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An interdisciplinary approach to integrated curriculum

Lynda Kozicz Leahey
Rowan University

An Interdisciplinary Approach to Integrated Curriculum

by
Lynda Kozicz Leahey

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Professor

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Abstract

Lynda Kozicz Leahey
An Interdisciplinary Approach to Integrated Curriculum
May, 1999
Dr. Ronald Capasso
School Administration

The purpose of this study was to explore the effectiveness of the interdisciplinary approach to teaching mathematics and science, specifically Geometry and Biology. The study used an action research design in which two teachers participated in a planned interdisciplinary activity that involved 160 high school students. The site of this study was a high school located in a middle-class, rural-suburban community. Data was gathered using a concept map to measure the amount of conceptual understanding students have of the relationship between Geometry and Biology. Data of those students who were enrolled in both Geometry and Biology were compared to those students who were only enrolled in Geometry. This data was analyzed using histograms and a non-parametric signs test. The histograms showed an increase in the number of associations students were able to make between Geometry and Biology. The number of associations increased 35% for interdisciplinary students and 25% for non-interdisciplinary students. The signs test supported the findings of the histogram analysis: interdisciplinary curriculum gave students a better understanding of the relationship between subjects.

Mini Abstract

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Table of Contents

Table of Contents

List of Figures

List of Tables and Graphs

Chapter 1

Introduction

Focus of the Study

All too often students, parents and teachers, argue that instructional material presented in the classroom is fragmented and is not applicable to real life situations. We have all heard or said "When am I going to use this?" Mathematics is especially subject to this lament. Students have difficulty understanding why they need to learn how to solve an algebraic equation, or construct a geometric proof. Adolescents live in the here and now; the future is a far-off place that has little meaning. By articulating and interrelating subject area disciplines, especially math and science, we can begin to see how and why we must learn both fields of study. High school math and science courses, such as Geometry and Biology, can incorporate practical applications. The word Geometry means to measure the earth, and Biology is the study of living organisms. Both of these disciplines govern our very lives. By examining more practical aspects of these typically tedious subjects, education becomes more meaningful, and hopefully students will be more willing to prepare for their future.

This study focuses on combining Geometry and Biology classes. Through interdisciplinary teaching, students and teachers will concentrate on both the application and methodology of *real world* experiences. The teachers will work together to create and discover the linkage between the two disciplines. The students will experience the application of mathematics within the sciences. In this way, there will be a greater understanding of how and why mathematics is applied and learned.

To evaluate this project, the intern will conduct concept map surveys with the students involved in the experiment and compare the results of the concept maps completed by students before and after interdisciplinary activities. The intern will also interview the supervisor of math and science and the teachers involved in the study. These interviews will focus on the benefits and shortcomings of combining math and science classes.

Purpose of the Study

The purpose of this study is to explore the effectiveness of the interdisciplinary approach to teaching mathematics and science, specifically Geometry and Biology using an action research design. The study will result in a report to inform the supervisor of science and mathematics of the feasibility of an interdisciplinary approach.

At the end of the school year, the supervisor will determine if this project should be expanded to include more sections of Geometry and Biology. If the report shows a positive outcome of student achievement, teacher cooperation and interesting subject matter then expansion is sure to occur. If there is no change in student achievement, or if scheduling is too difficult or teacher dynamics are negative then the interdisciplinary approach will probably be abandoned.

Definitions

Integration - An integrated curriculum can have different meanings for different educators. It can be as simple as relating one aspect of a subject area to that of another or as complex as engaging all disciplines to solve a problem. In general, integration means combining different disciplines in a learning activity to illustrate their relationship or to draw from different subject areas to solve a problem.

Interdisciplinary - The interdisciplinary approach to education can be applied by one teacher or a team of educators. Various stages of interdisciplinary education are explained by Jacobs (1989) and Fogarty (1991) in their research. A single teacher may use examples from one or more disciplines to illustrate examples or to design lessons which include multiple content skills. Two or more teachers may decide to coordinate lessons so that topics coincide. As an example, an English teacher and social studies teacher who share common students may both teach topics that relate to World War II.

Team teaching - Two or more teachers working collaboratively with a common group of students. Typically, these teachers plan and execute lessons or activities jointly.

Thematic - An approach to education where a theme is named and an investigation ensues without regard to disciplinary lines.

Concept maps - An assessment instrument used to determine an individual's knowledge of the relationships between and among various topics or ideas. In this study, students link terms selected from a predetermined list of words derived from the interdisciplinary project. The links they form and the reasons they cite show the depth of knowledge they possess about the connections between disciplines.

Limitations of the Study

This study is confined to one of two high schools in a regional district. Only those students who are enrolled in the Geometry and Biology classes of the two teachers involved will participate in the study. Other students, although completing Geometry and Biology courses, are not included in the study. Thus, the benefits of generalization of this study are minimal. Students are studying Euclidean Geometry and college preparatory Biology. Insights made from this study on interdisciplinary education can probably be made for most similar Geometry and Biology classes and perhaps some other classes in science and mathematics. Generalizations for other disciplines or age levels would be inappropriate.

