In what sense is it true to claim that mathematics is culture-free?

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Abstract

There is considerable emphasis today on realistic applications of school mathematics. However, many educators assert that mathematics exists independently of its applications and that it should be taught in its "pure" form. Such an approach ignores the lessons learned from the history of mathematics when significant advances resulted from attempts to solve important social problems. These applications include such topics as geometry in Ancient Egypt, astronomy in the middle ages, and computers in the modern era. In modern mathematics, symbolism has been developed independent of applications. Nevertheless, for the mathematics to be meaningful, appropriate applications must be foundational. In the recent history of mathematics considerable interest has developed in the field of ethnomathematics, which D'Ambrosio interprets to mean the mathematics used by any cultural group. Thus we can say that the study of ethnomathematics focuses attention on the real meaning of the mathematics being studied. From an instructional standpoint this means that a mathematics curriculum should draw stimulus from the learner's environment. The presentation will include examples of an ethnomathematics approach to the curriculum from the presenter's experience.

Introduction

The statement "mathematics is culture-free" epitomizes the divergence of thinking about mathematics represented by the "math wars" in the United States and elsewhere. A traditional perspective is that mathematics exists independently of its applications and should therefore be taught in its "pure" form. An alternative perspective is that the applications of mathematics cannot be ignored when designing mathematics instruction. The purpose of this paper is to examine the conditions whereby it is true to claim that mathematics is culture-free.

A metaphor for the conflict mentioned above may be seen in the early history of mathematics. Historians of mathematics such as W. W. Rouse Ball (1960) assert that the history of mathematics began with the Greeks. This widely held position is based on the claim that the real study of mathematics called for its connection to abstract ideas. Speaking in general terms, Greek mathematicians (such as Thales) were the first to focus attention on general rather than specific results. On the other hand, the Egyptians had what were tantamount to calculating aids to help with finding unit fractions, an example of their problem solving strategies being more focused on finding answers to specific questions rather than on finding general patterns of solution. They certainly were not doing Greek style mathematics, but they were solving real mathematics problems. To claim that the Egyptians priests who re-surveyed the Nile River delta after its annual flooding, or the Babylonian astronomers making detailed astronomical observations were not doing significant mathematics is to posit a limited view of mathematics. Thus, on one hand, it is true that advances in mathematics have been generated by thinking about mathematics in an abstract way without any consideration of applications. An example of this would be George Boole's Laws of Thought in the mid-19th century. On the other hand, it has also been true throughout history that significant scientific advances have followed directly from the need to solve an immediate problem, such as the advances in computer technology which contributed to the ending of World War II.

One of the dramatic illustrations showing the impact of applications on the development of mathematics has been the invention of logarithms by John Napier and Henry Briggs. Tycho

Brahe's astronomical calculations yielded immense amounts of data which could not at that time be analyzed. His assistant (and successor), Johannes Kepler, was able to analyze this data because of access to logarithms as a calculating device. The advances in astronomy made during the Renaissance (such as those of Kepler and Newton) would not have been possible without the advent of logarithms. Examples such as these do not establish a cause and effect relationship between advances in mathematics and the solution of significant scientific problems, but they do show an interaction between these variables. Thus we may conclude that while the study of mathematics has not depended on applications for its growth, and is therefore "culture-free", there is evidence to support the applications as promoting the development of further mathematical ideas.

History of mathematics education reform

The current "math wars" in the United States have been attributed largely to the publication by the National Council of Teachers of Mathematics (NCTM) of the *Principles and Standards for School Mathematics* (2000) and its predecessor *Curriculum and Evaluation Standards for School Mathematics* (1989). In their analysis of this standards-based approach to mathematics instruction, critics have described it as "fuzzy math" and claimed that the NCTM has failed to recognize the importance of building students' ability to memorize certain basic math facts and procedures; that proficiency in basic skills was replaced by reliance on calculators; serious attention to algorithmic thinking was replaced by "real-life problems"; that having students discover their own methods to perform math operations could not lead to mastery; and individual accountability was replaced by group work (Hechinger, 2006). The intent in this paper is not to fuel the "math wars," but to try to understand why different groups within our society have different expectations of a school mathematics curriculum.

