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by Randy Lattimore

One of the most serious problems in mathematics education continues to be the dismal statewide mathematics proficiency test performance of African-American students in urban schools.[1] It has been argued that one of the best ways to improve performance is by connecting the pedagogy of mathematics to the lives and experiences of these students.[2] Although many theories have been implemented in the urban mathematics classroom to assist African-American students in developing and increasing conceptual understanding, members of the urban mathematics education community should take a closer, more serious look at the implementation of radical constructivism within urban mathematics classrooms.

A number of scholars, including Joyce Ladner in sociology, James Cone in theology, Robert L. Allen in political science, James A. Banks in education, Derrick A. Bell Jr. in law, and William F. Tate in mathematics education have moved beyond the traditional paradigmatic boundaries of their respective fields to provide a more cogent analysis of the African-American experience.[3] This boundary crossing represents a significant theoretical and interpretive resource to the academic community. This article moves beyond the traditional boundaries of the field of mathematics education and examines radical constructivism as an adequate research framework for learning mathematics in the urban mathematics classroom.

Radical Constructivism: Meaning and Assumptions

Radical constructivism is a dismantling of Western epistemological tradition. It is an unorthodox way of closely scrutinizing the conceptual underpinnings of Western tradition. Radical constructivism questions deeply rooted notions assumed to be grounded in truth, knowledge, representation, and reality. Because the dismantling of traditional theory and ideology is unpopular, proponents of this theory may be considered heretics, at least in terms of the usual course of evolution of Western tradition. The fundamental tenet of the radical constructivist position is that mathematics is not a pre-existing body of knowledge waiting to be discovered, but rather it is something which is personally constructed by individuals in an active way, inwardly and idiosyncratically, as they seek to give meaning to socially accepted notions of what can be regarded as mathematical knowledge. Ernst Von Glasersfeld, an advocate of the radical constructivist position in mathematics education, states:

> knowledge is the result of an individual subject's constructive activity, not a commodity that somehow resides outside the knower and can be conveyed or instilled by diligent perception or linguistic communication.[4]

According to von Glasersfeld, good teachers know the guidance which they give students "necessarily remains tentative and cannot ever approach absolute determination" because, from the constructivist point of view, there is more than one solution to a problem, and problem-solvers must approach problem situations from different perspectives.[5]

The cornerstone of radical constructivist theory is Piaget's emphasis on action (that is to say, all behavior that changes the knower-known relationship) as the basis of knowledge. An individual gets to know the real world only through action.[6]

As Paul Cobb has underscored, the crucial issue is not whether mathematics teachers *should allow* students to construct their knowledge, "for the simple reason that to learn is to actively construct." Rather, Cobb said, "the issue concerns the social and physical characteristics of settings in which students can productively construct mathematical knowledge."[7]

During the past ten years, the impact of radical constructivist thinking on mathematics education researchers and, increasingly, on teachers of mathematics in schools, has been considerable. Notwithstanding certain tensions between theory and practice, there has been a wave of research aimed at identifying the roles of teachers of mathematics who wish to adopt radical constructivist approaches.[8] It is appropriate, therefore, to pause for a moment not only to reflect on whether the claims of radical constructivism with respect to mathematics education are justifiable, but also to assess which aspects of the applications of radical constructivist thinking can be beneficial in the urban mathematics classroom and which are less beneficial.

Members of the urban mathematics education community should take a closer, more serious look at Nerida Ellerton and McKenzie Clements' three-point rationale for the use of radical constructivism in the urban mathematics classroom.[9] Ellerton and Clements propose the following:

1. Ownership of Mathematics by the Learner. A simple way of summarizing the radical constructivist position in mathematics education is in terms of the notions of ownership. A principle of radical constructivism is that, ultimately, mathematical knowledge is not something that is acquired by listening to teachers or reading textbooks, but is something that learners themselves construct through actively seeking out, and making, mental connections. When someone actively links aspects of her or his physical and social environments with certain numerical, spatial, and logical concepts a feeling of ownership may be generated. In such cases a learner is likely to make comments such as "I know this because I worked it out myself."