Setting of the Study

Greater Egg Harbor Regional School District is comprised of two high schools grades 9 through 12. The district serves students from Hamilton Township, Mullica Township, Egg Harbor City, Galloway Township, Washington Township and Port Republic. The site of this study is one of the two high schools, Absegami High School, located in Galloway Township, New Jersey. Students who attend Absegami High School are residents of Egg Harbor City, Galloway Township, Washington Township or Port Republic. The school is located in a middle-class, rural-suburban community 10 miles from Atlantic City and 50 miles from Philadelphia. Major highways, such as the Garden State Parkway and the Atlantic City Expressway make it very convenient to access these metropolitan areas. It is home to the area's only four-year college, Richard Stockton College of New Jersey. Galloway Township is a rapidly growing community evidenced by Absegami High School's near capacity enrollment of 1,600 students. The ethnic background of students is Caucasian 80%, Black 10%, Hispanic 8% and other 2%. The population of Hindu-Islamic-Pakistani students is increasing.

The students involved in this study were those enrolled in either Geometry or Biology classes or both courses. They ranged in age from 14 to 18 years. Geometry is the second course in a typical high school math curriculum. Students enrolled in this course completed Algebra 1. They are primarily tenth grade students but approximately 25% of those enrolled in Geometry may be ninth, eleventh or twelfth graders. Biology is the second course in Absegami High School's science sequence. Students are in the tenth grade and have completed Physical Science in their freshman year. The students who participated in this project worked together on activities designed by the Geometry and Biology teachers but otherwise, remained in their separate classrooms.

Significance of the Study

The need to actively engage adolescent students in their own education has motivated educators to look at alternatives to the departmentalized methods currently in use. Students withdraw from school both literally and figuratively because they feel isolated from both their peers and teachers. Students change classes up to seven times a day, moving to a new room, new teacher and new sets of classmates each time. This fosters feeling of isolation in adolescents who have a strong need to belong to a group. An integrated curriculum naturally lends itself to students working in teams to solve problems. Thus, students are no longer working independently but must combine their efforts to solve a problem. Critical thinking, human relations and personal skills are all a part of an integrated curriculum and are necessary for life in the next century. By using an integrated curriculum, educators can promote the value of the subject to be mastered and the interpersonal skills necessary for success in the workplace as well. An added benefit is the possibility that students will feel more connected to their school and their feeling of isolation will be reduced.

Organization of the Study

The remaining chapters describe the basis for the development of the study. Chapter 2 focuses on the current research on integrated and interdisciplinary education. The literature review supports the benefits of such a curriculum and illustrates some of the difficulties of implementation. Chapter 3 describes the design of the study. In order to determine the students' knowledge of the connections between Geometry and Biology, students complete a concept map both before and after interdisciplinary activities. Their construction of this assessment tool illustrates their understanding of the relationships between the disciplines. Chapter 4 is the presentation of these research findings. In this chapter, a comparison of the results of the pre and post concept maps is made. Lastly, Chapter 5 analyzes these results and develops conclusions from this data. Additionally, implications and suggestions for further study are made.

Chapter 2

Review of the Literature

Integration has become a buzzword for the nineties in education. Students are less inclined to passively sit still for teacher mandated lessons to be mastered and subjects that appear isolated from the demands of everyday life. Educators are looking for a panacea to cure these ills. Integration is a way to curb the wave of student apathy and recapture student interest in learning and school. Combining disciplines, such as math and science or social studies and English is one form of integration. In this type of curriculum students are exposed to the connections between different fields of study. This exposure enables the students to understand the importance of the subjects they must master.

The literature traces the historical background of integration from the early nineteen-hundreds. Junior high schools were established as an intermediary step between the comprehensive classroom of the elementary school and the departmentalized structure of high school (Cohen, 1978). The original intention was not to mimic the high school structure but to involve students in an integrated approach. In an integrated classroom, students work as a team to solve a given problem. They incorporate many disciplines into their work. Mathematics is not isolated from social science or reading, all subjects play a part in the solution. In addition, students must cooperate with each other and work as a team. The adolescent's desire to belong to a group is better met with this structure (Arhar, 1993).

The need for change in educating the junior high school student is well-documented in the literature; (Arhar, 1993; Jacobs, 1989; Mac Iver, 1990) the need for nurturing adolescents still exists and is exacerbated by the demands of life in the twentieth century. Current studies show that integrated education positively affects low socioeconomic students' attitudes toward school. Integration of disciplines provides the continuity needed by these students between schooling and the rest of their lives. (Davison, Miller, Metheny, 1995)

Integration has evolved into several different types with various stages of intensity. The demands of time, in-servicing, planning, structuring and staff dictate what type of curriculum is chosen by teachers and administrators. Educators, such as Jacobs (1989) and Fogarty (1991) have developed methods to implement an integrative approach to education. Others, such as Roth (1992) and Westbrook (1998) developed assessment methods to evaluate the effectiveness of interdisciplinary education on students.

