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# Native Science Connections Research Project: Integrating Relevant Cultural Knowledge into the Science Curriculum for Grades 4-6th

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## Introduction

American Indian students are capable of excelling in science education. In part, what makes this possible is the notion that if they are grounded in their own "cultural knowledge," or "funds of knowledge" (Moll et al, 1992; Moll and Gonzalez, 1997), this will further assist in acquiring and understanding science concepts. Unfortunately for some, this cultural knowledge is not recognized or valued by the educational system as part of the learning process. When the educational system neglects to accept the student's own traditional teachings nurtured in the home and the local community, this may cause students to unintentionally inhibit their desire to learn science, to avoid science professions, and cause them to question their own cultural identity. Therefore, it is imperative that educators and curriculum writers should clearly address these issues when developing curriculum that integrates the cultural aspects of American Indian people.

Clearly, American Indians, like all cultures, have been using science for all aspects of life - survival. Yet, this local native "cultural knowledge" has not been included in school science curricula. Instead, they are taught science concepts from a Western European perspective. If American Indian students are to become successful, they must be allowed to utilize their own cultural knowledge and experiences in order to better understand the concepts being taught in school. We should recognize that the cultural knowledge children bring to the classroom is just as important as what is being taught in the classroom.

## Research Design

Two hypothesis were considered for this research project: 1) that the Navajo (Diné) students will better learn the science curriculum in schools, if they are also grounded in their own "native" science concepts and related cultural knowledge; and after exposure to the Navajo Supplemental Science Curriculum (NSSC), 2) that the Navajo students will acquire positive attitudes toward science and science education. To test for the effectiveness of the NSSC and the science attitudes of children, a quasi experimental design with pre- and post-test repeated measures was employed. This was possible given the basic science training the project provided to all participating

teachers. The experimental classrooms received the Full Option Science System (FOSS) science lessons with the NSSC component (Treatment X) while the control classrooms employed FOSS science lessons alone. By administering pre (01) and post (02) tests on student science achievement and student attitudes toward science, and by subjecting these dependent variables to the appropriate statistical analyses, we were able to observe changes in achievement and attitudes across time, and within and between groups.

The temporal parameters of the research design were twelve weeks. The control and the experimental teachers taught their lessons during the same period. The pre- and post-test data were also collected one-week prior and one-week after the lessons were taught, respectively.

**Illustration A. Quasi Experimental Design**

| | | |
|---|---|---|
| Experimental Group (FOSS+NSSC Science) | 01 X | 02 |
| Control Group (FOSS only) | 01 | 02 |

01 = pre-tested subjects/classrooms
02 = post-tested subjects/classrooms
X = Treatment/Navajo Supplemental Science Curriculum

## Research Methodology

Obtaining permission to conduct research and maintaining a trusting relationship with the Navajo Nation need special mentioning as important parts of the methodology of this study. Negotiations were always initiated by obtaining the "blessings" from the Chairman/President and the members of the tribal council. Acknowledging that the investigator is also native, culturally binding formal "oral" permission was first obtained. Among Native Americans, oral agreements are as binding as written agreements are for the Western cultures. Having received their respective "blessings," the researcher then obtained formal "written" permission from the various boards of education and superintendents. The researcher presented the project to principals and to teachers. Discussion also took place with school community parents and their children. The investigator received written permission from all participants including children.

### Sample Size and Distribution

After screening for "full test" (defined as having both pre-posts on FOSS and SAI) and the required consent forms from the parents of all participating students the total n-count was 95 fifth-grade Navajo students that formed the student sample for this research. Table 1 shows the sample distribution of students (boys and girls) in the

Navajo Nation.

After careful screening of the sample to assure a robust analysis, only 95 student pre and post achievement and attitudes tests results were subjected to statistical analyses. A system file for screening was created using the Systat Data Editor computer program that included all the coded quantitative and demographic data. Those students who did not take both pre and post tests and/or did not have signed parental consent and student consent forms were eliminated from the analyses. Moreover, data from mainstreamed mentally challenged students who actively participated in all aspects of the study were not subjected to analyses.

Five schools, 7 teachers and 95 Navajo fifth grade students on the Navajo Nation participated in this study. Of all the 95 fifth grade students in the study, 56 were in the control group and 39 were in the experimental group. Gender representation was 54 boys and 41 girls. Four classrooms represented the control group, and three classrooms represented the experimental group. All the schools were located on the Navajo Nation, with two schools being public schools and the remainder being contract schools.

