American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)
ISSN (Print) 2313-4410, ISSN (Online) 2313-4402

http://asrjetsjournal.org/

Micro Pedagogies: Implementing a Micro-Spiral Science Curriculum for Minorities

Dr. Edith Davis*

Florida A & M University, Gore Education Complex,501 Orr Drive, B107 Tallahassee, FL
Email: edithdavis58@gmail.com

Abstract

The science curricula in the nation's middle schools have been considered one of the weaker links to the advancement of a scientifically literate society. Science education and scientific literacy are essential to the success of the nation. The purpose of the complete study was to compare the effectiveness of using an experimental spiral physics curriculum and a traditional linear curriculum. This work takes a close look at the effectiveness of the micro-spiral physics curriculum when comparing minorities. Both the experimental spiral physics curriculum and the traditional linear physics curriculum increased physics achievement; however, there was statistically significant difference in effectiveness of teaching experimental spiral physics curriculum in the sixth grade minorities compared to the traditional linear physics curriculum. It is important to note that the majority of the subgroups studied did show statistically significant differences in effectiveness for the experimental spiral physics curriculum compared to the traditional linear physics curriculum.

Keywords: Science Education; Micro-Spiral; Minorities; Curriculum; Increased Science Achievement

1. The Problem

The preparation of American science teachers is essential to our nation's intent to prepare our students for the 21st century's global economy. The more effectively we prepare our educational community their success is positive correlation to the success of our students on national and international assessments and their ability contribute intellectually to our science and technology community. Science educators are exploring new and innovate ways to disseminate science content to students. A scientifically literate nation can help assure a free and democratic society, an economically viable society, and a healthy society [1].

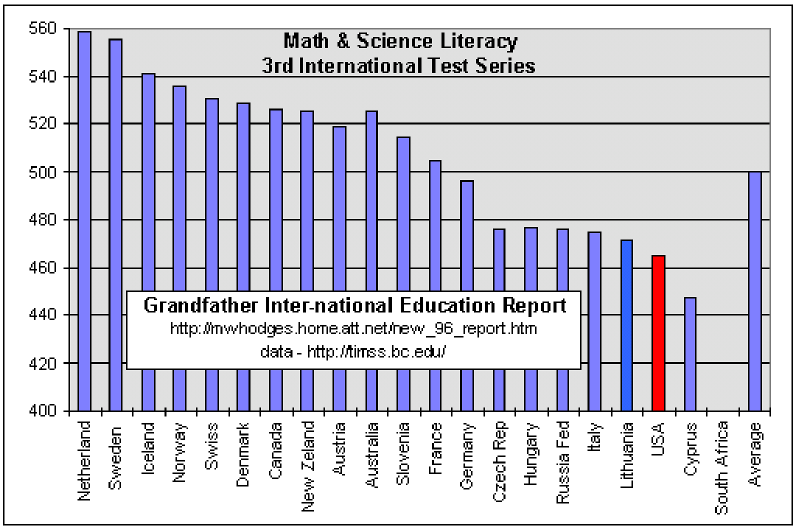
----

* Corresponding author.
E-mail address: edithdavis58@gmail.com.

Science focused summer camps have been a vital avenue for student and the educational community to explore multiple science disciplines. The rationale is that the more informed our educational communities are the greater opportunities our students will have to perform well in science and technology.

International, national, state, regional, and local science achievement data show that some United States' students have a lower understanding of science when they enter high school. According to George Nelson, Director of the American Association for the Advancement of Science Project 2061, the United States has not achieved its quest of scientific literary for all students. He stated that the National Assessment of Educational Progress (NAEP) science assessment results revealed that the nation's children are not prepared for the challenges that they will face in a world that is scientifically and technologically driven. Additionally, the relationship of educational achievement in the sciences impacts U.S. citizens as consumers, workers, policy makers, and parents. Scientific literacy is understood to have a direct relationship to a higher quality of life in America. (See Table 1)

Table 1: Third International Math and Science Study (TIMSS) Math & Science Literacy Chart