Mac Iver (1990) found that of the three types of schools: elementary, middle and secondary, the middle level used an interdisciplinary approach the most. The elementary level uses an integrated approach through a whole language curriculum (Willis, 1992). At the high school level, teachers are more entrenched in their chosen discipline and not as likely to relax constraints of the curriculum (Willis, 1992). However, guidelines by the National Council of Teachers' *Mathematics' Curriculum and Evaluation Standards* (1989) and the *National Science Educational Standards* (National Research Council, 1993) are currently influencing curricula at the high school level by promoting interdisciplinary projects and themes.

The Adolescent Learner

The need to actively engage adolescent students in their own education has motivated educators to look at alternatives to the departmentalized methods currently in use. Students withdraw from school both literally and figuratively because they feel isolated from both their peers and teachers. Students change classes up to seven times a day, moving to a new room, new teacher and new sets of classmates each time. They feel no one "in the school really knows them, or cares about them, or is available to help them with problems" (Mac Iver, 1990, p.458). This fosters feelings of isolation in adolescents who have a strong need to belong to a group. "Positive, caring relationships between teachers and students are especially important in the middle grades because students at this stage of development continue to need adult guidance and support, even as they seek greater independence and self reliance" (McPartland, 1990, p. 467). An integrated curriculum naturally lends itself to students working in teams with a teacher as a leader or guide to solve problems. Thus, students are no longer working independently but must combine their efforts with other students and look to an adult for guidance to solve a problem. Students will feel more connected to their school and their feeling of isolation may be reduced.

The History of Integration

This is not a new problem, in the 1930's there was a movement toward a core curriculum at the junior high school level. Students were dropping out of school after the eighth grade when the transition from the closed classroom of elementary school to the departmentalization of high school proved too taxing. A core curriculum was created that "disregarded subject matter boundaries and drew upon diverse forms of knowledge . . . and treated the problems of youth as an essential part of the curriculum" (Cohen, 1978, p.123). This thematic approach was documented in the Eight Year Study to produce graduates who performed as well or better than other students who were engaged in more traditional education (Cohen). In the 1950's and 1960's, the race for space cut short the spread of this core curriculum. Students had to excel in math and science if America was to reach the moon; and thus departmentalization became firmly entrenched in the American education system.

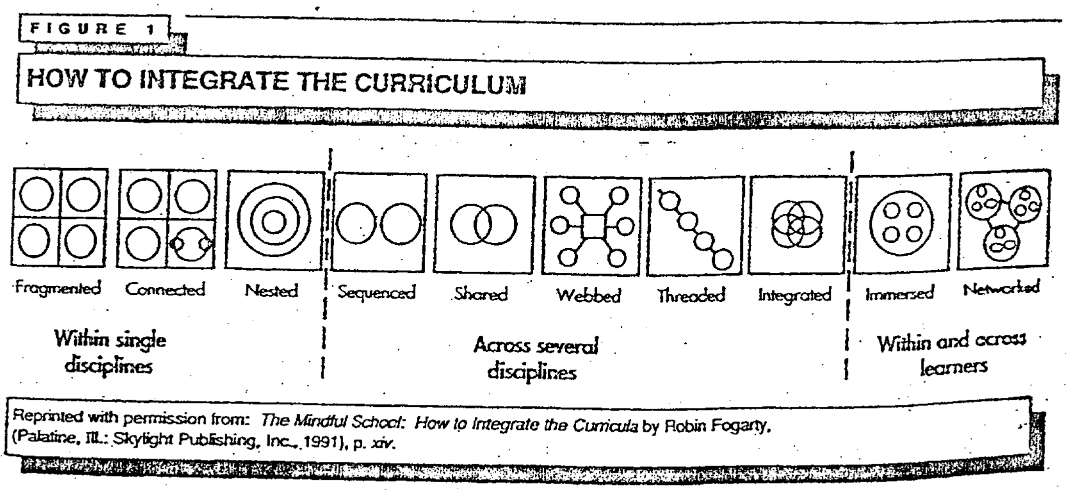
We have reached the moon, but our adolescents still have problems that need to be addressed. Arhar feels that if students are to psychologically invest themselves in the hard work of learning and mastery, that is, if they are to become academically engaged, they must perceive the school to be a worthwhile investment of their time and energy. By integrating disciplines, such as mathematics and science, students can see that these subjects are not isolated topics, but components of the world in which they live. "Mathematics, when integrated with science, provides the opportunity for students to apply the discipline to real situations, situations that are relevant to the student's world and presented from the students own perspective" (Davidson, Miller, Metheny, 1995, p. 226-7). Thus, students can choose what they want to study, and decide what information and techniques they must use to solve problems encountered along the way. This approach actively engages students from the start and therefore motivates, encourages and makes students feel more a part of the team.

Approaches to Integration

The thematic or integrated approach is one of many types of interdisciplinary approaches to education. Jacobs (1989) describes five levels: interdisciplinary, crossdisciplinary, multidisciplinary, pluridisciplinary and transdisciplinary. Interdisciplinary incorporates knowledge from more than one discipline to examine a central theme. Crossdisciplinary examines one discipline from the perspective of another. Multidisciplinary focuses several disciplines on one problem with no attempt to integrate. Pluridisciplinary combines related disciplines and transdisciplinary surpasses interdisciplinary by starting with a problem.

