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AUTHOR Keating, Joseph; Keating, Josephine Melenchek
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ABSTRACT

One of the major themes of reform in science education is that science should not be compartmentalized into single distinct disciplines but rather should be integrated. This study investigates the effectiveness of integrated programs and impediments to their success in K-12 education. The research was carried out collaboratively by California State University at San Marcos and science teachers at the San Dieguito High School (now San Dieguito Learning Academy). Approximately 100 high school students were followed through three years of science in this suburban San Diego high school. Approximately half of these students took three years of integrated science and half took the more traditional track of science courses. After establishing baseline levels, the research focused on a number of variables such as changes in student attitudes toward science, individual and group problem solving, effectiveness of cooperative group work, and subject matter achievement mastery. Preliminary statistical analysis and interview data from both teachers and students have indicated a number of significant differences between the control and experimental groups indicating a positive effect from the use of integrated science programs. (Author/JRH)

Preliminary Results, Implications and Applications from a Study Comparing a Traditional vs. an Integrated High School Science Program

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by:

Joe Keating, Ph.D., Assistant Professor of Science Education and Secondary Credential Program Coordinator
California State University at San Marcos
Phone: 619-7504321 Email: jkeating@mailhost1.csusm.edu

Josephine Melenchek Keating, MS , Full Time Instructor of Science Education and Co-Coordinator of Concurrent Credential Program,
California State University at San Marcos
Phone: 619-7504298 Email: joskeat@mailhost1.csusm.edu

Abstract:

One of the major themes of reform in science education today is that science should be not be compartmentalized into single distinct disciplines but rather should be integrated. The purpose of this restructuring is to model the fact that in the real world science investigations are carried out by accessing information and resources from a variety of science disciplines. California science educators have been leaders in this reform effort to have the sciences taught with an integrated approach as illustrated by initiation of programs such as Scope, Sequence and Coordination (SSC) as well as state frameworks (California Frameworks in Science). Likewise, many international science education programs have integrated the sciences successfully for years (Japan, Germany).

Many national efforts such as *Science for All Americans* not only encourage integrating the sciences but also connecting this integrative process to interdisciplinary, thematic applications. John Dewey and more recently Howard Gardner are among prominent educators encouraging connecting the disciplines as a natural process to facilitate student learning. Reform efforts in addition to Science, such as the National Council of Mathematics and National Council of Social Studies are encouraging the implementation of interdisciplinary teaching since there are so many natural connections between science, mathematics, social science and language arts.

How effective are integrated programs and what are the impediments to their success in K-12 education.? This presentation will address these questions by focusing on results and implications of a recent collaborative research project that studied students involved in three years of integrated high school science.

This research project was carried out collaboratively by California State University San Marcos and science teachers at San Dieguito High School (now San Dieguito Learning Academy) from 1993-6. Approximately one hundred high school students were followed through three years of science in this suburban San Diego high school. Approximately half of these students took three years of integrated science (SSC) and half took the more traditional track of science courses (Biology, Chemistry and Physics). After establishing baseline levels, the research focused on a number of variables such as changes in student attitudes toward science, individual and group problem solving, effectiveness of cooperative group work, and subject matter achievement mastery.

Preliminary statistical analysis and interview data from both teachers and students have indicated a number of significant differences between the control and experimental groups indicating a positive effect for the use of integrated science programs.

In addition to presenting the results and implications of this study in part 1, specific examples of applications of interdisciplinary, integrated science units used in conjunction with students in K-University will be discussed in part 2.

Summary of Study

1)Methodology:

a) Control (traditional)-emphasized:

I) text driven curriculum with a single discipline (Biology-10th and Chemistry-11th)

II) direct instruction/individual student tasks

III) use of traditional lab manual and closed ended laboratory exercises

IV) short answer type assessment with emphasis on recall of content

b) **Experimental** (integrated)--emphasized:

I) the use of thematic, integrated units (Physics, Chemistry, Biology and Earth Science) that primarily used teacher developed and supplementary materials developed by teacher teams vs. texts (ex. Human Genome Project, Physics of Sports, Studies of Local Ecosystems, Energy systems--stars, electricity, motion).

II) limited amount of direct instruction with extensive use of hands-on, minds-on (inquiry) student centered (constructivist) field and lab activities many of which involved cooperative group projects.

III) use of open ended, problem solving type research where connections were made to mathematics, language arts and social issues.

IV) use of portfolio's and performance type of assessments with an emphasis on major concepts and processes.

