# Using a Cultural Context to Integrate Mathematics and Science Education

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**Abstract**
The purpose of this paper is threefold: (a) to briefly review the literature related to integrated science and mathematics education, (b) to describe a process for developing integrated mathematics and science learning environments using culturally-relevant mathematics and scientific problems arising out of the environment, and (c) to provide some examples of culturally-relevant, integrated mathematical and scientific experiences as models that can be generalized to different areas of the world and diverse populations.

**Introduction**
It seems that mathematics students regularly ask, "When are we ever going to use this?" and lament the abstract nature of mathematics while science students often struggle with the mathematics needed to solve scientific problems. During the past century, one distinctive effort to improve science and mathematics education is an approach that recognizes the natural and logical relationships between science and mathematics and seeks to appropriately and effectively integrate these two disciplines in teaching and learning through real-world problem solving situations.

A review of over a century of literature focused on integration yields 15 different terms: alliance, connection, cooperation, coordinated, correlated, cross-disciplinary, fused, interaction, interdependent, interdisciplinary, interrelated, link, multidisciplinary, transdisciplinary, and unified. This litany of terms for "integration" leads to the need to clearly and comprehensively describe what one means by "integration," regardless of the choice of terms.

**Models of Integration**
A series of three conferences over the last 30 years have attempted to craft a definition of integration through the development of theoretical models. The first model, an outcome of the 1969 Cambridge Conference on the Correlation of Science and Mathematics in the Schools, defined five categories of interaction between science and mathematics: math for math, math for science, math and science, science for math, and science for science (Education Development Center, 1970). Throughout the literature, one finds numerous authors using this same linear continuum with minor word-smithing for each of the categories (e.g., Huntley, 1998; Lonning & DeFranco, 1997). A simple representation of this continuum, with a capital letter denoting the primary emphasis and a lower case letter representing the secondary focus, is illustrated in Figure 1.

| **M** | **Ms** | **MS** | **Sm** | **S** |
|---|---|---|---|---|
| **Math** | **Math - Science Context** | **Math and Science** | **Science- Apply Math** | **Science** |

*Figure 1.* Math and science linear integration continuum.

Either end of the continuum represents the pure mathematics or the pure science whereby each discipline is preserved as a separate entity. The beauty and abstractness of mathematics is explored without an obligatory application or use and the science phenomena are investigated without need for quantification. The next category (Ms) that focuses upon mathematics utilizes the science context as a way to enhance student use and understanding of mathematics. Similarly, the category (Sm) that focuses upon science applies the tools of mathematics to quantify scientific patterns and relationships.

Rather than using a linear integration continuum, this author proposes a more complex approach to this process of designing integrated mathematics and science learning environments. Figure 2 depicts a multi-directional sequence model in contrast to the often cited linear integration continuum model. The starting point must be the curricula standards for both science and mathematics to identify the mandated content and processes to be taught to achieve the desired student conceptual, procedural, and attitudinal outcomes. It is important that both the science teacher and the mathematics teacher work together to decide upon the appropriate sequence in the integrated learning environment so that the perspectives of both disciplines are fairly represented in a coherent and cohesive manner.

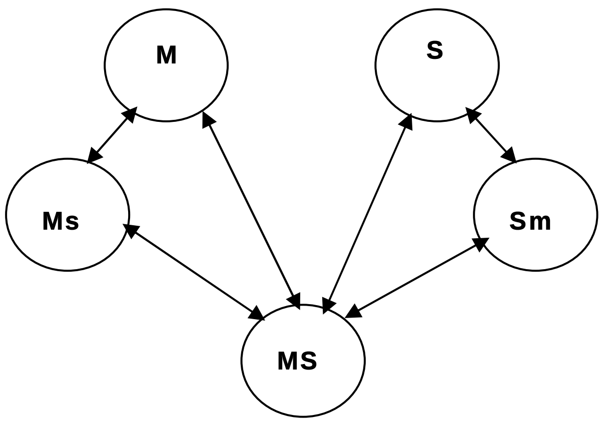


*Figure 2.* Science and mathematics integration sequence.

However, MS or the balance between mathematics and science warrants further clarification. Only one theoretical model, the Berlin-White Integrated Science and Mathematics (BWISM) Model (Berlin & White, 1994, 1995, 1998), uniquely describes the center of the continuum, mathematics and science (MS). Evolving over a period of 15 years, BWISM reflects a comprehensive review of literature spanning 100 years, the perspectives of the science and mathematics K-16 communities, curriculum research and development projects, and current standards-based reform documents. Thus, the BWISM blends the conceptual, procedural, and attitudinal aspects of science and mathematics without compromising the integrity of either discipline.