Fogarty (1991) illustrates ten different integration models as views on the world through various objects, from the periscope to the microscope. Fragmented, or departmentalized curriculum is the world seen through the periscope, one narrow focus. Nested, through 3-D glasses: lessons designed to include multiple content skills. Shared or sequenced, through binoculars or eyeglasses: teachers either team teach common ideas or arrange topics to coincide. Integrated, through a kaleidoscope: blends disciplines by overlapping skills, concepts and attitudes. The ultimate is integrated curriculum in the immersed or networked stage, Fogarty limits these stages to students in advanced studies or professionals engaged in solving problems.

Figure 1



(Fogarty, 1991, p.62)

Beane (1993) objects to anything other than a thematic approach being referred to as integrated. In such an approach a theme is named and investigation takes place without regard to disciplinary lines. The other multi-disciplinary approaches are simply attempts to match the subject to a given theme. Jacobs feels that schools should not avoid departmentalization entirely but seek to "create learning experiences that periodically demonstrate the relationship of the disciplines, thus heightening their relevancy" (Jacobs, 1989, p.5). Tom Gatewood echoes this theme when he says, "More emphasis should be on experiential, hands-on learning and higher-order thinking through active dialogue and discussion, open-ended questioning, and use of primary data sources in testing of hypotheses and reflective thinking" (Gatewood, 1998,p.28).

Jacobs (1989) states that there is credibility in both discipline-based and interdisciplinary models. Projects such as integrating Algebra and Physical Science classes, and developing interdisciplinary units support this. When integrating classes: "Team teaching algebra and science during a two-period block allowed sufficient time for laboratory explorations and student interaction. Emphasis was placed on concept development, application of mathematical and scientific content to everyday problem solving, conceptual connections across disciplines, and authentic assessment techniques" (Westbrook, 1998, p. 86). To develop interdisciplinary units: "Conversations in hallways and classrooms can provide teachers glimpses of topics about which students have genuine interest and curiosity. Such topics can serve as organizing themes for powerful interdisciplinary units. (Webbing) allows a team of teachers to generate a variety of topics and activities related to the central theme" (McDonald, Czerniak, 1994, p. 5).

To assess the students' knowledge and understanding of concepts presented in interdisciplinary studies, both Roth (1992) and Westbrook (1998) used concept maps. These have been "useful in ascertaining students conceptual organization in science classrooms" (Westbrook, 1998, p.87). By adjoining terms selected from a predetermined list, students can show how they view relationships. The links they form and the reasons they cite show the depth of knowledge the student possesses about the connection between disciplines.

Teacher's Reactions Toward Integration

When incorporating an integrated curriculum into a classroom or school, experts recommend starting on a small scale (Willis, 1995). The tasks associated with a thematic approach can be daunting. Most teachers respond that time for planning, research and dialogue with colleagues are the biggest obstacles in integrating the curriculum (Boyer, 1993; Mac Iver, 1990). In her case study of middle school interdisciplinary teams, Schumacher (1992) found that teachers' attitudes and knowledge of interdisciplinary studies influenced the success of an integrated approach. Tad Watanabe and Mary Ann Huntley (1998) cited the barriers of time versus content coverage. "Many practicing teachers viewed integration as a topic to add to an already overloaded curriculum" (p. 24). Additionally, they found that some teachers felt they were not adequately versed in the content of related disciplines or the appropriate instructional methods to teach them competently.

Gehrke's (1991) naturalistic study of six groups of teachers using various forms of integrative curriculum supports this need for time and education. Gehrke also found that teachers need to share information of personal interests and talents as well as academic knowledge. Mac Iver (1990) cites a need for a team leader to facilitate planning time; interdisciplinary teams spend more time on team activities when a formal leader is in place. Integration should not be a "top-down mandate…(but) when teachers on a (interdisciplinary) team have regular, weekly curriculum conversations about what they are required to teach in their respective subject disciplines, they will discover many natural links between and among subject areas" (Gatewood, 1998, p.27). Jacobs (1989) observes two problems in planning interdisciplinary courses: the lack of an inherent structure and the territorial views held by some teachers. If interdisciplinary curricula have a carefully conceived design, a scope and sequence, and if both discipline-field-based and interdisciplinary experiences are present, these problems can be overcome.

Integration projects currently in use in Bucks County, Pa, (Seif, 1993), Anchorage, Alaska, (Keitz, 1987) and Indianapolis, Indiana (Bolanos, 1990) all have met obstacles of time, planning and scheduling in incorporating the new curriculum, but all remain committed. These districts feel the problems faced by students in the near future can best be met through an integrated approach to learning. Family structure, economic base, the environment and society will all change in the twenty-first century. "Education must address the skills students will need to lead productive lives in a future shaped by these trends" (Keitz, 1987, p.69). Critical thinking, human relations and personal skills are all a part of an integrated curriculum and necessary for life in the next century.

The studies cited in this review are a good beginning to the research needed to support what appears to be a viable option to encourage students to value education. To impose an integrated approach on an entire school would be daunting. The literature reviewed here indicates that this curriculum should start small and then build to incorporate the remainder of teachers and students. There is much written on isolated schools involved in interdisciplinary education. These studies show success using this method. Additional studies, that can validate the students' knowledge and understanding of concepts presented in interdisciplinary education are needed to promote this worthwhile method of instruction.

