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Ethnomathematics and Its Integration within the Mathematics Curriculum

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"Ethnomathematics" is often defined as the research on the relationship between mathematics (mathematics education) and the corresponding social and cultural backgrounds, namely the research shows "how is mathematics produced, transferred, diffused and specialized in diverse cultural systems". As far as the mathematics curriculum is concerned, it is certainly rational to integrate Ethnomathematics and the mathematics curriculum, taking the methods of "rectangle bases" construction commonly used among the Mozambican peasantry in Africa. This paper explores the possibility of adding "Ethnomathematics" into mathematics curriculum, and then discusses the enlightenment of the curriculum reform with the example of vector teaching in new high school mathematics courses in China.

Key words: ethnomathematics, mathematics curriculum, multiculture, mathematics teaching.

Introduction

There are no definitions of "Ethnomathematics" in any standard dictionary. This is to say that the definition of Ethnomathematics has not been standardized yet. Relating to etymology, "Ethnomathematics" is initialed by "ethno" and ends with "mathematics". Thus, literature that refers to two different fields -anthropology and mathematics- can be used to survey "Ethnomathematics". We can speculate to a certain extent that Ethnomathematics should be discussed at the cross point of culture and mathematics with etymological evidence. We know that "Ethnomathematics" is a compound word if we look over the word itself and the definitions of its word-initial "ethno" and the etyma "mathematics". The word-initial "ethno" is part of the word "ethnology" which is defined as "the science that analyzes and compares human cultures" or "cultural anthropology" in the dictionary and the definition of "mathematics" is "a science dealing with 'quantitative relations' and 'spatial forms' in the real world".

It is very likely that little research has been conducted on ethnomathematics mainly because people believe in the universality of mathematics, a viewpoint which is being questioned by anthropologists. Their research shows that "daily mathematics" is not completely the same as "school mathematics" that is taught in general school systems. This kind of distinction exists even in the most typical mathematics branches as do as calculation, arrangement, classification, measurement and weighing.

As a research area, "Ethnomathematics" is often defined as the research on the relationship between mathematics (mathematics education) and the corresponding social and cultural backgrounds, namely the research to show "how is mathematics produced, transferred, diffused and specialized in diverse cultural systems". An obvious conclusion can be drawn from what is said above, that the research on ethnomathematics is very close to or even part of that of ethnology, especially when the multicultural point is considered as a main conclusion of people's study on culture. As a result, considering the existence of diverse forms of civilization during the history of mankind, relevant mathematics forms should also be studied specifically. One matter which should be pointed out is that the "mathematics" referred to here has a broader meaning, not only should it contain mathematical knowledge, mathematical skills and mathematical ways of thinking, but mathematics that is not fully developed and even still in an embryonic state should also be involved or that the diversity of mathematics forms should be definitely confirmed.

Additionally, as the modern concept of "culture" has gained a more generalized sense, namely that it not only refers to the macro-sense of the variety of human civilization such as the unique cultural traditions in different regions, countries and races, but it also refers to the special characteristic of "lifestyles" and "working ways" in various communities. In accordance with this kind of understanding, we should clearly affirm the fact that different cultural groups, such as different professional groups or even children of different ages, can all develop special mathematics forms from their own cultures. In fact, this has evidently and greatly broadened the scope of research on "ethnomathematics". It is no longer confined to the traditional scope of human culture, but also includes historical and realistic, macro and micro research (Zheng, 1999).

Cases of Integrating Ethnomathematics into Mathematics Curriculum

Gerdes (2001) points out that "The mathematical thinking and methods are quite different in different cultures… Teachers should look over and analyze the proper activities from different cultural backgrounds, then find the activities that are appropriate to be integrated into the class, and create a really rich and inspiring environment to help students develop their potentials" (Gerdes, 2001). Taking the methods of "rectangle bases" construction commonly used among the Mozambican peasantry in Africa as the example, he figures out the possibility of adding "Ethnomathematics" into mathematics curriculum (Gerdes, 1999).

Most African peoples south of the Sahara traditionally build houses with circular or rectangular bases. Among the Mozambican peasantry, two methods for the construction of the rectangular bases are common. People from a different cultural environment may be surprised to see that rectangles can be constructed without starting by constructing the right angles one by one.