Any deficiency in science education programs would hinder the progress of the U.S, yet national and international science achievement data show that the American students lag behind other nations' students in their understanding of science once they enter high school [2]. For instance, American middle schools have consistently scored lower on international math and science standardize test and is believe to considered one of the weaker links to the advancement of a scientifically literate society [3]. Even more pronounced is the fact that the science performance of historically under-represented students (African American, Hispanic, low income, urban and rural students) continues to remain lower than the performance of their more affluent and Anglo peers. Ten years into the 21st century, the National Assessment of Educational Progress (NAEP) science achievement gap between Anglo and culturally, linguistically, and ethnically diverse students is pronounced and unrelenting. For instance, the average NAEP score gap between Anglo and African American twelfth graders is 31 points. Three percent of African American students were considered to be proficient in science whereas 23 % of Anglo students were proficient in science. The brief narrowing of the gap in the early 80s between ethnic groups was primarily due to the decline in the science achievement of Anglo students by five points[4].

2. Hypothesis

It was hypothesized that the experimental spiral physics curriculum taught to sixth grade minorities would produce significantly higher achievement in science compared to sixth grade minorities who received the traditional linear science curriculum instruction. The following is one of the research questions which were derived from the hypothesis.

3. Research Questions

The question guiding this study was: Were there significant differences in physics achievement scores for minority students who received instruction using an experimental spiral physics curriculum as compared to minority students who received the traditional linear physics curriculum?

4. A Solution

Science educators continue to explore strategies that increase the science content knowledge of teachers in science. The rationale is that when the content knowledge of teachers is robust in these areas then students have increased opportunities for performing well on standardized science achievement measurements. The Micro-Spiral Pedagogies science summer camps are an exploratory research project to address the United States of America Challenge that asks, "How can all students be assured the opportunity to learn significant STEM content?" In addition to addressing the aforementioned challenge, the Micro-Spiral Pedagogies science methodology address persistent challenges in science education related to teacher quality and diversity. The science study also evaluates impacts to students participating in the studies that are some of the most educationally and economically disadvantage citizens in the metropolitan area.

5. The Micro-Spiral Method

The conventional linear curricula which are prominent in school science are characterized by sequential presentation of concepts. Linear curriculum takes the body of knowledge that is to be taught to the student and builds upon each concept, block by block, each concept supposedly interlocking with the next. Mastery of previous concepts is essential before proceeding to the next concept. The overall objective is the mastery of the body of knowledge that is being taught. However, this approach to teaching has several limitations. Even when the necessary instructional practices are in place, teachers are still taxed with aligning the existing curriculum to their instructional approaches. The linear curriculum often fails to address or change student's misconceptions or preconceptions about physical phenomena. Overall, the approach does not take into consideration how prior based cultural experiences mediate student learning and actually determine whether or not the conceptual blocks actually link together for coherent conceptual understanding. Furthermore, the approach does not provide opportunities to revisit concepts that may have been marginally mastered.

The concept of a Micro-Spiral curriculum is one in which there is an iterative revisiting of concepts, subjects or themes throughout the course. A review of the literature revealed that few studies exist on increasing science achievement using a spiral curriculum Davis [4]. Wineland and Stephens [5] conducted a study on the impact of a spiral curriculum on the science performance of 8th and 9th grade students. The eighth graders who were tested using the spiral method scored significantly higher than the control group in a basic mathematics course. The ninth graders who were tested using the spiral method scored significantly higher than the control group on pre-algebra assessments [5] . In another study, DiBiasio, Clark, Comparini and O'Connor [6] evaluated a spiral chemical engineering curriculum for college students. The open-ended project emphasized learning through engagement. The spiral curriculum reinforced students' understanding of the basic concepts and highlighted the concepts' interrelationships.