Chapter 3

Design of the Study

General Description of the Research Design

This study sought to illustrate the positive effects of combining disciplines, specifically Biology and Geometry. Some of the positive outcomes of interdisciplinary education may include greater student achievement, collegiality among staff involved, and a better understanding by students of the relationship between disciplines. The research design in this study was intended to measure the last of these outcomes.

Professional research and standards have shown that education should not be a set of isolated lessons. Students want and need to learn by using practical application of the concepts they are expected to master. One way this application to real life situations can be accomplished is through combining classes in an interdisciplinary project. In this study science and mathematics classes were combined so students would gain a greater understanding of the relationship between these disciplines.

The teachers involved in this study developed a project that would combine topics from their respective disciplines, Geometry and Biology. Students were given classroom instruction and participated in a field trip. In class, they received instruction from both teachers on quadrat analysis and on ratio and proportion. Each teacher explained these topics relative to her own discipline. The Geometry teacher concentrated on ratio and proportion topics and the Biology teacher emphasized biotic and abiotic species. During the field trip, students were given additional instruction on orienteering, how to use an magnetic compass and map to find their way on a charted course through the woods. While walking the course, students were to collect specimens of various tree leaves to be identified and classified. After lunch, students estimated the population of various species by using quadrat analysis. They measured a meter square area, surveyed the marked region and then measured a smaller square within the square meter. Using this smaller region, the students counted each biotic and abiotic species found. Lastly, the students estimated the total population of each species for the larger area by using ratio and proportion. Geometry concepts utilized were ratio and proportion, measurement, area, hierarchical structure, and angle measure. Identifying various species and estimating population using quadrat analysis were the Biology topics covered.

Development and Design of the Research Instruments

To measure the effectiveness of interdisciplinary education on student understanding of the relationship between disciplines, students completed a concept map both before and after classroom instruction and the field trip. Measuring the effect of interdisciplinary education on student's knowledge and understanding with traditional multiple choice or fill in the blank questions would be difficult. Concept mapping was developed by Novak and Musonda in their research conducted at Cornell University on student understanding of science concepts. A concept map is a structural representation of a person's understanding of a particular concept and the concept's linkage to other ideas and examples (Westbrook,1998, p. 86) This study will use concept mapping to measure the amount of conceptual understanding of the relationship between Geometry and Biology.

The concept map used was modeled after the research design of Susan Westbrook of North Carolina State University. In her study on integrating Algebra and Physical Science classes, Susan Westbrook utilized concept maps as a tool to determine the students conceptual organization of the topics examined in a particular course. Because the course was an integration of two related disciplines, Algebra and Physical science, she used concept mapping as a tool to determine if the students developed a more integrated understanding of science and mathematics. She found the student's mapping structures to be stable when measuring commonly understood notions and sensitive to measuring the changes in student understanding. (Westbrook)

In this study, concept maps were used to answer a similar question: What affect does integrating Geometry and Biology have on students understanding of the relationship of topics presented?

Students in this study were given a list of 35 words related to Geometry and Biology, specifically terms that related to the quadrat analysis and orienteering they studied on the field trip. After a brief explanation of how to construct a concept map, students were told to construct their own mapping of the list of terms provided. The students were free to form their own association of the terms without assistance or guidance by the teacher. This assessment was performed both before and after classroom instruction and the field trip.

Figure 2

Concept Map

Develop a *concept map* based on the terms below. First group terms into categories (more than 2 less than 5) of your own choosing. You do not have to use all terms. Then create a concept map to show relationships among these terms.

Endangered
Direction
Ecosystem
Organism
Food chains/webs
Hypothesis/conclusion
Biology
Ecologist
Classification
Geometry
Genus
Quatrat
Orienteering
Proportion
Species
Hierarchy
Area
Science
Math
Metric system
Count
Angle measure
Habitats
Estimate
Biotic
Abiotic
Survey
Measure
Identify
Compass
Environment
Family
Map
Logic
If-then statements

Description of the Sample and Sampling Techniques

Of the 160 students who participated in the study, 105 Geometry students completed the concept maps. Some students were enrolled either Geometry or Biology and did not receive interdisciplinary instruction. Only those students enrolled in both Geometry and Biology were able to experience the benefits of being exposed to similar topics under the guise of two disciplines. Thus, those students enrolled in both Geometry and Biology were included in the first sample. Concepts maps from those remaining were randomly selected to form a control group for comparative analysis.

Description of the Data Collection Approach

Prior to class instruction and the field trip, students were asked to complete a concept map. The teacher explained the technique of concept mapping by demonstrating an example of a concept map for a non-Geometry/Biology topic. While completing the mapping, students were aided in the technique of mapping but not how to link terms together. The students were given forty minutes to complete the concept map.

Students completed the post concept map immediately following the field trip and class instruction. The testing procedure was handled in a similar fashion as the pre-test assessment.