A random sampling of subjects (students, schools and classrooms) was not possible. Instead, a convenience sampling technique was used to constitute the control and experimental groups.

**Table 1**
**Sample Distribution across Tribe, Group, Classrooms, and Gender**

| Tribe | Group (n) | No. of Classrooms | Boys | Girls | Total |
|---|---|---|---|---|---|
| Navajo [n=95] | Control [n=56] | 4 Classrooms | 34 | 22 | 56 |
| | Experimental [n=39] | 3 Classrooms | 20 | 19 | 39 |
| Navajo | 2 Groups | 5 Schools (4+3) = 7 Classrooms | 54 | 41 | 95 |

## Data Collection

Overall, data was collected from the seven participating fifth grade classrooms on the Navajo Nation. Both the experimental and control group participating teachers received intense (teacher) training on the Full Option Science System (FOSS) treatment materials for three weeks by the Science Math and Learning Center (SMLC) on the campus of Northern Arizona University, Flagstaff Arizona. The experimental group teachers received training in the use of and implementation of the Navajo Science Supplemental Curriculum for an additional two weeks. The same achievement (FOSS) and attitude (Science Attitude Inventory - SAI) tests were administrated as pre- and post-test on both control and experimental groups. The students of both control and

experimental groups were taught the FOSS materials for twelve weeks. The treatment group was taught the materials with a Navajo cultural component integrated into the traditional science (FOSS) curriculum utilizing the Instructional Sequence model. The time between the pre- and post-test was approximately twelve weeks, the treatment period for the study. The respective classroom teachers who taught those classes under the direct supervision of the investigator administrated both tests.

Two instruments were used to collect quantitative data in this research: a) Achievement test (open-ended) on Full Option Science System (FOSS); and b) Attitude test (5 point Likert-type scale) on Science Attitude Inventory (SAI). The achievement test on FOSS material contained 14 questions covering the modules that were taught in the classrooms for twelve weeks. Since the responses were open-ended (in words), inter-ratter reliability was conducted on all 14 questions to identify correct/near correct answers. The inter-ratter reliability coefficient for individual items of the FOSS achievement test was found to be very high (ranged between .80 - .90). Then the tests were graded as 1 for a correct answer and 0 (zero) for a wrong answer. Therefore, the range of scores for this instrument was 00 to 14.

The Science Attitude Inventory (SAI) was adopted from Matthews (1990). The instrument is a Likert-type closed-ended questionnaire on a 5-point scale: Really Agree-5; Kind of Agree-4; Don't Know-3: Kind of Disagree-2: and Really Disagree-1. The 5-point scale has a neutral/average point as "Don't Know" - 3 which breaks the continuum between "Agree" and "Disagree." The 40-item questionnaire happened to contain 20 negative statements. However, once the data were collected all 40 items were taken into account for statistical analyses.

## Results: Descriptive Analysis of FOSS and SAI Data Using Student t-Tests

Results of the Navajo Nation study are presented in tables and figures to compare mean and standard deviation using Student t-test: Independent t-tests with separate variance for group comparisons and paired t-tests for pre- and post-tests comparisons. Independent t-tests were computed on all mean totals of FOSS and SAI to compare control and experimental groups' scores; where as Paired t-tests were computed on paired scores of FOSS and SAI separately for individual control and experimental groups.

Independent samples t-tests (using Systat 5.1) were computed to determine if there were any significant mean difference between control and experimental groups on FOSS and SAI pre- and posttests. Although both separate and pooled t-tests were made available from the computer analysis, only the separate variance t-statistics is reported here at a significant level of $p<.01$. To compare control and experimental groups, four representative variables were considered. They are: achievement totals of FOSS pre- and post-tests (specified as FOSS pre-total mean, and FOSS post-total mean); and attitude totals of SAI pre- and post-tests (specified as SAI pre-total mean and SAI post-total mean). The FOSS achievement was a 14 item test with maximum score of (14 X 1)

14; the attitude test was a Likert-type survey on a 5 point scale (5 being most positive and 1 being most negative). Hence, the range (of minimum and maximum scores on this instrument) was 40-200.

## Comparison of Experimental and Control Group on FOSS and SAI Means

As mentioned earlier, Independent samples t-tests were computed to determine if there were any significant difference between the control non-treatment and experimental-treatment group on both the pre- and post-tests means of FOSS and SAI. The results with separate variance t-tests on four variables grouped by control and experimental are shown in Table 2.