Conventional, linear curricula, which is prominent in school science classrooms, often fails to address or change students' misconceptions or preconceptions about physical phenomena. The linear curriculum is characterized by sequential presentation of concepts. Linear curriculum takes the body of knowledge that is to be taught to the student and builds upon each concept, block by block, each concept supposedly interlocking with the next. Mastery of previous concepts is essential before proceeding to the next concept. The overall objective is the mastery of the body of knowledge that is being taught. However, this approach to teaching has several limitations. Overall, the approach does not take into consideration how prior cultural and/or experiential based experiences mediate student learning and actually determine whether or not the conceptual blocks actually link together for coherent conceptual understanding. Further, the approach does not provide opportunities to revisit concepts that may have been marginally mastered. The concept of a spiral curriculum is one in which there is an iterative revisiting of concepts, subjects or themes throughout the course (similar to, but not the same as, a learning progression). The open-ended project emphasized learning through engagement. The spiral curriculum reinforced students' understanding of the basic concepts and highlighted the concepts' interrelationships.

6. Research Design—The Quantitative Solomon Four Group Design for the Complete Study

Participants at each campus were randomly assigned to one of four groups using the same method that was performed in the pilot study. Group one received the traditional linear curriculum and was pre-tested, group two received experimental spiral physics curriculum and was pre-tested, group three received the traditional linear curriculum and was not pre-tested and group four received the experimental spiral curriculum and was not pre-tested. Again groups one and two received the pre-test; groups three and four did not receive a pre-test. Groups two and four received the experimental spiral physics curriculum, while groups one and three were given the traditional linear physics curriculum. All four groups one, two, three, and four took the post-test.

7. Validity and Reliability Issues

The study used the Solomon Four group design. Solomon Four group design controls for many sources of invalidity. The content validation consisted of multiple reviews of the content by the researcher along with Dr. Truell Hyde and the National Science Foundation Research Teacher fellows. Items identified by these individuals as not appropriately measuring the intended objective were revised and further reviewed. This process was iterated several times during the development of the instrument in order to assure agreement with the content of individual items and the integrity and completeness of the overall instrument. The content was also validated by the pilot study. The study's reliability was increased with the elimination of all test questions commonly answered correct or incorrect prior to being administered to the experimental groups in the complete study in 2006. The test was validated by the Cronbach alpha reliability method with an alpha of 0.740 for the pilot study and 0.799 for the complete study. The Cronbach alpha for the combined data set was 0.749. Cronbach's alpha measures how well a set of variables measures a single one-dimensional construct. Cronbach's alpha is a coefficient of reliability or consistency. Cronbach's alpha can be written as a function of the number of test variables and the average inter-correlation among the variables.

8. Summary

The complete study included rural, urban, and suburban students who represented all of the socio-economic and ethnic strata of Central Texas McLennan County. The data collection instrument for the quantitative part of the study was the physics evaluation test designed by Dr. Truell Hyde, NSF RET fellow, and the researcher. The dependent variable measured in the quantitative part of the study was student physics achievement. The experimental groups in the quantitative part of the study were students receiving the experimental spiral physics curriculum and the traditional linear physics curriculum. The control groups in the study were subjects/participants that received the traditional linear physics curriculum and did not receive the pre-test. The traditional linear physics curriculum entailed the concepts built upon each other once mastery had been achieved. The quantitative measures collected the pre-test and the post-test scores on the PET from the subject/participants. The quantitative portion of the study used the Solomon Four group research design. The quantitative random design permits the results, which in this case would be a measure of physics achievement, to be generalized to the larger population. The randomization factor enables the researcher to possibly infer from the sample population to the general population, if the results prove to be significant in the study.

9. Results

9.1 Complete Study Results by Research Questions

The researcher will discuss research question number three in the case of the complete study.

Research Question Three: Were there significant differences in physics achievement scores for minority students who received instruction using an experimental spiral physics curriculum treatment as compared to minority students who received the traditional linear physics curriculum treatment?

9.2 The Complete Study—SPC Participants Ethnicity

The ethnicity of the students is described in the table 4.28. CMS participants totaled 59 students initially as participants in the complete SPC study. CMS' final number of participants in the complete SPC study was 36 which represented (65%) of the original sample population. The number of Latino students was 33 which represented (92%) and three African American students which represented (8%) that participated in the complete study of the final sample population. CSI had a total of 24 students initially to participate in the complete SPC study. CSI's final number of participants in the complete SPC study was 23students or (96%) participation. The number of CSI students was 22 (96%) represented by Anglo students and one (4%) Latino student who participated in the complete SPC study.