Method 1: The house builders start by lying down on the floor two long bamboo sticks of equal length. Then these first sticks are combined with two other sticks also of equal length, but normally shorter than the first ones (1-a). Now the sticks are moved to form the closure of a quadrilateral (1-b). The figure is further adjusted until the diagonals -measured with a rope- become equal (1-c). Then, from where the sticks are now lying on the floor, lines are drawn and the house builders can start.

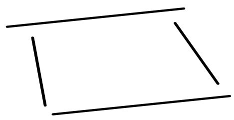

Figure 1-a

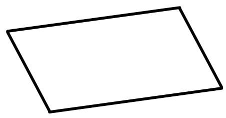

Figure 1-b

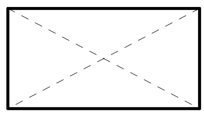

Figure 1-c

Method 2: The house builders start with two ropes of equal length, that are tied together at their midpoints (2-a). A bamboo stick, whose length is equal to that of the desired width of the house, is laid down on the floor and at its endpoints pins are hit into the ground. An endpoint of each of the ropes is tied to one of the pins (2-b). Then the ropes are stretched and at the remaining two endpoints of the ropes, new pins are hit into the ground. These four pins determine the four vertices of the house to be built (2-c).

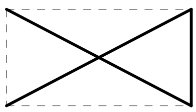

Figure 2-a

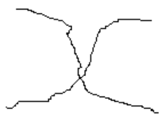

Figure 2-b

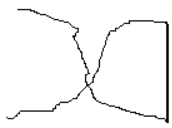

Figure 2-c

No right angles are constructed until the rectangle bases are finished, but it is not hard for readers to find that the knowledge behind these rectangle constructions is equivalent to theorems in Euclidean geometry:

There are two theorems hidden in Method 1: One is "If the opposite sides in a quadrilateral are the same length, then the figure is a parallelogram." The other one is "A parallelogram with congruent diagonals is a rectangle".

Also, one is hidden in method 2: A quadrilateral with congruent diagonals that intersect at their midpoints is a rectangle.

Looking for possibly interesting didactic alternatives of axiomatic constructions for Euclidean geometry in secondary or in mathematics teachers' education, the "rectangle axiom" proposed by Alexandrov of the former Soviet Union may be used as a substitute for Euclid's famous fifth postulate. Alexandrov's "rectangle axiom" (RA) says following (see figure 3):

RA: If in a quadrilateral $ABCD$, $AD=BC$ and $\angle A$ and $\angle B$ are right angles, then $AB=CD$ and $\angle C$ and $\angle D$ are also right angles.

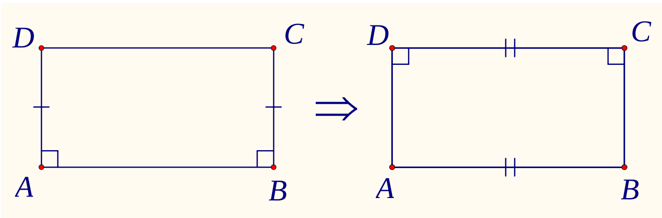

Figure 3

The knowledge underlying the traditional Mozambican house building techniques might be used to formulate alternative "rectangle axioms".

RA1: If in a quadrilateral $ABCD$, $AB=CD$, $AD=BC$ and AC=BD, then $\angle A, \angle B, \angle C$ and $\angle D$ are all angles (see figure 4).

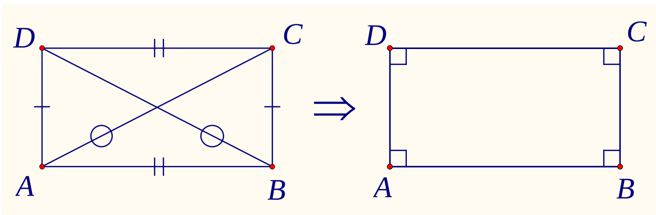

Figure 4

RA2: If in a quadrilateral $ABCD$, $M=AC\cap BD$ and $AM=BM=CM=DM$, then $\angle A, \angle B, \angle C$ and $\angle D$ are right angles, $AB=CD$ and $AD=BC$ (see figure 5).

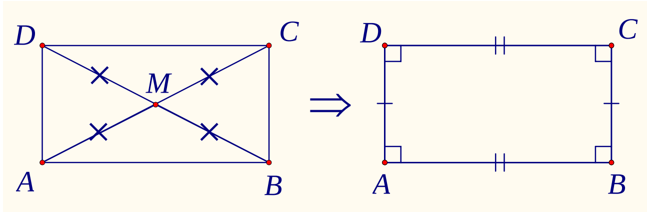

Figure 5

To use these rectangle constructions from traditional house building as source of inspiration to formulate alternative rectangle axioms is one of several interesting possibilities of exploring them educationally and mathematically.