Data Analysis Plan

To analyze the data, the intern used all of concept maps completed by the Geometry/Biology students and a random selection from those students only enrolled in Geometry. The maps were examined to determine the number of links between math terms and science terms. A point system was utilized to give a numerical value to each student's concept map. Pre and post survey results were compared to determine if interdisciplinary curriculum causes a difference in the number of links student form. In addition, results of the Geometry/Biology students were compared to those non-interdisciplinary students.

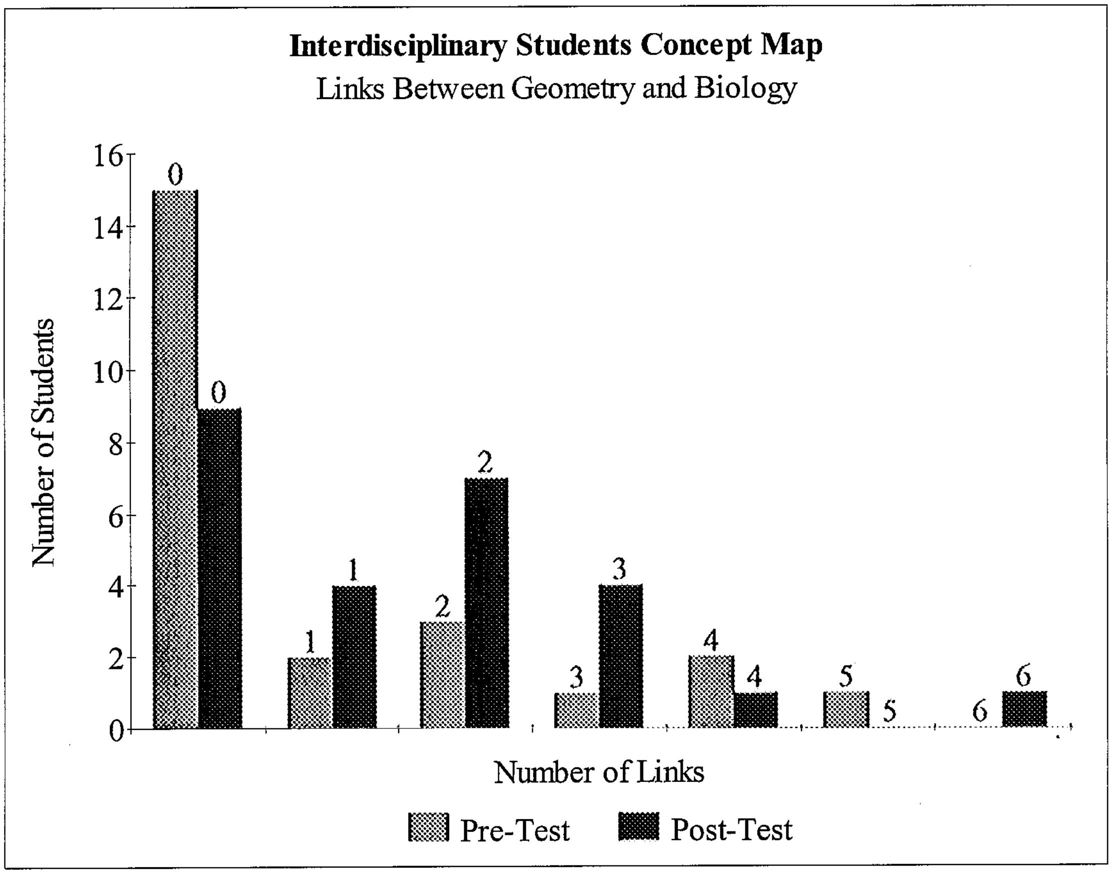
Chapter 4

Presentation of the Research Findings

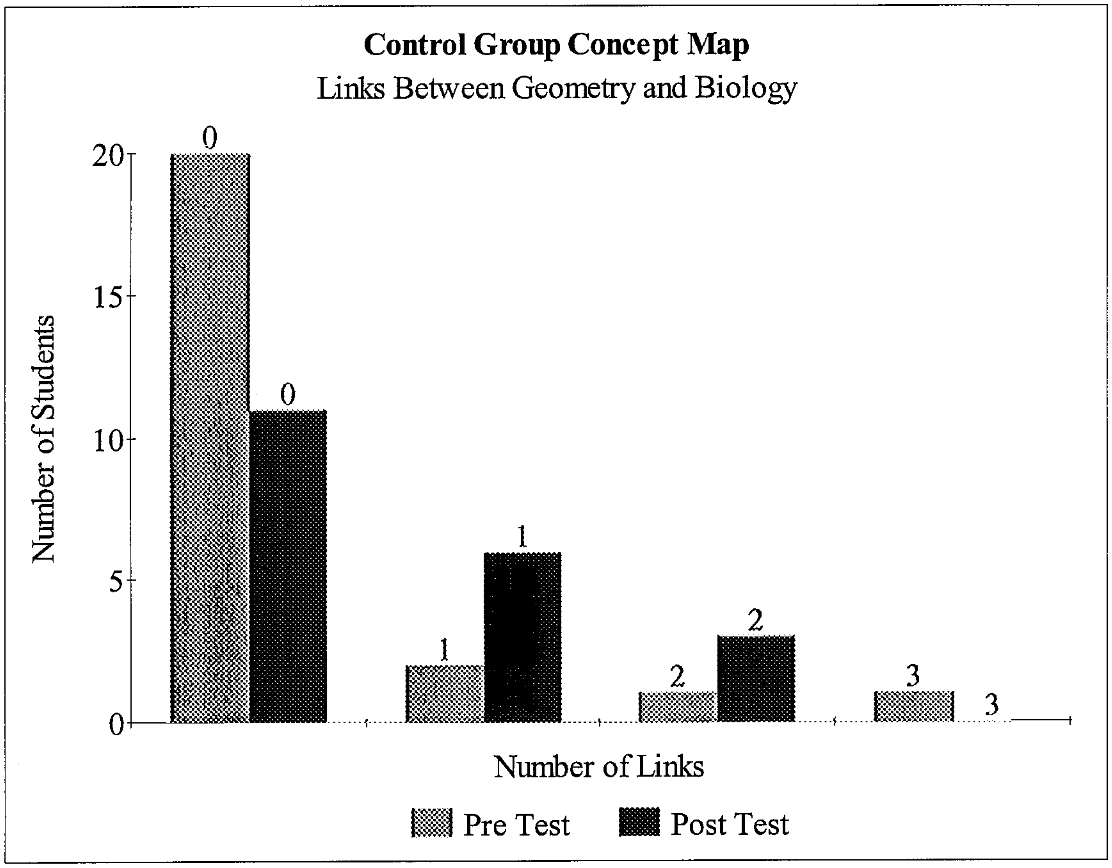
Two groups were formed from the concept maps the students constructed. First, the concept maps of the interdisciplinary students who were enrolled in both Geometry and Biology were analyzed. Then, a second group was chosen randomly from the remaining concept maps. These maps were constructed by non-interdisciplinary students, those students only enrolled in Geometry or who may also be taking Biology but not with the Biology teacher who participated in the study. This second group was a control group. The results of the two groups were compared to determine if there was a difference between the results.

To analyze the data collected, a simple point system was used. Maps were studied to find any links between Geometry terms and Biology terms. For example, matching Geometry to proportions and quadrat to proportions illustrated that the student understood that the concept of proportions was used in both math and science. Other examples included area and measurement as both science and math concepts. Some student's concept maps did link math and science terms, but incorrectly. These links were ignored for the purpose of this analysis. Each map was assigned a value based on the number of correct links.

Graph 1


Interdisciplinary Students Concept Map
Links Between Geometry and Biology
Number of Students
16
14
12
10
8
6
4
2
0
0
0
1
1
2
2
3
3
4
4
5
5
6
6
Number of Links
Pre-Test
Post-Test

Graph 2


Control Group Concept Map
Links Between Geometry and Biology
Number of Students
20
15
10
5
0
0
0
1
1
2
2
3
3
Number of Links
Pre Test
Post Test

These values were ranked and grouped. Two histograms were drawn to compare the pre and post test results from both the interdisciplinary students and the non-interdisciplinary students. The pre test results from both groups showed a large percentage of students who had not formed any links between math and science terms: fifteen of the twenty-four interdisciplinary students and twenty of the twenty-four non-interdisciplinary students.

