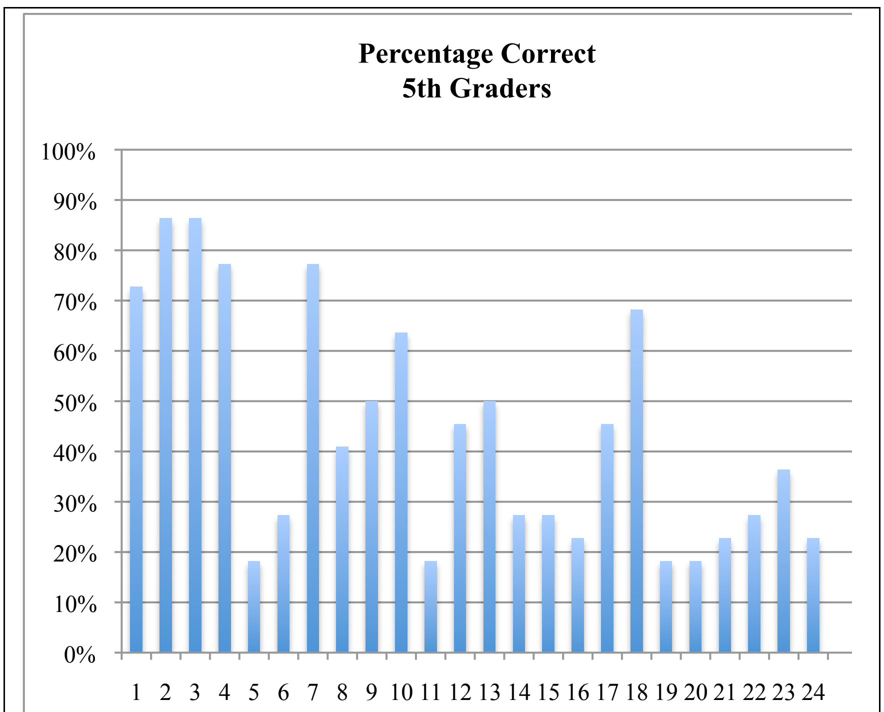
A 24-item test was created, matched with North Dakota state standards for grades two through six. It was initially planned to use released items from the state standards test. However, North Dakota is one of the few states that does not release test items. Thus, released items from the California state standards test were used. The published California standards addressed by these items matched verbatim with North Dakota standards. Test items with related standards are included in Appendix B.

The percentage correct for each item on the pre-test can be seen in Figure 1 for fourth-grade students and in Figure 2 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 third-grade level that the fourth-grade students' percentage correct was higher than the 25% predicted by chance. Similarly, on only one item at the fifth-grade level did the fifth-grade students answer correctly more often than would be predicted by random guessing. The internal consistency reliability coefficient for the 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.



2nd Grade	3rd Grade	4th Grade	5th Grade

Figure 1: Grade Four Pre-Test Scores, All students



2nd Grade	3rd Grade	4th Grade	5th Grade

Figure 2: Grade Five Pre-Test Scores, All students

Data Collection

Four types of data were collected; pre-test/ post-test data, usage data, responses to in-game challenges and quiz data. The pre- and post-test values were used to assess the effectiveness of the Dakota Language Project. 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 experimental group and all students from the control group school took the post-test.

Usage data were collected to monitor percentage and total time on task during the hours allotted for the experimental 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 by subtracting the time of first input from a student in the class from the time the last student in class answered a question. The data from these input forms were also used to monitor the speed of progress of students in the game and problem difficulty. A second measure of usage was collected automatically by a file installed on each computer that recorded each remote website visited as well as accesses of files stored locally. To preserve confidentiality, individual student data was not recorded.

Quiz data are collected using Surveymonkey software. Students are routed to progressively easier or more difficult questions based on their responses.

Data Analysis

Descriptive statistics were computed for demographics, total minutes of usage, pre-test and post-test scores, by grade level and by school. Two repeated measures analysis of variance (ANOVA) was performed 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.