**Table 2**
**Comparison of Navajo Control and Experimental Group on FOSS and SAI with Independent t-Statistics and p-Significance**

| Variable | Control Group [n=56] | | Experimental Group [n=39] | | t-Statistics with DF | Significance of P |
|---|---|---|---|---|---|---|
| Total | Mean | S.D. | Mean | S.D. | Separate Variance | */** |
| FOSS Pre-total | 4.54 | 2.18 | 4.36 | 1.83 | t=0.43; DF = 89.8 | p=0.67 |
| FOSS Post-total | 6.46 | 1.72 | 8.64 | 2.68 | t=4.47; DF = 59.4 | p=0.000** |
| SAI Pre-total | 131.00 | 16.13 | 134.51 | 12.14 | t=1.21; DF = 92.4 | p=0.23 |
| SAI Post-total | 136.32 | 14.45 | 138.36 | 13.79 | t=0.70; DF = 84.3 | p=0.49 |

**Note: ** Significant at p<.01; * Significant at p<.05**

It is apparent that except for the FOSS post-test mean difference between the control and the experimental groups, no other mean-difference on three other variables are statistically significant. The mean-difference projected in Table 2 on both FOSS and SAI tests between the control and experimental groups are summarized in Figures 1 and 2.

**Figure 1**
**Navajo Control and Experimental Group Comparison on FOSS Means**

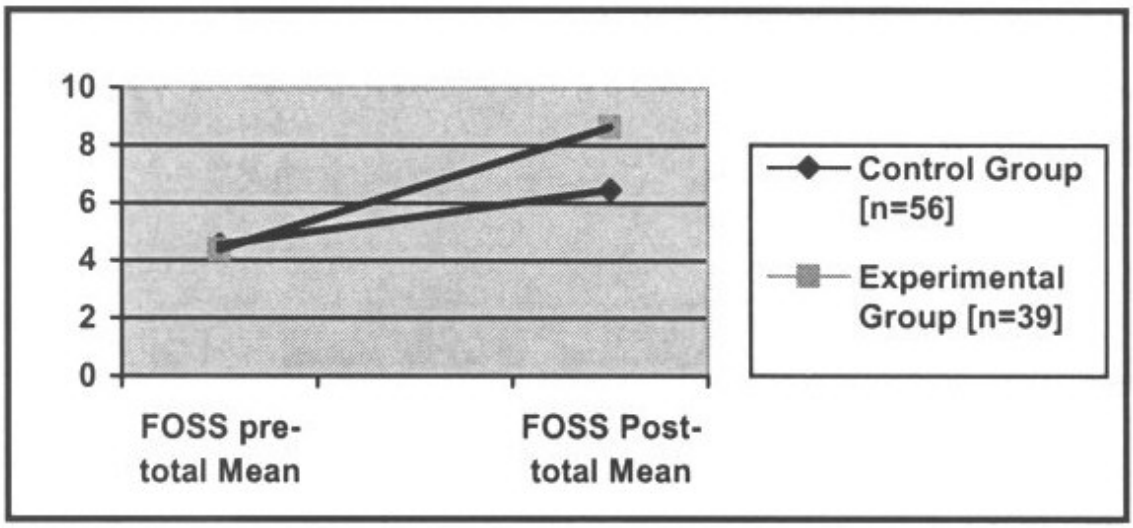
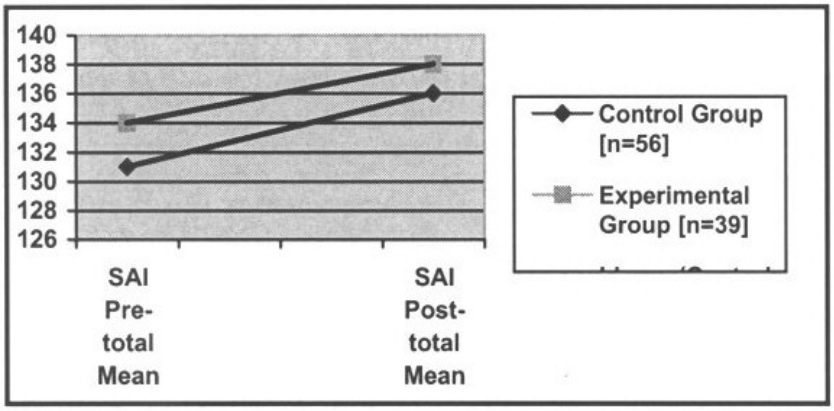



**Figure 2**
**Navajo Control and Experimental Group Comparison on SAI Means**




## Overall Comparison for Navajo Sub-groups on Pre- and Post-tests

Overall, in the Navajo sub-group, there was some increase in mean scores from pre- to post-test on both the FOSS and the SAI. For this group, the increase in

FOSS (2.90) and in SAI (4.72) were statistically significant at p<.01. Taking this sub-group (n=95) as a whole, the gain is shown in Table 3.