Post test results showed a decrease in the number of students who did not form any connections between math and science terms. Of the interdisciplinary students, only nine saw no relationship and of the non-interdisciplinary students, only eleven saw no relationship.

Both the pre and post graphs were skewed to the left, favoring zero, but the post test graph showed more data distributed over the number of links greater than zero. An examination of both the interdisciplinary students results and the non-interdisciplinary students showed an increase at almost every value. Interdisciplinary results for the number of links greater than zero increased a total of 35% and the same type of non-interdisciplinary increased a total of 25%. The fact that results of both groups showed an increase of the number of links between Geometry and Biology terms indicates that even a limited amount of interdisciplinary activities teaches students the relationship between subjects normally isolated in the curriculum.

Table 1

Signs Test Data
Interdisciplinary Students

Student	Post	Pre	Difference
1	1	1	
2	2	0	2
3	0	0	
4	0	5	-5
5	4	0	4
6	2	2	
7	2	0	2
8	2	1	1
9	0	0	
10	1	0	1
11	1	0	1
12	2	4	-2
13	3	0	3
14	0	0	
15	3	3	
16	6	0	6
17	1	0	1
18	0	0	
19	0	0	
20	0	0	
21	0	0	
Number of Positive Values			9

Table 2

Signs Test Data
Control Group
Non-Interdisciplinary Students

Student	Post	Pre	Difference
C1	2	0	2
C2	1	0	1
C3	1	0	1
C4		0	
C5	0	0	
C6	0	0	
C7	0	3	-3
C8	0	0	
C9	0	0	
C10	1	2	-1
C11	1	0	1
C12	2	0	2
C13		0	
C14	0	0	
C15	1	1	
C16	1	1	
C17		0	
C18		0	
C19	0	0	
C20	0	0	
C21	0	0	
C22	2	0	2
C23	0	0	
C24	0	0	
Number of Positive Values			6

The data was then analyzed using a non-parametric statistical test. Non-parametric tests are used when the data is not normally distributed. Since this data is skewed left, the non-parametric, signs test (Byrkit, 1972, p. 324) was chosen to analyze data. This test compares before and after results for groups of data to show if there is a difference between them. In this study, the data was analyzed to determine if there is a difference in students' understanding of the relationship between Geometry and Biology before and after the interdisciplinary field trip. To use the signs test, the intern subtracted the post and pre test scores of each individual student. The results were positive and negative values. The positive values indicated that the student had a better understanding of the relationship between math and science after the interdisciplinary activities. Negative values indicate that the student appreciation of the relationship between subjects decreased. Values of zero showed that no change occurred and those values were eliminated from this part of the study.