2)Data Analysis

A) Student Attitudes toward Science:

Pre and post surveys of students attitudes towards science used the Test of Science Related Attitutes (Fraser) or TOSRA and was analyzed using an ANCOVA. In addition, exit interview data was used to provide related information.

B) Group and Individual Problem Solving Ability:

Pre and post results from group and individual problem solving tasks and related processes used teacher designed rubrics to score and was analyzed using an ANCOVA. In addition, exit interview data was used to provide related information.

C) Achievement in Science:

Final grades in science were reported by teachers and students for each year of the project in exit interviews and compared to prior years (as reported by students).

2) Preliminary Results (general trends of the experimental groups compared to the control groups)

A) Attitudes--greater increases in positive attitudes and likelihood for taking more science courses in the future.

B) Problem Solving--greater increases in group problem solving ability.

C) Cooperative group processes--more frequent use and comfort level in applying group tasks.

D) Achievement--higher average grades than in previous science courses.

3) Implications and considerations:

a)From the perspective of the Science Teachers the study found:

I) that conceptually integrating the sciences is an effective, successful and interesting way to teach students that may result in increased positive attitudes towards science, group problem solving skills and abilities and higher achievement in science.

II) that in order to effectively implement integrated science it is important that the teachers have training and professional background preparation both in the concept of integrating the sciences as well as interdisciplinary teaming. Since undergraduate science courses and teacher training programs usually do not address either of these concepts inservice training needs to be established.

III) that development of integrated curriculum takes time and consequently there needs to be designated times and possibly funding to provide for pre-planning, development of units and reflections on implementation processes.

IV) that there needs to be support by administrations to encourage (not just allow) opportunities for increased use of teaming with instructors for both integrated and interdisciplinary approaches to the teaching of science.

IV) that there needs to be greater acceptance of the value of integrated courses at local and state level to encourage all of the above.

b) From the perspective of the Students the study found:

I) that they thought that integrating the sciences was more realistic, challenging and interesting resulting in increased and effective use of cooperative groups, a greater variety of assessment techniques and an increased in science achievement levels.

II) that they attributed these successes at least in part to the great variety of learning modalities and styles used for presentation and assessment by the teachers.

III) that there is a need for teachers to more frequently clarify and review both the purposes of an activity and 'connections' of that activity to other major concepts.

Part 2: K-University Examples of Integrated/Interdisciplinary Units:

The disciplines of science can be very naturally connected to each other as was done in the research study. A natural extension of this pedagogical process is to connect the non-science disciplines to the unit of study. In many cases teachers do this anyway, sometimes unknowingly. For example when students read, write and express themselves orally as they do in science, they are utilizing language arts skills. Likewise, when they are collecting and analyzing data, mathematical processes are being utilized. When they address issues of ethics and environmental impact, social issues are being infused. The real world application of science is not done devoid of other disciplines. By consciously incorporating multidisciplines into the study of science, teachers are modeling more exactly how science is actually applied to real problems.

The following are brief descriptions of examples of units of study in elementary, middle, high school and

university teacher training that apply an integrated, interdisciplinary approach to the teaching of science.

A) Elementary School:

Includes grades K-5, in some districts grades K-6. A teacher in a self-contained class has the option of integrating instruction across the curriculum. This can be quite difficult because the textbooks teachers are given to work with are often not connected at all, and the emphasis on "basic skills" may mean that teachers are pressured to teach skills out of context.

In a second grade classroom on the Navajo reservation in New Mexico, a unit on classifying animals, specifically distinguishing between amphibians and reptiles was taught in late August and early September, at the start of the school year, when the summer monsoons have produced mud puddles with a bumper crop of tadpoles and garter snakes feeding on them. Many live specimens were brought in, generally by the children themselves. Tadpoles would be kept long enough for students to observe their metamorphosis into frogs. A "horny toad" might enter the room in a child's pocket after recess, to be looked at, to have its scaly skin felt and admired, and then be returned immediately to the field where it had been caught.

Dozens of trade books on reptiles and amphibians were used: the teacher read some to the class, some were put on tape in a center for children to listen to, and all were available for children to peruse. In some cases children could read all or part of a book to themselves, or they could study the pictures and diagrams.

An additional connection to literature was made by studying stories from various cultures, including the Navajo culture, which have to do with reptiles and amphibians. Frogs, snakes, and horned lizards have great significance in Navajo culture. The children also read some of the Frog and Toad stories by Arnold Lobel.