**Table 3**
**A Mean and Standard Deviation Comparison of Pre- and Post-tests on FOSS and SAI for the Navajo Sub-group (n=95)**

| Tests | Pre-tests [n=56] | | Post-tests [n=56] | | Mean difference | Student t with DF |
|---|---|---|---|---|---|---|
| Type | Mean | S.D. | Mean | S.D. | +/- Gain | P-Significance |
| FOSS | 4.54 | 2.18 | 6.46 | 1.72 | 1.92 | [t=6.27; DF=55] at p=0.000** |
| SAI | 131.00 | 16.08 | 136.32 | 14.45 | 5.32 | [t=3.18; DF=55] at p=0.002** |

**Note: ** Significant at p<.01; * Significant**

## Mean Comparison for Navajo Control Group on Pre- and Post-test

Like the overall mean for this sub-group, both the control and experimental groups showed some increase in the mean scores from pre- to post-tests. Table 4 and 5 respectively describes the increase on both FOSS and SAI for the control and experimental groups. For the Navajo control group, the increase in FOSS (1.92) and in SAI (5.32) were statistically significant at p<.01 (see Table 4).

**Table 4**
**A mean and Standard Deviation Comparison of Pre- and Post-tests on FOSS and SAI for the Navajo Control-group (n=56)**

| Tests | Pre-tests [n=56] | | Post-tests [n=56] | | Mean difference | Student t with DF |
|---|---|---|---|---|---|---|
| Type | Mean | S.D. | Mean | S.D. | +/- Gain | P-Significance |
| FOSS | 4.54 | 2.18 | 6.46 | 1.72 | 1.92 | [t=6.27; DF=55] at p=0.000** |
| SAI | 131.00 | 16.08 | 136.32 | 14.45 | 5.32 | [t=3.18; DF = 55] at p = 0.002** |

**Note: **Significant at p<.01**

## Mean Comparison for Navajo Experimental Group on Pre- and Post-test

For the Navajo Experimental group, the increase in FOSS (4.28) was statistically significant at the p<.01 level; however, the increase in SAI (3.85) was not

statistically significant (see Table 5).

**Table 5**
**A Mean and Standard Deviation Comparison of Pre- and post-tests on FOSS and SAI for the Navajo Experimental group (n=39)**

| Tests | Pre-tests [n=56] | | Post-tests [n=56] | | Mean difference | Student t with DF |
|---|---|---|---|---|---|---|
| Type | Mean | S.D. | Mean | S.D | +/- Gain | P-Significance |
| FOSS | 4.36 | 1.83 | 8.64 | 2.68 | 4.28 | [t=-10.11: DF=38] at p = 0.000** |
| SAI | 134.51 | 12.30 | 138.36 | 13.79 | 3.85 | [t=1.84: DF = 38] at p = 0.073 |

**Note: **Significant at p<.01**

## Conclusions and Implications

The results of the Navajo Nation leads to ascertain the hypothesis of the research that the Navajo students would learn the traditional science curriculum (FOSS) in schools if they were also grounded in their own "native" science concepts and related cultural knowledge. It also illuminated the fact that after the students were exposed to the Navajo Science Supplemental Curriculum, they could comprehend the science concepts better than before.

The trend in this research also implies that the Navajo students would acquire positive attitudes toward science and science education if they are exposed to such science curricula for a considerable longer period of time. From the experience of this research, it is also expected that students might score better both on FOSS and SAI when these tests are made suitable according to the language proficiency and grade-level aptitude of the Navajo students. Such conclusions imply further research in the field and a closer scrutiny of the conditions that prevail in the Navajo schools.

Our direct classroom observations in the Navajo classrooms confirm that the students were actively learning science through a small group cooperative learning approach modeling actual scientists at work. Most teachers mentioned that the small group independent learning approach was a new experience in their pedagogy. They learned that active learning classrooms are not quiet classrooms. In addition, the teachers were able to utilize the didactic approach to teaching where students were given a certain problem to solve, and they were able to solve the problem by "discovery learning." They were also allowed to question, test, discuss, inquire and discover solutions for a specific problem. Utilizing the cooperative learning approach allowed all students the opportunity to participate in carrying out all experiments in the classroom.