The BWISM Model is a multidimensional model that includes six aspects: (a) ways of learning, (b) ways of knowing, (c) content knowledge, (d) process and thinking skills, (e) attitudes and perceptions, and (f) teaching strategies. Using the analogy of a kaleidoscope, the integration of science and mathematics teaching and learning can be described as an every-changing combination and interplay of aspects appearing in the visual foreground or background. The Berlin-White Integrated Science and Mathematics Model is designed to provide a conceptual base and a common language that advances the research agenda, serves as a template for characterizing current resources, and guides in the development of new materials related to integrated science and mathematics teaching and learning.

**Contextualizing Integration**

With this deeper understanding of integration, one can now begin to contextualize integrated science and mathematics teaching and learning by connecting integrated instructional activities to the community and the culture of the students. Figure 3 illustrates this contextualization.

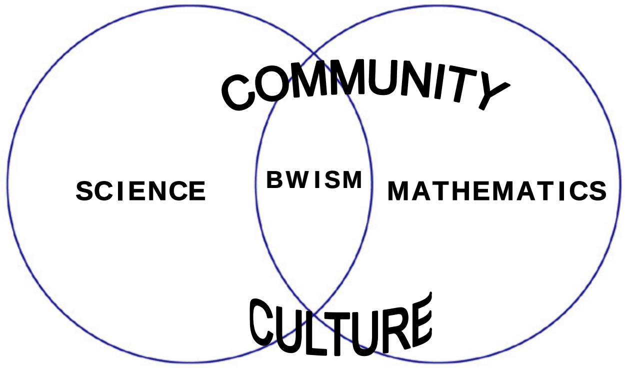


*Figure 3.* Contextualizing science and mathematics integration.

Mathematics and science are a part of the student's personal life, community, and cultural heritage. Contextualizing the integration of mathematics and science education embeds the teaching and learning of mathematics and science within specific communities or cultures. Using a cultural context as the catalyst to design integrated mathematics and science experiences may make the teaching and learning more accessible, relevant, and meaningful to individual students as well as groups of students. This enculturation of integrated mathematics and science teaching and learning is an innovative approach to provide students with unique opportunities to:

1. investigate the important relationships between culture and mathematics and science;
2. develop an awareness of the relationships between the real needs and interests of human beings and the development of mathematics and science;
3. develop an understanding of the history and development of knowledge in mathematics (e.g., numbers, space, and patterns); the sciences (e.g., astronomy, biology, botany, chemistry, physics, earth sciences); and their applications (e.g., agriculture, anthropology, architecture, engineering, textiles);
4. develop an understanding of the history and development of knowledge in mathematics and the sciences as related to the arts, history, literature, music, and religion;
5. develop an awareness and understanding of the scientific and mathematical advancements and technologies developed by one's culture;
6. identify and connect the science and mathematics curriculum to one's culture to enrich the curriculum through unique, compelling, relevant activities; and
7. develop an awareness, sensitivity, appreciation, respect, and pride in one's culture.

**Using a Cultural Context to Integrate Science and Mathematics: Puerto Rico**

An example of contextualized, integrated science and mathematics that is relevant to junior high school students in Puerto Rico is the adaptation of a commonly taught science lesson on natural selection that addresses the science standards of collecting and organizing data, diversity and adaptation, genetic variation, graphing, hypothesizing, interpreting data, measuring, modeling, observing, organisms and their environment, and prediction. Similarly, this activity is aligned with the mathematics standards of algebraic equations, area measurement (standard and non-standard units), graphing, ratio and proportion, percentage, and probability.

To culturally contextualize the natural selection lesson, I have chosen to focus upon the coquí, a unique species of tree frogs that is part of the natural and cultural heritage of Puerto Rico. There are approximately 17 different species of coquí, 13 that are indigenous to Puerto Rico. They range in size from 15 mm to 80 mm and their coloration can be gray, brown, olive, or yellowish-gold; some may have lines or bands that traverse their backs. All have disks or pads on the tips of their toes to help them stick to slippery surfaces like moistened leaves. Unfortunately, many of the coquíes are in danger of extinction, including the golden coquí. Birds, snakes (e.g., the Puerto Rican racer), and the giant crab spiders are natural predators of the coquí. Deforestation and development of homes and agriculture have contributed to their threatened status as they no longer can be camouflaged in the foliage and undergrowth of the forest floor. For this integrated activity, students will be modeling natural selection for gold and brown coquíes and explore area, ratio and proportion, and probability to predict survival rate.