B) Middle School:

Middle school generally includes grades 6-8, in some districts includes grades 7-8. Frequently language arts and social studies are taught as a two-period block by one teacher. Math, science, and other subjects are generally taught by specialists.

At any grade level in middle school, connections can be made between science and other subjects. In sixth grade, students are to study Ancient Civilizations in Social Science. A science teacher might use the FOSS module on Levers and Pulleys to correlate with the development of technology and the invention of what we consider simple machines which took place in Mesopotamia, Ancient Egypt, and Rome.

C) High School:

I) Comparing the Anasazi and Navajo Cultures

High school students enrolled in the same Science, Social Studies and Language Arts classes studied the differences and similarities between two cultures---the Anasazi (ancestors of the Pueblo Indians) and the Navajo who inhabit the same geographical region of the southwest. Both cultures are studied in parallel by incorporating concepts of the sciences of archeology, ethnobotany, ethnoastronomy, architecture, ecology and their connections to the humanities (arts, music) and social sciences (anthropology). A variety of learning strategies are intertwined to assist in information gathering and analysis including the use of laboratory exercises, field trips, guest speakers, films, computer simulations and readings all culminating in individual and group research projects.

II) Evolution vs. Creationism

High school students enrolled in the same Science, Social Studies and Language Arts classes study the Theory of Evolution in Science, historical setting and documents from Darwin's explorations in World History and origins

from the perspectives of different religion beliefs in Language Arts. Students connect all of these perspectives through a variety of strategies including laboratory experiences, computer simulations, film, guest speakers, field trips and readings to gain an understanding of the difference between science and belief systems. Using these perspectives they write position papers, carry out research and do presentations related to the debate between evolution and creationism.

D) University:

I) Invention Convention

In order to practice and model the process of integrated, interdisciplinary curriculum secondary preservice teacher candidates at California State University at San Marcos are given an assignment in which they have to apply the creative process of invention. In cooperative groups they have to determine an everyday problem and apply a technological solution to it. In a presentation and written report they must demonstrate how the invention works and the processes they went through to design, model, and market it. They must also present a commercial to sell it. Also, they must explain the scientific principles involved and justify the invention environmentally and ethically. This project is interdisciplinary in that it is student centered, involves problem solving, cooperative group processes and to some extent the disciplines of science, technology, mathematics, social science, economics, humanities and language communication skills.

In one example, preservice secondary teachers addressed a possible solution to the problem of lack of effective communication with the parents of high school students. In their solution they "invented" a Teacher Auto Caller (TAC) that would use prerecorded messages to send a variety of individualized information to parents (via computer modem) such as achievement level, homework and other suggestions. They demonstrated on a computer how the TAC would work, presented a commercial to "sell it" to school districts, provided a cost analysis and

explained the science and technology required for implementation. Time was also provided for other students to critique the invention and ask questions for clarification. Many of the students applied this unit, with appropriate modifications, during their own field experiences.

II) Interdisciplinary Unit Plan

In another example that provides practice and modeling of this process, secondary preservice teachers are given an assignment that includes the design of an interdisciplinary unit. They are organized into teams that have one representative from each core discipline. This assignment is one of the outcomes of a course titled: *Disciplinary/Interdisciplinary Methods* (EDSS 541). Over a six week period instructors provide information related to the logistics of this holistic process as well as examples from previous classes. The final products are in the form of a written document as well as a creative oral presentation. Students also have opportunities to reflect and critique each interdisciplinary unit presented. Students are also encouraged, when possible, to implement the lessons during their field experiences.

One example of an interdisciplinary unit produced as a result of this assignment was the study of the development of Medicine in the Americas. In this unit, the core of the study was science (medicines) but intertwined throughout was literature, language (Spanish), history and culture that would allow the students to understand what forces drive discoveries of medicines by indigenous populations. In this study, the preservice teachers were addressing very appropriately the interests of the population they were teaching (Latino) as well as providing for them the interconnectiveness of all the disciplines within the study.

The following are references that will assist teachers in the processes of conceptualizing and developing science interdisciplinary units. Many examples from K-12 classroom applications are given that model this concept.

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Signature: Dr. Joseph Keating	Printed Name/Position/Title: Joseph Keating, Asst Prof Sci Ed	
Organization/Address: College of Education. CSU San Marcos San Marcos, CA 92096	Telephone: 619-750 4321	FAX: 619-750 3237
	e-mail address: jkeating@mailhost1.csusm.edu	Date: 1/2/97

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