Radical constructivism notion of ownership is powerfully relevant to school mathematics. It has been maintained that previously, too much emphasis was placed on a linguistic communication pattern by which the teacher explained to students what they had to do, and how they could do it. Few mathematics educators would deny that traditionally, school mathematics has been regarded by students as a fixed body of knowledge, owned by the teachers, textbook and worksheet writers, external examiners, and by great, mysterious figures of the past such as Pythagoras and Euclid. During the 1980s, however, constructivist mathematics educators around the world called for teachers to establish teaching and learning environments in which students, as a matter of course, created mathematics themselves and therefore came to feel that they owned the mathematics they were learning.[10]

2. Quality Social Interaction as the Basis for Quality Mathematics Learning. Neil A. Pateman and David C. Johnson claimed that it has been "constructivist" teachers of mathematics who led the recent movement towards establishing mathematics learning environments that nurture interest and understanding through cooperation and high quality social interaction.[11] Such environments are likely to foster a kind of socio-cognitive conflict and challenge that stimulate learning. Pateman and Johnson maintained, as did Leslie P. Steffe, that children construct their own actions. Their reflections on those actions (in social settings) provide a framework for those responsible for devising mathematics curricula and school mathematics programs.

According to Pateman and Johnson: Content can hardly be rigidly prescribed in advance by the constructivist teacher, neither can methodology which probably needs to be idiosyncratic to children and context, or even assessment. The constructivist teacher will need to be somewhat of an opportunist, and also an able elementary mathematician willing to continue to learn both about mathematics and children in the attempt to develop them as autonomous creators of their own mathematics.[12]

The implication is that this will call for richer, more expressive, interaction patterns in mathematics classrooms. Steffe articulated ten principles for the mathematics curriculum design that are in keeping with the main radical constructivist thrusts and identified the following social norms for worthwhile whole-class discussion in mathematics classrooms:[13]

- Explaining how an instructional activity that a small group has completed was interpreted and solved.
- Listening and trying to make sense of explanations given by others.
- Indicating agreement, disagreement, or failure to understand the interpretations and solutions of others.
- Attempting to justify a solution and questioning alternatives in situations where a conflict between interpretations or solutions has become apparent.

Perhaps experienced teachers imagine these norms already apply in whole-class discussions that occur in their own classroom, but classroom analyses indicate that this is rarely the case.[14]

Cobb called for constructivist mathematics educators to develop a new context—a "mathematico-anthropological context"—that will assist coherent discussion on the specifics of learning and teaching mathematics.[15] According to Cobb, there is research support for moving to establish mathematics classroom environments that incorporate the following qualities:

- Learning should be an interactive as well as a constructive activity—that is to say, there should always be ample opportunity for creative discussion, in which each learner has a genuine voice.
- Presentation and discussion of conflicting points of view should be encouraged.
- Reconstructions and verbalization of mathematical ideas and solutions should be commonplace.
- Students and teachers should learn to distance themselves from ongoing activities in order to understand alternative interpretations or solutions.
- The need to work towards a consensus in which various mathematical ideas are coordinated are recognized.

Many teachers of mathematics would accept all five of these points. Nevertheless, much needs to be done, for too often in school mathematics, rhetoric and classroom realities do not bear much resemblance to each other.[16] The principles of radical constructivism are poised to refine and apply these ideas to mathematics classrooms however difficult and time-consuming this process might prove to be.[17]

3. Principles for Improved Mathematics Discourse. Radical constructivism is a theory that should assist in the establishment of learning environments that result in students owning the mathematics they learn. There have been positive features arising from the application of radical constructivist theories to mathematics education, though these are all related to the ownership issue. These pluses were summarized by Cobb whose writings attempted to draw together the threads of the constructivist movement in mathematics education. Cobb and colleagues at Purdue University, sought to explore how the theoretical positions held by radical constructivists might most advantageously be interpreted in mathematics classrooms.[18]