Three outliers, one from the experimental group and two from the control group, were deleted from the final analysis. All 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 experimental group.

Results

Means, standard deviations and number of subjects (N) for experimental and control groups are shown in Table 3.

Table 3
Descriptive Statistics, By Group and Grade Level

	EXPERIMENTAL						CONTROL					
	Pre-Test			Post-test			Pre-Test			Post-test		
	Mean	S.D.	N	Mean	S.D	N	Mean	S.D	N	Mean	S.D	N
All	9.3	2.3	37	14.3	5.2	40	9.0	2.1	21	9.7	2.6	22
Grade												
4	9.2	2.5	25	15.1	5.3	28	9.3	2.5	10	9.9	1.9	11
5	9.5	1.9	12	12.3	4.6	12	8.6	1.7	11	9.5	3.3	11

The effect is best illustrated graphically, as in Figure 3. It can be seen that the two experimental groups increased dramatically on the tests. 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.

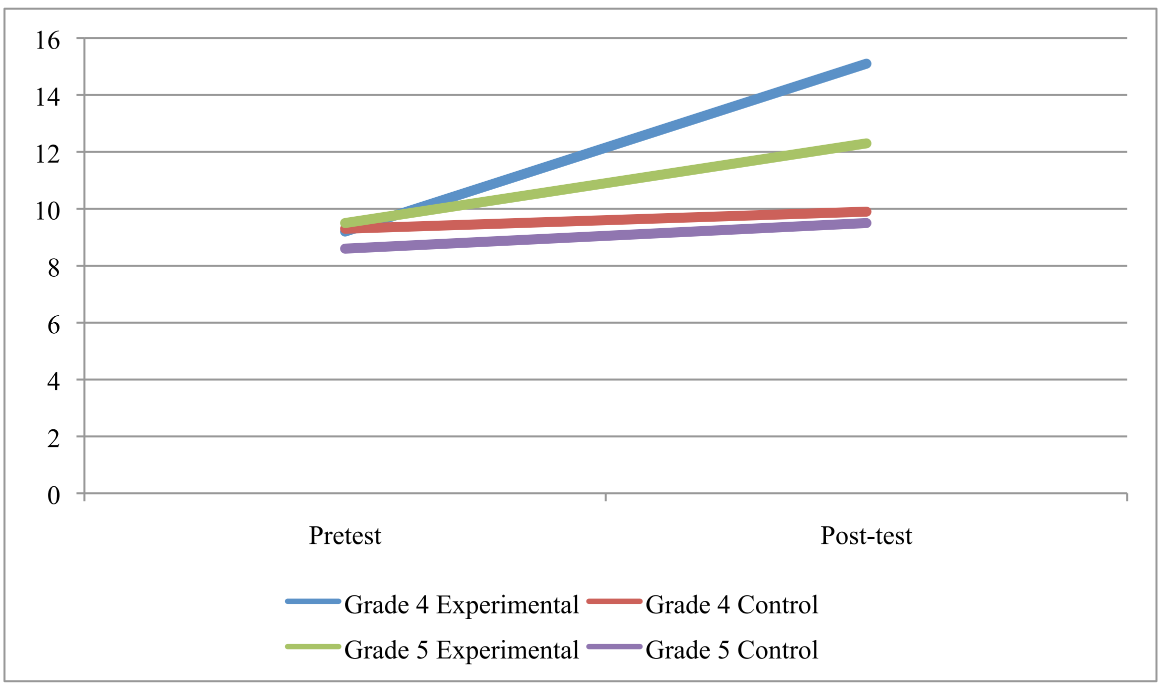


Figure 3: Pre-test and Post-test mean scores by grade and school

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.