In teacher training institutions, teachers are encouraged to learn about their school's community social and cultural aspects so that they may incorporate this knowledge into the existing curriculum. However, a model for accomplishing this in science was noticeably absent. Although teachers have many responsibilities, we also believe that teachers must become "social" scientists. Teachers must establish a working relationship with the local community in which they teach. They must acquire cultural information about the culture in which they work, and at the same time, utilize the cultural experts in the community. One of the most important findings of this study may well be that a successful model now exists.

The majority of the teachers in this study were not native teachers. For many non-native teachers, there is still a great concern about teaching culture other than their own. The Navajo Science Supplemental Curriculum was developed with these teachers in mind since they are the ones who must teach the children. We have found that both native and non-native teachers can learn to successfully integrate native (Diné) knowledge into science lessons. The Navajo Supplemental Science Curriculum promoted teacher research into local communities. Their training included how to gather cultural information from the local community and then how to integrate this knowledge into the curriculum. One outcome of this experiment is that all teachers felt comfortable teaching about their students' culture. We recommend comparative research on the effectiveness of native teachers and non-native teachers. We learned not to assume that just because a teacher is native, that he/she will have inherent skills in teaching native culture. They too must learn skills to obtain and incorporate knowledge into the classroom lessons.

Regarding the attitude survey, it was clear that attitudes regarding school science should be measured over a lengthier time frame than a twelve-week period. To obtain a more accurate reading on attitudes the students should be subjected to an entire school year science program. However, in this twelve week period, our classroom observations discovered that when the teacher integrated the students' culture and language, the students showed a high level of interest in learning. Initially at the beginning, the students reflected a stereotypical "Einstein" type scientist. By the end of the twelve week period, many of the students saw themselves as scientists. It was also discovered that not all the Navajo students were proficient in their home language (Diné), and had little knowledge of their own culture. The teachers and cultural experts working together were able to provide the necessary cultural knowledge to help in learning the traditional science concepts being taught in class. It is important to note that when one works with a specific culture, it cannot assume that all children know everything about their own culture.

It is also important to note that although this research tested for the effectiveness of the Navajo Science Supplemental Curriculum, a major unintended outcome was discovered. The schools realized that part of the problem why Navajo children and other Native children fail in school science is that the schools lacked coherent and continuous science programs across and within the grades. When teachers were interviewed, it was apparent that some teachers, not all, are either reluctant to teach science as part of their

curriculum, and in some cases, they did not teach science at all. It was also discovered that some schools were using out-dated science textbooks that did not include the latest National Science Standards.

In addition, elementary teachers need training in Science Education at both the graduate and undergraduate levels. It is interesting to note that many elementary teacher training undergraduate programs do not require courses in science teaching methods. I would argue the point that although all subjects are important, the subject of science is more of a concern because there are very few Native American professionals in the sciences. Therefore, it is imperative that programs such as this should start at the elementary level, and continue its progression up through the higher grades. This warrants further discussion with Native people.

The findings of this study suggest that minority cultural knowledge integrated with the traditional science curriculum does not hinder but rather enhances learning. There are many culturally relevant science curriculums written and being used in schools today. However, one must keep in mind that the purpose is not to replace the existing science curriculum, but to integrate the students' cultural knowledge, background and experiences to help in learning science concepts. It is anticipated that these findings will especially encourage other indigenous people to bring into the classroom their respective cultural knowledge.

A major component of the development of the Navajo Science Supplemental Curriculum is the parents/guardians of the local communities. In every lesson that was developed and taught, parental/guardian involvement played a major role. For example, students were given questionnaires (homework) to take home and to be completed with the assistance of their parents/guardians. In addition, parents/guardians were invited to the classrooms as participants. Classroom observations discovered that parents/guardians became involved in carrying out science experiments along side their children and students. One parent stated that "I wish science was taught to me in this manner when I was going to school." There was an overwhelming approval by the parents/guardians on integrating their native culture knowledge and language as part of the science curriculum. After all, "parents are the first teachers."

Finally, while it has been shown that integrating Navajo native culture into school science can make a difference in teaching and learning, the researcher strongly believes that this approach is applicable to all schools everywhere. For example, African American students might also improve their science achievement scores, if they are also grounded in African perspectives on science. Anglo American students could also benefit from other cultural views on science. It be more interesting and beneficial to have, for example, Puerto Rican students in Boston learn not only about American school science perspectives, but also those of the Boricua (indigenous people of Puerto Rico), and those of other Native Nations.

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