Some Enlightenment for High School Mathematics Curriculum Reform in China

The materials referred above are of some enlightenment to the mathematics curriculum reform of high school in China. Vector is an important element of "*Compulsory Mathematics Textbook 4*" prepared based on "*Senior High School Mathematics Curriculum Standards*", and that is one of the important and basic concepts of modern mathematics. It is a useful tool to communicate algebra, geometry and trigonometry and also has its own practical background with richness. The knowledge involved in the two methods for the construction of the rectangular bases of traditional houses can be related deeply to vector.

Now let's go back to method 1, we have: $|p+q|=|p-q| \Leftrightarrow p \perp q$ (see figure 6), where p and q represent vectors. It is easy to prove this proposition:

$|p+q|=|p-q| \Leftrightarrow (p+q)^2=(p-q)^2 \Leftrightarrow p^2+q^2+2pq=p^2+q^2-2pq \Leftrightarrow pq=0 \Leftrightarrow p \perp q$

, so $|p+q|=|p-q| \Leftrightarrow p \perp q$.

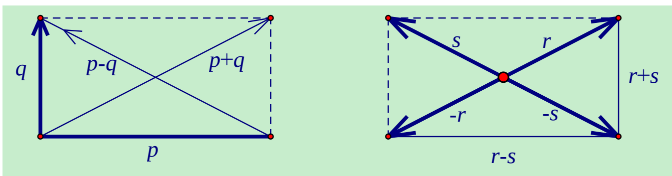

Figure 6 *Figure 7*

In method 2, we also have $|r|=|s| \Leftrightarrow (r+s) \perp (r-s)$ (see figure 7), where r and s represent vectors. It is also easily proved:

$|r|=|s| \Leftrightarrow r^2=s^2 \Leftrightarrow r^2-s^2=0 \Leftrightarrow (r+s)(r-s)=0 \Leftrightarrow (r+s) \perp (r-s)$, so $|r|=|s| \Leftrightarrow (r+s) \perp (r-s)$.

The cases above show that abundant mathematical knowledge is involved in the process of house building for Mozambican peasants although the manifestations are quite different from the “formal mathematics” in our common cognition, it can be considered as the manifestations of their own “ethnomathematics”. Since Euclidean geometry to the representation method of vector can be found in contact with local residents’ behaviors, plenty of good materials can be absorbed into the mathematics curriculum if we carefully analyze the behavior and dig out the mathematical contents involved. The process of constructing rectangle bases is simple and it can be shown in the classroom, with which the students will have a “re-creation” and deeply experience the process of “mathematicization”.

We can easily find many reasons to integrate the common event of how Mozambican peasants build houses in Africa into the mathematics curriculum, therefore we can conclude that it is with significant referential value and has practical implications in respect to the cultural differences between different races and we can explore their mathematical thinking.

China has a long history of culture and tradition from which we can find lots of contents to integrate into the mathematics curriculum. For example, Mahjong, which can be called the “national essence” in China, can also provide good materials for mathematics curriculum after the mathematical knowledge and cultural connotations involved are carefully excavated (Zhang, 2007). Because of the different historical origins of different national cultures, the methods to estimate the endless roots in different cultures are quite flexible. Trying to introduce and comment on these diverse solving methods in the history from the viewpoint of multicultural mathematics, we can enrich the contents, increase the fun and reflect diversity while preparing the new mathematics textbooks to enhance students’ desire to explore the mathematical theories involved.

What’s more, mathematics in different cultures can also be shown to students to give them a rich background knowledge, which will help them share the results created by people of all ethnic groups, admire mathematical achievements with different mathematics cultural tradition and understand how calculating tools influence mathematics and people’s daily life. Then the aims of mathematics education under the multicultural viewpoint may be finally reached (Fu & Zhang, 2005).

To sum up the above arguments, just as what P. Gerdes says, integrating materials from different cultures into the curriculum, and then making correct evaluations of all students with different cultural backgrounds, as well as enhancing everyone’s confidence and learning to respect all ethnic groups and cultures, will be helpful in helping students adapt to an environment of multiculture in the future (Gerdes, 1996). It has a certain rationality to integrate ethnomathematics and mathematics curriculum, and with the integration, the inherent mathematical value in special cultures and societies will be understood and respected.

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