Table 4
Repeated Measures Analysis of Variance, Tests of Hypotheses

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Time	1	164.9709833	164.9709833	12.91	0.0007
time*school	1	91.0408001	91.0408001	7.13	0.0100
time*grade	1	11.5785050	11.5785050	0.91	0.3454
time*school*grade	1	21.9684761	21.9684761	1.72	0.1953
Error(time)	54	689.9678788	12.7771829		

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.

Commercialization

A Kickstarter crowd-funding campaign was developed during the grant period and conducted in February, 2013. Although less than 4% of Kickstarter projects succeed with a target of $20,000 or higher (Kickstarter, 2013), our project, marketed as 7 Generation Games, exceeded its target, receiving over $21,000 from 255 backers. Funds were received in March, 2013 and are being used to fund continued development of the game and related analysis programs. Applications have been submitted to the Pearson EdTech accelerator program and NYC Schools Gap App challenge. The company presented to a group of 142 investors and developers as one of nine start-ups invited to present at the 106 Miles Women in Tech Demo in February, 2013. These commercialization activities offer both bridge funding from Phase I to Phase II and increased market visibility. An extensive and detailed commercialization plan was written, in consultation with a consulting company provided by USDA (LARTA) and is included in the Phase II proposal submitted in February, 2013.

CONCLUSION

The Phase I results were <u>extremely</u> promising in establishing both feasibility and commercialization. All technical objectives were met. The game proved to be highly engaging to the students and related to significantly higher test scores. Before Phase I had ended, the company had been contacted by schools and after-school programs in three states asking to be part of the beta-testing or purchase the application. The major goal of Phase I, to establish feasibility, was accomplished.

Phase I also identified technical and research design issues that will be applied to guide Phase II research design. As some schools are still using Windows XP, the project has a choice of developing for an operating system soon to be obsolete or supplying computers with Windows 7 or higher for the test site. For non-BIE schools, this is not an issue. For testing purposes in Phase I, The Julia Group shipped 15 laptop computers owned by the company to the experimental school, with the program installed.

Developing this product now puts the Dakota Learning Project even further ahead of the competition in terms of meeting the needs for BIE schools when they do, out of necessity, upgrade their systems. However, it also mandates purchasing a sufficient number of laptop computers to conduct research in the schools still using obsolete equipment.

In the interest of creating a workable prototype within a short time frame, commercial solutions were used, Surveymonkey for collecting quizzes, pre-test and post-test and SAS software for data management and statistical analysis. In Phase II, all data collection will be done using internal programs to increase flexibility in data collection format and reduce reliance on vendor-supplied components.

Teacher reports, the site coordinator observations and the time students were on task all support a high level of student engagement. Research reviewed for the Phase I proposal, as well as our own research (De Mars & Gill, 2007) have shown efforts to promote student engagement – that is, time on task, persistence in the face of difficult problems – to be a factor in high-performing classrooms. In Phase II, student engagement will be measured directly on pre- and post-test at experimental and control schools to test for a positive effect of the application on improving students' effort and time on task in mathematics assignments.

Several changes will be made in the Phase II design based on eight months of interaction with the schools. Problems in organization and low-performance in these low-performing rural schools were greater than anticipated. Achievement was lower, resources scarcer, absenteeism higher and staff turnover greater even than the high level of challenge we had anticipated based on past experience in this and similar reservation communities. On the positive side, these high needs make the future commercial potential of Dakota Learning Project even brighter.

In an effort to minimize time required for data collection, demographic data were collected at the post-test only, based on the presumption that, eight weeks later, the same students would be tested. This assumption significantly underestimated the absenteeism and transfer rate from these schools. 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". In Phase II, demographic data will be collected at pretest to enable comparisons with students with and without missing data.

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.

The original plan was to use Warwick as the experimental school and Tate Topa as the control group. Administrators at both schools agreed to be a possible experimental site. In the end, Tate Topa was selected as it was somewhat larger - 73 eligible students in grades four and five, compared to 48 at Warwick. As one indication of the high level of school interest in our product, the experimental school has agreed to fund facilities, transportation and insurance costs in Phase II for students to participate in the Dakota Learning Project research in the after-school program. As nearly all students ride the school bus, transportation is a high, and essential, cost for after-school use. Conducting testing after school will eliminate many of the scheduling problems experienced.