In the second half of the 1980s, there was a veritable flood of education literature on the nature of discourse in mathematics classrooms.[19] Cobb summarized research which attempted to assess the effectiveness of the applications of radical constructivist ideas to mathematics teaching and learning.[20] Cobb makes five points:

a) To claim that students can discover mathematics on their own is an absurdity.

b) Students do not learn mathematics by internalizing it from objects, pictures, or the like. Mathematics is not a property of learning materials, in other words.

c) The pedagogical wisdom of the traditional pattern of first teaching mathematical rules and skills, and then providing opportunities to apply these real life situations, is questionable. An alternative approach takes seriously the observation that from a historical perspective, pragmatic informal mathematical problem-solving constituted the basis from which formal, codified mathematics evolved.

d) The teacher should not legitimize just any conceptual action that a student might construct to resolve a personal mathematical problem. This is because mathematics is, from an anthropological perspective, a normative conceptual activity, and learning mathematics can be seen as a process of acculturation into that practice. Cobb notes that certain other societies and social groups have developed routine arithmetical practices that differ from those taught in Western schools.[21]

e) Mathematical thought is a process by which we act on conceptual objects that are themselves a product of our prior conceptual actions. From the very beginning of primary schooling, students should participate in, and contribute to, a communal mathematical practice that has as its focus the existence, nature of, and relationships between mathematical objects.

For Cobb, understanding mathematics is constructing and acting on what he calls "taken-to-be-shared" mathematical objects.[22] The statements identified in this section of the article refer to important developments in mathematics education that can be linked, at least partly, to the radical constructivist movement.

Conclusion

This essay proposes the implementation of radical constructivism within the urban mathematics classroom. The relatively simple concept of radical constructivism becomes a crucial aspect of mathematics education given the dismal statewide proficiency test performance in urban mathematics classrooms. Moreover, radical constructivism is a viable theory for improving mathematics test performance of African-American students. Rather than ignoring or devaluing their life experiences, radical constructivism redefines teaching and creates environments that connect mathematics pedagogy to the lives and experiences of African-American students.

Notes

[1]Randy Lattimore, *Assessing the Mathematical Competence of African American Tenth Graders in Preparation for a Mathematics Proficiency Test: A Qualitative Study* (Ph.D. dissertation, Ohio State University, 1996).

[2]William F. Tate, "Race, Retrenchment, and the Reform of School Mathematics," *Phi Delta Kappan* 75 (1994), 477-484.

[3]Robert L. Allen, *Reluctant Reformers: the Impact of Racism on American Social Reform Movements* (Washington, DC: Howard University, 1974); James A. Banks, "Relevant Social Studies for Black Pupils." in James. A. Banks & William W. Joyce, eds., *Teaching Social Studies to Culturally Different Children* (Menlo Park, CA: Addison Wesley, 1971), 202–209; Derrick A. Bell Jr., *Race, Racism and American Law* 2nd ed. (Boston: Little, Brown. 1980); James Cone, *a Black Theology of Liberation* (Philadelphia: Lippincott, 1970); Joyce Ladner, *The Death of White Sociology* (New York: Vintage Books, 1973); William F. Tate, Gloria Ladson-Billings, and Carl A. Grant, "The Brown Decision Revisited: Mathematizing Social Problems," *Educational Policy*, 7 (1993), 255–275.

[4]Ernst von Glasersfeld, "Environment and Communication" in Leslie P. Steffe & Terry Wood, eds., *Transforming Children's Mathematics Education: International Perspectives* (Hillsdale, NJ: Lawrence Erlbaum, 1990), 37.

[5]Ibid.