McKeown (Hoff, 2000) claimed that the NCTM and its critics agree on "platitudes", but disagree about how much emphasis to put on them. Thus the real issue seems to hinge on different philosophical considerations about the nature of mathematics education. Ernest (1991) describes the two opposing perspectives as the absolutist view of mathematical knowledge (consisting of certain and unchallengeable truths) and the fallibilist view (that mathematical truth is fallible and corrigible, and can never be regarded as beyond revision and correction). He maintains that the rejection of the absolutist view "leads to the acceptance of the opposing fallibilist view" (p. 18). Although Ernest asserts that teachers' strategies in the classroom depend upon their philosophical perspective, he emphasizes the importance of social context. That is, teachers who have different philosophical perspectives may still teach in similar ways and adopt similar classroom practices depending upon the socialization effect of the context. Implementing a fallibilist view in practice, for instance, is far less likely if a teacher's peers and school climate support the absolutist perspective. Teachers may "shift their pedagogical intentions and practices away from their espoused theories" (p. 289) when faced with constraints created by the social context.

The melding of Ernest's absolutist and fallibilist perspectives, however, has not been visible in the history of American mathematics education. E. L. Thorndike's emphases on recitation and rote memorization followed by measurement of outcomes through achievement testing, advocated in the early years of the twentieth century, have determined the state of affairs in mathematics education. Students trained in an absolutist philosophy who become teachers will likely teach from the absolutist standpoint.

The new math reforms took on different formats in various countries. In the United States and Europe, there was concern that an insufficient number of well-qualified students would be proceeding to post-secondary mathematics. There was a belief among university mathematicians that the secondary school mathematics syllabus needed to be reformed. Two prominent reform groups formed in the 1950's, the University of Illinois Commission on School Mathematics and the School Mathematics Study Group, focused on the development of abstract mathematical ideas. Likewise, in France, Lucienne Felix (1961) characterized the revolution there as a response to the need to replenish the supply of potential mathematicians, so many of whom were victims of the war. By contrast, in the United Kingdom, there was considerable involvement by the teaching community in the reforms undertaken. Bryan Thwaites, director of the School Mathematics Project, had teachers writing curriculum, while the funding came from industry, not the government.

Not all mathematicians in the United States were supportive of the direction their colleagues had chosen. Morris Kline (1958) deplored the university domination of the reform efforts which he accused of being more interested in training a new generation of mathematicians than in providing mathematics courses for all. His comments reflect the emphasis in curriculum materials developed in this era; the curriculum was devoid of discussion of applications because, we were told, we could not predict what the applications of mathematics would be in 15 years time. While that statement proved to be true, to present mathematics instruction devoid of applications is to ignore the use of meaningful applications to stimulate student learning. However, this outcome does reflect the dichotomy discussed above. If one's view of mathematics is simply a relationship involving symbols, then there is no need to consider applications as they serve only as a distraction from the "real mathematics". On the other hand, if applications are viewed as a basis for mathematics study, then their study cannot be divorced from the mathematics they exemplify. Thus, while it may be true to claim that the mathematics is culture-free, the use of contexts as a stimulus for learning the mathematics provides students with appropriate connections to reality.

One implication of asserting that mathematics is culture-free is that it can then be taught to all students in comparable ways. Thus, under the auspices of the 2001 No Child Left Behind Act, all students should be taught in the same way, and be expected to manifest appropriate achievement gains, regardless of prior background. This takes no account of learners with special needs, including English language learners. In fact, current curriculum reform efforts have students draw on their prior experiences to make real meaning of the curriculum. I will now address how I have found the use of students' culture to be an essential ingredient of a meaningful mathematics curriculum.

Ethnomathematics

In reviewing the history of mathematical ideas and the recent history of mathematics curriculum reform, we observe that mathematics curriculum and instruction cannot be isolated from the social context. Ubi D'Ambrosio's (1985) definition of "ethnomathematics" as the mathematics required by any societal group can guide us in viewing this from a balanced perspective. We note that this does not preclude the consideration of the mathematics required by a particular ethnic group, but this is only a subset of ethnomathematics. Alan Bishop (1988) suggests that the cultural backgrounds of the students are rich resources from which mathematics concepts may be developed. It follows, then, that mathematics curricula should be aligned with culture for learning opportunities to be enhanced. It is important to note that such an approach does not restrict the curriculum to local interests and culture. In fact, while the local perspective is important, the organization of mathematical ideas and the development of a structured curriculum might then be overlooked.