It was 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 Phase II, fourth- and fifth-grade students will be used as participants in the research in the first year, with sixth-graders added in year two. Again, as evidence of a pent-up demand for a computer application to increase mathematics achievement for children living on reservations, schools on two additional reservations, as well as the control and experimental schools in the Phase I research, have all offered to participate in Phase II, insuring a more than adequate number of subjects, even accounting for the substantial attrition that we know to expect.

In conclusion, Phase I has been an extremely successful project in meeting all technical objectives and clearly establishing the technical and commercial feasibility of the Dakota Learning Project. Of equal importance, data collected in this phase has identified specific challenges to be addressed in Phase II and to a large extent, provided the directions to meet those challenges, resulting in a final product that is effective in promoting rural development and commercially sustainable.

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Appendix A
List of Technical Publications

Conference symposium proceedings

De Mars, A. (2013). Use of SAS On-Demand software for analysis of "real data" in teaching statistics. Presentation at the SAS Global Forum, San Francisco, CA (Invited paper to be presented April, 2013)

Website developed

7 Generation Games website http://www.7generationgames.com

APPENDIX B

Protocol Developed
Promotional materials

Items on Pre-test by California Standards Test Item,
Grade Level and Standard Tested

Test item	CST Item	Grade	Standard tested	Standard Number
20	30	5	Demonstrate proficiency with division, including division with positive decimals and long division with multi-digit divisors	5NS2.2
21	31	5	Demonstrate proficiency with division, including division with positive decimals and long division with multi-digit divisors	5NS2.2
22	78	5	Differentiate between, and use appropriate units of measures for, two- and three- dimensional objects (i.e., find perimeter, area, volume).	5MG1.4
23	61	5	Identify and graph ordered pairs in the four quadrants of the coordinate plane	5AF1.4
24	92	5	Organize and display single-variable data in appropriate graphs and representations (e.g., histogram, circle graphs)	5PS1.2
19	3	5	Compute a given percent of a whole number	5NS1.2
13	17	4	Use concepts of negative numbers (e.g., on a number line, in counting, in temperature, in "owing").	4NS1.8
9	1	4	Read and write whole numbers in the millions	4NS1.1
10	3	4	Read and write whole numbers in the millions	4NS1.1
12	33	4	Solve problems involving multiplication of multidigit numbers by two-digit numbers.	4NS3.3
14	38	4	Solve problems involving division of multidigit numbers by one-digit numbers	4NS3.4
11	41	4	Solve problems involving division of multidigit numbers by one-digit numbers	4NS3.4
15	40	4	Solve problems involving division of multidigit numbers by one-digit numbers	4NS3.4
16	42	4	Solve problems involving division of multidigit numbers by one-digit numbers	4NS3.4
17	92	4	Interpret one- and two-variable data graphs to answer questions about a situation.	4PS1.3
18	95	4	Express outcomes of experimental probability situations verbally and numerically	4PS2.2
5	37	3	Solve simple problems involving multiplication of multi-digit numbers by one-digit numbers	3NS2.4
6	42	3	Solve division problems in which a multi-digit number is evenly divided by a one-digit number	3N32.5
4	1	3	Count, read and write whole numbers up to 10,000	3NS1.1

7	32	3	Use the inverse relationship of multiplication and division to compute and check results	3NS2.3
8	56	3	Select appropriate operational and relational symbols that make an expression true	3AF1.3
1	26	2	Use repeated addition, arrays and counting by multiples to do multiplication	2NS3.1
2	33	2	Know the multiplication tables of 2s, 5s and 10s	2NS3.3
3	75	2	Tell time to the nearest quarter hour and know relationships of time (e.g., minutes in an hour)/	2MG1.4


SPIRIT LAKE OYATE
THE GAME