[6]Hermine Sinclair, "Learning: the Interactive Recreation of Knowledge" in Leslie P. Steffe & Terry Wood, eds., *Transforming Children's Mathematics Education: International Perspectives* (Hillsdale, NJ: Lawrence Erlbaum, 1990), 19-29.

[7]Paul Cobb, "Reconstructing Elementary School Mathematics," *Focus on Learning Problems in Mathematics* 13(2) (1991), 5.

[8]Terry Wood and Erna Yackel, "The Development of Collaborative Dialogue Within Small Group Interaction" in Leslie P. Steffe and Terry Wood, eds., *Transforming Children's Mathematics Education: International Perspectives* (Hillsdale, NJ: Lawrence Erlbaum, 1990). 244-252.

[9]Nerida Ellerton and McKenzie A. Clements, "Some Pluses and Minuses of Radical Constructivism in Mathematics Education." Paper Presented at the Fifteenth Annual Meeting of the Mathematics Education Research Group of Australia, University of Western Sydney Hawkesbury, 1992.

[10]See Confrey, "'Misconceptions' Across Subject Matters: Science, Mathematics, and Programming," 1987; Willibald Dorfler, "Protocols of Actions as a Cognitive Tool for Knowledge Schemata from Actions," 1989: Willibald Dorfler, "Empirical Investigations of the Construction of Cognitive Schemata from Actions." in Jere Confrey, Bergerson, Nell Herscovics, and Carolyn Kieran, eds., *Proceedings of the Eleventh International Conference for the Psychology of Mathematics Education*. Vol. 3. (Montreal: International Group for the Psychology for the Psychology of Mathematics Education, 1987), 3-9.

[11]Neil A. Pateman and David C. Johnson, "Curriculum and Constructivism in Early Childhood Mathematics: Sources of Tension and Possible Resolution. In Steffe and Wood, eds., *Transforming Children's Mathematics Education* (Hillsdale, NJ: Lawrence Erlbaum, 1990), 346-356.

[12]Ibid., 351.

[13]Steffe, *Transforming Children's Mathematics Education: International Perspectives*; Cobb, "Reconstructing Elementary School Mathematics," 208.

[14]See for example Ellerton and Clements, "Some Pluses and Minuses of Radical Constructivism," 1992. Robert B. Davis, Carolyn A. Maher, and Nel Noddings, eds., *Journal for Research in Mathematics Education* Monograph Number 4 (Reston, Va: National Council of Teachers of Mathematics, 1990) and Magdalene Lampert, "The Teacher's Role in Reinventing the Meaning of Mathematical Knowing in the Classroom." in Merylon J. Behr, Carole B. Lacampagne, and Margariete M. Wheeler, eds., *Proceedings of the Tenth Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (Dekalb, Il: Northern Illinois University, 1988).

[15]Cobb, 209-210.

[16]Charles Desforges, "Classroom Processes and Mathematical Discussions: A Cautionary Note." in P. Ernest, ed., *Mathematics Teaching: the State of the Art* (East Sussex: Falmer Press, 1989), 143-150.

[17]Leslie P. Steffe, "Mathematics Curriculum Design." in Leslie P. Steffe and Terry Wood, eds., *Transforming Children's Mathematics Education: International Perspectives*, 389-398.

[18]Cobb, "Reconstructing Elementary School Mathematics," and Yackel and Wood, "The Development of Collaborative Dialogue Within Small Group Interaction," 1992.

[19]The literature of the eighties built on important early works by Noam Chomsky, *Syntactic Structures* (The Hague: Mouton, 1957); Hugh Mehan and Houston Wood, *The Reality of Ethnomethodology* (New York: John Wiley & Sons, 1975); and Heinrich Bauerfeld, "Hidden Dimensions in the So-called Reality of a Mathematics Classroom," *Educational Studies in Mathematics* 11.1 (1980), 23-41.

[20]Cobb, 1991.

[21]Ibid.

[22]Ibid.

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