GMS had a total of 22 students initially to participate in the complete SPC study. GMS' final number of participants in the complete SPC study was 18 students or (82%) participation. The number of GMS students was 17 (94%) African American students and one (6%) Latino in the final sample population who participated in the complete SPC study.

Finally, WMS had a total of 16 students initially to participate in the complete SPC study. WMS' final number of participants in the complete SPC study was 14 students which represented (88%) of the original sample population. WMS had 12 (86%) Anglo student participants and two (14%) Latino students in the complete SPC study of the final sample population (see Table 2).

Table 2: *Spiral Physics Curriculum Study Participant's Ethnicity*

Ethnicity	CMS % = Raw #	CSI %= Raw #	GMS % = Raw #	WMS % = Raw #
Anglo	0%=0	96% = 23	0% =0	86%=12
African American	8%=3	0% = 0	94% =17	0%=0
Latino	92%=33	4% = 1	6% =1	14%=2

In the case of the pilot all students were minorities; however, in the case of the complete study the ethnicity included both minorities and the majority. Table 3 below gives inferential statistics of the experimental spiral physics curriculum treatment and traditional linear physics curriculum treatment impact on males. The final sample size for the complete study was 54 subjects. The minority and majority students' F value of 5.177 with 53 total degrees of freedom and a significance of 0.009 which did meet the $p<.05$ requirement that would enable the researcher to have a 95 % confidence that the treatments impacted the dependent variable of physics' achievement by ethnicity. This means that the experimental spiral curriculum increased physics achievement in minority and majority students. The experimental spiral curriculum treatment produced the higher mean score and the differential was large enough to overcome the high variability within and between groups in order to show an F test of significance. The high variability was due to the broad range of socioeconomic factors such as income, race and gender present within and between groups. The dependent variable was physics' achievement and the independent variables were the experimental spiral physics curriculum and the traditional linear physics curriculum (see Table 3).

A statistically significant difference with F value of 5.177 with a statistically significant value of .009 which is below the $p<.05$ was found in favor of the minority and majority students that received the experimental spiral physics curriculum treatment. Also the experimental spiral physics curriculum mean score was higher mean score that those who had the traditional linear physics curriculum. The table 4 describes the complete study in relationship to ethnicity pre and post achievement scores based on ethnicity. The African Americans sample size was 16. The mean score was 48.81 and SD 9.921. The Latinos sample size was 5. The mean score was 63.00 with a SD 21.178. The Anglos sample size was 33. The mean score was 69.21 with a SD 16.280 (see Table 4).

Table 3: *Complete Study Inferential Statistics (Levene Test) of Ethnicity Post-Test*

N	Mean	SD	F	df1	df2	Sig
54	62.59	17.503	5.177	2	51	.009*

Note. Tests the null hypothesis that the error variance of the dependent variable is equal across groups

Design: Intercept + Ethnicity.*p<.05

Table 4: *Complete Study Descriptive Statistics of Ethnicity Combined Post-Test*

Ethnicity	N	Mean	Std. Deviation
African American	16	48.81	9.921
Latino	5	63.00	21.178
Anglo	33	69.21	16.280

Table 5 describes the complete study of ethnicity descriptive statistics for the experimental spiral physics curriculum treatment. The African American experimental spiral physics curriculum treatment sample size was 7 with a mean score of 50.43 and SD of 10.470 The traditional linear physics curriculum treatment sample size of 9 had a mean score of 47.56 and SD 9.914 which reflects a 2.87 points advantage for the experimental spiral physics curriculum treatment . The Latino experimental spiral physics curriculum treatment sample size was 4 with a mean score of 58.00 and SD 20.769. This shows that the spiral physics curriculum did increase physics achievement of the targeted population. The traditional linear physics curriculum treatment sample size of one had a score of 83.00 which reflects a 25 points advantage for the traditional linear physics curriculum treatment. The Anglos experimental spiral physics curriculum treatment sample size was 17 with a mean score of 71.82 and SD 15.212. The traditional linear physics curriculum treatment sample size of 16 had a mean score of 66.44 with SD 17.397 which reflects a 5.38 points advantage for the experimental spiral physics curriculum treatment. This shows that all students increased in physics achievement where the Anglo students had the highest, Latino had the second highest and African Americans had the third highest increase in physics achievement (see Table 5).