To illustrate my thesis I will discuss a number of applications from American Indian students' classrooms to link mathematics with American Indian culture. (See Davison, 2002, for more detail about these applications.) This needs to be a very deliberate effort. In earlier work

(Davison, 1992), I found from interviews with Indian bilingual students that they saw no applications other than money for their study of mathematics. Moreover, because many students were not familiar with the traditional culture, prior knowledge of the culture could not be used to enhance the learning of mathematics. However, when the curriculum is planned to provide instruction and culture at the same time, productive learning will follow.

In a sixth grade bilingual classroom, the Crow Indian students integrated mathematics and culture through the creation of a plaster relief map of the Crow reservation. Each group of students was responsible for constructing a plaster relief model of their chosen segment of the reservation, and then the 15 segments were glued together. In mathematics, the students were learning scale drawing, and in Crow culture they were learning the geography of the reservation. In this way, the two disciplines were appropriately integrated.

Geometric activities linked with American Indian culture include bead working, star quilting, painting, and weaving. All of these culture-based activities can be used in the classroom, preferably guided by a traditional exponent of the craft. Links between the mathematics and art curricula are seen when the students use manipulatives such as pattern blocks to create artistic designs which are typically representative of native art work. I have found that when asked to create a geometrical design, most students develop a symmetrical pattern which is typically related to their culture. Marina Krause's (1983) *Multicultural Mathematics Materials* is a valuable source for such examples.

Other culture activities focus on the development of number sense. Recipes for Indian fry bread are available in many commercial recipe collections as well as in traditional American Indian collections. Students investigate ratios as they prepare the recipe, say for three times the original number of servings. Of course, the lesson typically involves baking and eating the fry bread! Also, many American Indian students and teachers are involved with powwows. Thus they will be familiar with the scoring of competitive dancing. A former student, a Crow Indian dancer and teacher, illustrated how this traditional activity could be used to enhance students' number sense. Given the scores of the contestants on the First and Second Day's Grand Entry Points, and the First and Second Day's Contest Points, determine: Which contestant skipped the first day of competition? Which contestant made all the grand entries? Which contestant won?

Since many Crow Indian students are delayed English proficient, any strategy designed to improve their mathematics achievement must attend to the language issue. Traditional stories related to the culture seem to be a productive approach. But very few traditional American Indian stories have a mathematics focus. However, I found that interest is generated even if the story related to some other culture. In a third grade Crow Indian classroom I read *Two Ways to Count to Ten* (1988), a folk-tale of Liberian origin. The students enjoyed the story, and after my reading the story to them, the class explored other ways to count to 10. After that, we explored different ways to count to other numbers such as 24 and 36. Other well-known children's stories, such as *Anno's Mysterious Multiplying Jar* (1983), which I used with upper grades students, proved popular because the stories are engaging. Even though I appeared to succeed in having the students grasp the use of factorial notation, they had difficulty in writing their own stories leading to the production of 10! The important issue here is to engage the students in applying the story by extending the mathematics inherent in the story either by writing their own story or by exploring the mathematics on their own.

The examples discussed from the Crow Indian culture are not idiosyncratic: applications are chosen that are relevant to the students' interests. This is clearly true as a means of engaging all students in the study of mathematics, especially those who find no meaning in an academic mathematics curriculum. I have observed this to be especially true of American Indian students in a variety of contexts. Unless they have a purpose to their study of mathematics, they are ill inclined to devote effort to it. Textbooks are no help, because they are market-driven and devote little if any attention to American Indians. It is natural for these students to feel disenfranchised by the educational system. This means that for them to believe that education has meaning for them, the regular curriculum needs to be enriched with examples that have meaning for them.

Conclusion

"Mathematics is culture-free, but its contexts are not". I encountered this statement in a long-forgotten source, but it does reflect the position I have sought to argue in this paper. Curricular traditionalists believe that mathematics is its own language and needs no reference to applications. I have suggested that this is a limited view which inhibits students from experiencing the richness of the mathematics. It is true that the mathematics exists independently of its applications, but it is the applications that give meaning to the mathematics. This is particularly true of disadvantaged mathematics learners. Only when the curriculum is related to their experiences can such learners be connected to the mathematics and become productive mathematics students.

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