In calculating the data, nine interdisciplinary students showed a positive increase in the number of links they formed between Geometry and Biology terms; six non-interdisciplinary had a positive increase. Both groups had two students who had negative values when their pre and post concept maps were compared. When comparing these values to tables that convert results to probabilities, both groups had probabilities greater than 0.50. These results allowed the intern to reject a hypothesis that the interdisciplinary project had no effect on student's understanding of the relationship between math and science. Hence, an interdisciplinary curriculum does give students a better understanding of the relationship between subjects.

Chapter 5

Conclusions, Implications and Further Study

The data collected in this study showed that interdisciplinary activities can give students a better understanding of the relationship between disciplines. In the histograms of the interdisciplinary and non-disciplinary students' scores, more data was distributed over values greater than zero. In the signs test, more students' scores had a difference of a positive value than those students whose difference was negative. Both of these illustrated an increase in the number of connections students were able to make. Thus, more students were able to see the relationships between mathematics and science.

However, many student's scores on the signs test were a null value. That is, they did not show an increase or a decrease in their ability to link math and science terms. The reasons for this can be attributed both to the study itself and to the method of collecting the data.

The study was intended to be a full year of interdisciplinary activities. The two teachers involved were to share the same group of students for all of the Geometry and Biology classes they were to teach. The teachers would have then be able to group the students over a two period block of time and coordinate lessons. Unfortunately, scheduling prevented this approach. In it's place, the Geometry and Biology teachers decided to plan a field trip that would include both math and science concepts. This activity involved instruction beforehand in the classroom and activities in the field to incorporate both disciplines. While this activity was a success, its duration was short-lived. Students were not involved in repeated examples of the linkages between math and science. The data showed that some students were able to see the reliance of science on mathematics, but not all were.

The data from both the interdisciplinary students and the non-interdisciplinary students showed similar results for both the histogram and the signs test. This further supports the need for more frequent lessons that incorporate both disciplines. While both groups were able to participate equally in the field trip, only the interdisciplinary group benefited by a limited amount of classroom instruction on the same topic by both the Geometry and Biology teachers. By increasing the frequency of the links between disciplines, the ability for students to appreciate the interrelationship in different fields of study would become more apparent. The small increase in the data for the interdisciplinary students as opposed to their non-interdisciplinary counterparts hints at this.

The activities were planned by the teachers and executed by the students. If students were involved in interdisciplinary activities more frequently they might learn to plan for themselves how to apply mathematics to solve science problems. Future studies should look towards having students involved in several interdisciplinary projects over a longer period of time. Such studies may find that student understanding of the interplay among disciplines is greater and that students may become able to find these relationships on their own.

The concept maps were a good way to measure the ability for students to illustrate how well they were able to link the disciplines. The open ended nature of this test allowed for individuality on the students' part and the near elimination of the power of suggestion by the test giver. However, the students need more experience with completing this type of activity before it is used as an assessment tool for a study such as this. Even with an example and explanation by the teacher, some students were unable to complete the activity correctly. Some students did link terms together but did not give a reason for the links between these words. Some students made lists of words or grouped them in a Venn diagram model. The directions should not tell students to make subgroups of the list of terms because this seemed to cause some students to only link the terms within the subgroups and not to other subgroups they created. This itself may be why there was not a greater increase in the number of links between math and science terms in the post survey. Future use of such a test should include practice of the use of concept maps beforehand and instructions that do not include the requirement that students create subgroups.

Further study in the field of interdisciplinary education is important. A review of the literature showed interdisciplinary projects in many fields. Math and science are natural courses to link because of the way science can be modeled with mathematical equations. Other disciplines also can have natural linkages: writing skills to explain mathematical proofs, the historical background of Julius Ceasar while reading the Shakespearian play, the foods eaten and clothes worn during colonial times are some examples. Interdisciplinary education is a valuable method to spark student interest in topics that are otherwise boring and tedious to today's students. In this study, both the teachers and the students involved were eager for more activities of this type. The teachers enjoyed the planning and the collegiality that resulted. The students experienced the practical application of often tedious subject matter. All of these outcomes are benefits hard to measure by any statistical instrument but they are excellent examples of good educational practice. Further studies should explore interdisciplinary connections in fields such as history and literature, music and art, art and history, mathematics and writing as well as mathematics and science. Lastly, a meta-analysis of those studies in the literature would be another means to validate the impact this type of education has on student performance.

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