Table 6 describes below the complete study by school post achievement scores by ethnicity. The CSI African American sample size was 0. The CSI Latino sample size was one with the post mean score of 48.00. The CSI Anglo sample size was 21 with the post mean score of 67.24 and SD 15.722. The GMS African American sample size was 16 with the post mean score of 48.81 and SD 9.921. The GMS Latino sample size was 2 with the post mean score of 47.50 and SD 3.536. The GMS Anglo sample size was 0.

Table 5: *Complete Study Descriptive Statistics of Ethnicity and Method Post-Test*

Method	Ethnicity	N	Mean	Std. Deviation
Spiral		28		
	African American	7	50.43	10.470
	Latino	4	58.00	20.769
	Anglo	17	71.82	15.212
Linear		26		
	African American	9	47.56	9.914
	Latino	1	83.00	na
	Anglo	16	66.44	17.397

The WMS sample size was 4. The post mean score was 66.75 with SD 29.010. The WMS African American sample size was 0. The WMS Latino sample size was two with the post score of 86.00 with SD 4.243. The CSI Anglo sample size was 12 with the post score of 72.67 and SD 17.354. In summary, this shows that all races had an increase in physics achievement after receiving the spiral and the linear physics curriculum; however, in the majority of the cases the experimental spiral physics curriculum produced the highest means with the exception of one Latino student (see Table 6).

Table 7 gives inferential statistics of the method for the complete study by ethnicity. The final sample size for the complete study was 54 subjects/participants. The mean score of the sample population was 62.59 with a SD 17.503 and a F test of 2.789 with 53 total degrees of freedom and a significance of .011 which did meet the $p<.05$ requirement. This would enable the researcher to have a 95 % confidence that the treatments impacted the dependent variable of physics' achievement in relation with method based on students' ethnicity. The experimental spiral curriculum treatment produced the higher mean score and the differential was large enough to overcome the high variability within and between groups in order to show an F test of significance.

The high variability was due to the broad range of socioeconomic factors such as income, race and gender present within and between groups. The dependent variable was physics 'achievement and the independent variables were the experimental spiral physics curriculum and the traditional linear physics curriculum (see Table 7).

Table 8 describes the complete study inferential statistics for the traditional linear physics curriculum treatment pre and post pairwise data. The inferential statistics include the impact of the design and ethnicity. The F value for design was 9.723 with a significance of 0.000 and effective size of 0.276. The inferential statistic for the design indicate that the design had an impact on predicting physics achievement in students based on ethnicity and that the effect was significant and the size of the effect of the design was small.

Table 6: *Complete Study Descriptive Statistics of Ethnicity and School Post-Test*

School	Ethnicity	N	Mean	SD
CSI	African American	0	a	na
	Latino	1	48.00	na
	Anglo	21	67.24	15.722
GMS	African American	16	48.81	9.921
	Latino	2	47.50	3.536
	Anglo	0	a	na
WMS	African American	0	**a**	na
	Latino	2	86.00	4.243
	Anglo	12	72.67	17.354

aThis level combination of factors is not observed

Table 7: *Complete Study Inferential Statistics Ethnicity, Method, and School Post-Test*

N	Mean	SD	F	df1	df2	Sig
54	62.59	17.503	2.786	9	44	.011*

Note. Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

Design: Intercept+ Ethnicity + Method + School+ Ethnic*Method+ Ethnic*School + Method* School + Ethnic * Method * School * Ethnicity and Design*p<.05

The researcher can be 95% confident in this result. The F value for ethnicity was 9.723 with a significance of 0.000 and effective size of 0.276. The inferential statistic for the ethnicity indicate that the schools had a impact on predicting physics achievement in students based on ethnicity and that the effect was significant and the size of the effect of the schools was small. The researcher can be 95% confident in this result. The experimental spiral curriculum treatment produced the higher mean score and the differential was large enough to overcome the high variability within and between groups in order to show an F test of significance. The high variability was due to the broad range of socioeconomic factors such as income, race and gender present within and between groups. The dependent variable was physics' achievement and the independent variables were the experimental spiral physics curriculum and the traditional linear physics curriculum (see Table 8).