The materials needed for this activity include three environments represented by three sheets of 8 ½ x 11 inch brown paper, one with two gold squares, one with a gold circle, and one with a gold irregular shape on it; a supply of brown-colored and gold-colored hole punches; an 8 ½ x 11 inch box with a lid; graph paper; and a transparent centimeter grid. This activity engages students in a contextualized experience in which conceptual, procedural, and attitudinal aspects of science and mathematics are developed. Specifically,

1. Students model natural selection using "brown" environments with different "gold" shapes and colored dots to represent brown and gold coquíes that are randomly dispersed in the environment.
2. Students determine the area of the environment and calculate the area of the various shapes in the environment using the transparent centimeter grid.
3. Students model the survival rate of the brown and gold coquíes over 5 generations.
4. Students use ratios and proportions and predict which organisms will be most likely to "survive."
5. Students graph their results and find a line of best fit to support their predictions.

**Using a Cultural Context to Integrate Science and Mathematics: The Bahamas**

The Islands of The Bahamas include over 700 islands, uninhabited cays, and large rocks that form a 100,000-sq-mile archipelago in the Atlantic Ocean. Mollusks are abundant in The Bahamas. Mollusks are a phylum of soft-bodied invertebrate animals that live inside of shells that they grow for protection. The shell is really the exoskeleton, or outside skeleton, of the mollusk. Many mollusks have a hard external shell, but others do not. Some major classes of mollusks found in The Bahamas include the bivalves (like clams, oysters, and scallops), cephalopods (like octopi and squid), and gastropods (like snails and conchs). Mollusks, and in particular the Queen Conch, play an important role in the daily life of the Bahamians. They are associated with a vast array of experiences related to art and architecture, food, industry/agriculture, medicine, tools, trade goods/money, music and communication, personal adornment, and religion.

An activity that uses a dichotomous key to classify mollusks is an ideal activity to develop student ability to classify, a process that is common to both science and mathematics education. Students make a series of yes/no choices to classify shells according to selected criteria. For example:

1. Is the shell small?
2. Is the shell larger than 1 cm?
3. Is the shell dark?
4. Is the texture of the shell rough?
5. Is the shell circular?
6. Is the shell a spiral?
7. Is the shell symmetrical?
8. Does the shell have a hinge?
9. Is the shell hinge pointed?
10. Is the shell biconvex?

These questions help students to develop both science and mathematics vocabulary and concepts related to an integral part of their natural environment. Also, students can be involved in higher-order thinking as they participate in follow-up discussions such as the following:

1. Why are the shapes different (e.g., advantages of shapes for protection)?
2. What ways do the various mollusks obtain their food?
3. Do the mollusks move around or are they stationary?
4. Do the mollusks bury themselves in the sand or are they found on the reef?
5. What is the relationship between the shell shape and these factors?

More advanced students can explore Fibonacci Rectangles or the set of rectangles whose sides are two successive Fibonacci numbers in length and are composed of squares with sides that are Fibonacci numbers. A spiral, or a quarter of a circle drawn in each of these squares, can often be found in the shells of mollusks. A logarithmic or equiangular spiral follows the following rule: for a given rotation angle (such as one revolution), the distance from the pole (spiral origin) is multiplied by a fixed amount. This fixed amount has been linked to the golden ratio or golden number (approximately 1.618034).

Students can use various mollusks to explore their growth pattern in relationship to the golden ratio or golden number. For example, students can use the nautilus shell and draw a line from the center out in any direction. Students then find two places where the shell crosses the line. Students can compute the ratio between the distance from the outer crossing point to the center and the distance between the next inner crossing point from the center. Students can collect various mollusks to explore shell spirals and analyze their growth pattern in relation to the golden ratio, an issue that is currently debated by both mathematicians and scientists.

## Conclusion

Using a cultural context to integrate science and mathematics teaching and learning exploits students' daily life experiences, cultural heritage, and background experiences and vocabulary to frame science and mathematics problems in the classroom and (b) helps students to make connections between their community, national, ethnic, and cultural identities which can promote awareness, sensitivity, appreciation, respect, and pride in community and culture. This learning environment can stimulate student interest and motivation while developing important science and mathematics concepts, processes, and skills. Science and mathematics teachers in various countries, communities, and cultures can design integrated and contextualized experiences that are aligned with their science and mathematics curriculum standards and make science and mathematics more relevant and meaningful to their students.

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