Table 8: Complete Study Inferential Statistics of Ethnicity and Design Post-Test

Source	**df**	**F**	**Sig**	**Partial Eta Squared Effect Size**
Design Model	2	9.732	.000*	.276
Ethnic	2	9.732	.000*	.276
Error	51			
Total	54			

Note. R Squared .276 = (Adjusted R Squared = .248) *p<.05

Anglos, African Americans, and Latinos, showed an increase in physics achievement once they received the treatment of the experimental spiral physics curriculum treatment. It is important to note that the traditional linear physics curriculum treatment also increased physics achievement in Anglos, African Americans, and Latinos; however, the mean scores were lower than the experimental spiral curriculum (see Table 6).

9.3 Complete Study Summary Research Question Three.

All races showed an increase in science achievement after receiving the spiral and the linear curriculum and the spiral curriculum increased post test scores more than the linear curriculum and the difference was statistically significant with a F value of 9.732 and a F value of .000 well below the p<0.05. This means that there was statistically significant difference between the experimental spiral physics curriculum to the traditional linear physics curriculum impact on students' physics achievement based on ethnicity.

9.4 Dunn-Šidák (t_{DS}): The Complete Study Results Statistical Analysis by Hypotheses Dunn Šidák

Another method of evaluating results is the use of Dunn Šidák. Dr. Roger Kirk assisted the researcher in the use of the Dunn Šidák method. Dunn Šidák is a way of evaluating a portion of the above design which could validate that the treatment significantly affected the dependent variable (physics achievement) in students through the analysis of contrast (Kirk, 1995). The researcher's rationale for using the Dunn-Šidák method of evaluating the above design was that the design was priori and non-orthogonal. The Dunn-Šidák (t_{DS}) statistics for H1: $O_2 > O_1$ where the t_{DS} was 4.974*, meaning that the pre-tested group that received the experimental spiral physics curriculum (O_2) scored significantly higher than students who had not received the new experimental spiral physics curriculum (O_1). The pre-tested students receiving the experimental spiral physics curriculum compared to the students that were pre-tested (O_2) and received the traditional linear physics curriculum (O_4) and showed no significant difference for H1: $O_2 > O_4$ where the t_{DS} was -0.13. This meant that the difference between the experimental spiral physics and the traditional linear physics curriculum was not significant. The analysis revealed that there was no significant difference between students who were not pre-tested and received the experimental spiral physics curriculum and students that were not pre-tested and received the traditional linear physics curriculum. The researcher's hypothesis for (H1); H1: $O_5 > O_6$ where the t_{DS} was 1.23, means that the difference between the experimental spiral physics and the traditional linear physics curriculum was not significant. The analysis also revealed that there was a significant difference between students that were not pre-tested and received the experimental spiral physics curriculum (O_5) when compared to students who had not received the experimental spiral physics curriculum (O_6). The researcher's hypothesis for H1: $O_5 > O_3$ where the t_{DS} was 5.45*, meaning that the group receiving no pre–PET and the experimental spiral physics curriculum (O_5) scored significantly higher than the group that had not received the spiral physics curriculum (O_3).

If all of the following contrasts are positive, it suggests that the treatment did affect the dependent variable (Kirk, 1995) (see Figure 1).

1.	**$O_2 > O_1$**	**4.974***	**(is significant)**
2.	**$O_2 > O_4$**	**-0.13**	**(is not significant)**
3.	**$O_4 > O_3$**	**4.484***	**(is significant)**
4.	**$O_5 > O_6$**	**1.23**	**(is not significant)**
5.	**$O_5 > O_3$**	**5.45***	**(is significant)**

Figure 1: Dunn-Šidák (t_{DS}) Analysis—The Complete Study

9.5 ***The complete Study - Dunn-Šidák (t_{DS}) Analysis***

The multiple comparison procedure for a priori contrasts where the contrasts are non-orthogonal is the Dunn-Šidák (t_{DS}) analysis. In making the multiple comparisons, the researcher/teacher already had formulated a specific hypothesis that she wished to test via an experiment such as the Solomon Four group design, a priori or planned test. In most cases, an infinite number of contrasts can be derived or expressed as a linear function of another contrasts. In some cases, these contrasts are redundant, or in other words they can be described as a linear function of another contrast or non- orthogonal contrast. When contrasts are mutually non-redundant they are called orthogonal contrasts; no other contrast can express the linear function of these contrasts. In this study, the hypothesis was expressed prior to the performance of the experiment, making it a priori and the contrast could be expressed by the linear functions of other contrasts or non-orthogonal. In the case of this study, the recommended multiple comparison tests would be the Dunn-Šidák test. The Dunn-Šidák (t_{DS}) analysis of contrast showed significance, which means the treatment did affect the dependent variable and that the experimental spiral physics curriculum does increase physics achievement in students. A common error made in using the Dunn- Šidák (t_{DS}) analysis is the correct use of the tables to find the correct critical value. Dr. Roger E.

Kirk and Fanni Natanegara of Baylor University discovered that researchers tend to double α in a two-tailed t table to obtain the critical value in a one tail test. The problem lies in the fact that doubling α in a one-tailed test will give the researcher a critical value that is too small. This particular error was avoided in this analysis.

10. Conclusion

The researcher in the complete study compared the effectiveness of teaching physics using an experimental spiral physics curriculum in the sixth grade to teaching a traditional linear physics curriculum. Both the experimental spiral physics curriculum and the traditional linear physics curriculum increased physics achievement; however, there was no statistically significant difference in effectiveness of teaching experimental spiral physics curriculum in the sixth grade compared to the traditional linear physics curriculum in the aggregated data set. The high variability within sample groups and between sample groups masked the variance due to the difference between the experimental spiral physics and the traditional physics curricula. Each sample group was characterized by high variability that was the result of a broad range of socioeconomic factors such as income, race and gender which was present within and between groups. However, it is important to note in the analyzes of the subgroups of gender, the experimental spiral physics curriculum was statistically more significant in its effect on physics achievement than the traditional linear physics curriculum in the majority of the subgroups. The data also showed that the experimental spiral physics curriculum did produce higher mean scores in the majority of the subgroups**.**

10.1 Ethnicity

The complete study data of the subgroups for African Americans and Anglos showed that there was a statistically significant difference in the effectiveness of teaching experimental spiral physics curriculum when compared to traditional linear physics curriculum. The subgroups of African Americans and Anglos that received the experimental spiral physics curriculum produced significantly higher mean scores than the group receiving the traditional linear physics curriculum. However, in the case of the Latinos, the subgroup was inadequate in size to prove statistical significance.

References

[1] Pascal Forgione. *International Test Scores Poor U.S. Test Results Tied To Weak Curriculum*, 1999. Excerpted from a speech by Pascal D. Forgione, Jr., PhD, U.S. Commissioner of Education Statistics URL: http://4Brevard.com/choice/international-test-scores.htm.

[2] National Science Board (NSB). *Transformative Research Final Report and Background Materials.* National Science Foundation. *(*Arlington, VA, 1997): http://www.nsf.gov/nsb/documents/2007/tr_report.pdf. (accessed January, 2007)

[3] Forgione, International Test Scores Poor U.S. Test Results Tied To Weak Curriculum.

[4]National Assessment Governing Board (NAGB). *2001 Science framework for the 1996 and 2000 national assessment of educational progress. (*Washington, DC, 2000).

[4] Davis Edith G. *Micro Pedagogies: Implementing a Micro-Spiral Science Curriculum for Middle School Children*. The International Journal of Science In Society Volume 2. Champaign, Illinois, USA: 2007, 2011.

[5] Wineland and Stephens, Effects of spiral testing and review on retention and mathematical achievement for below-average eighth- and ninth-grade students

[6] DiBiasio and Clark, Evaluation of a spiral curriculum for engineering.