Contextualized Mathematics Instruction: Moving Beyond Recent Proposals

PAUL E. HECKMAN, JULIAN WEISSGLASS

Traditional teaching strategies in mathematics often perpetuate the gap between learning and not learning by failing to stimulate interest and engage students in purposeful activities While educators and researchers are aware of the shortfall in learning, changes in curricula and teaching practices have been slow in coming.

Approaches that advocate contextualized teaching and embrace apprenticeship training have been proposed in recent years and provide some solid evidence of progress toward reform. Among them are situated cognition [1] [Brown, Collins, & Duguid, 1989] and anchored instruction [2] [Cognition and Technology Group at Vanderbilt, 1990]. However, these and other proposals are confined to school-structured situations or simulated apprenticeships, rather than actual situations that relate directly to the student. They often fail to challenge the "culture of mathematics instruction" that exists in our schools [Weissglass, 1992]

We believe that mathematics will be learned by more students (1) if taught with other subjects in a real-world context, (2) if practical learning apprenticeships are developed, and (3) if educators articulate and challenge their own beliefs and values about mathematics, learning and teaching.

Furthermore, we maintain that the intellectual practice of teaching mathematics in the abstract serves to limit the learning of students of lower socio-economic status.

Recommendations suggested here for effecting change in mathematics curricula relate particularly to early school years They are based on the three-year experience of the five-year, foundation-funded Educational and Community Change (ECC) project, which is involved with reinventing education in two urban, elementary schools in a low-income, multi-language area of a southwestern city.

Recently proposed concepts

Situated cognition

In *Situated cognition and the culture of learning,* Brown, Collins & Duguid [1989] explain why activity and situations are integral to cognition and learning and suggest that by ignoring the situated nature of cognition, education defeats its own goal of providing usable, robust knowledge. They further advocate *cognitive apprenticeships* [Collins, Brown, & Newman, 1989], which "try to enculturate students into authentic practice through activity and social interaction in a way similar to that which is evident—and evidently successful—in craft apprenticeship" [p. 37].

Brown, *et al* [1989] use as examples of situated cognition a mathematics investigation conducted by Alan Schoenfeld [1985] for college students and a math lesson taught by Magdalene Lampert [1986] for fourth graders.

The Schoenfeld illustration attempts to show college students how to think mathematically about the world through a study of "magic squares." Brown, *et al.* explain that this approach goes beyond problem-solving strategies: "it provides students with the opportunity to enter the culture of mathematical practice."

This approach is appealing in that students are actively engaged in "doing" mathematics, but the magic-square problem is quite abstract and represents logico-mathematical thinking and mathematics removed from the world and its concerns.

Earlier [1988], Brown, *et al.* noted that solving a particular magic square is easy, but the extension of the problem—in particular the discovery of general principles—is far more elusive. Schoenfeld's approach builds "a mathematical belief system around his own and the class's intuitive responses to the problem" [Brown, Collins, & Duguid, 1988, p. 19]

Schoenfeld's magic-square investigation is an intellectual exercise that is based on the belief that certain ways of thinking should generalize across contexts However, we view such a generalized way of problem-solving as reflecting an intellectual level of thinking that can preclude its application in most real-world problems or contexts. In the exercise, mind and thought are separated from body and action—and such a view has subtle implications that ultimately contribute to social and educational inequalities [Lave, 1988; Rogoff & Lave, 1984].

In Western society, persons who work with their hands are considered "less intelligent" (and are consequently less valued) than those who work with their heads. Widely used Binet-type intelligence and aptitude tests sort individuals according to their ability to solve abstract problems and reason in a "logical" fashion [Gazzaniza, 1988]. Those who score in the highest range—the "geniuses"—are commonly believed to be the ones who can create, innovate, and invent [Amabile, 1983; Wallace & Gruber,, 1989; Guilford, 1967, 1971; May, 1975; Taylor, 1988] A belief in the importance of this kind of intelligence encourages a view of the teaching of school mathematics as logical abstract reasoning [Stanic, 1987].

Intelligence and creativity, however, are not limited to a few individuals who have certain abilities and ways of thinking [Amabile, 1983; Johnson-Laird, 1988; Perkins, 1988]. Instead, context and social circumstances have emerged as important variables that interact with individual characteristics to promote learning and reasoning.

D'Ambrosio [1983] contends that "mathematics has been used as a barrier to social access, reinforcing the power structure which prevails" [p. 363]. Why then promote a general math problem-solving strategy as a model, if such a strategy is not useful in most situations?

One might argue that the "culture of mathematics" advocated by the magic square investigation is precisely what has led to the present methods of mathematics instruction—methods that have failed to meet the needs of so many students when they leave school and confront the world. While Brown, *et al.* and others address the culture of mathematics in their situated cognition articles, the failure to address the *values* of the culture in which educators wish to enculturate students is a serious shortcoming.

The Lampert example cited by Brown, *et al.* seems, at first glance, more closely related to the life of the student than magic squares. Lampert asks the fourth-grade students: "Can anyone give me a story that would go with the multiplication of 12 × 4?" A student suggests that there are 12 jars and each has four butterflies in it. The teacher draws on the board a picture of the jars with butterflies and says to the students: "It will be easier for us to count how many butterflies there are altogether if we think of the jars in groups ...." She then, using the grouping process, goes on to arrive at the answer.

We acknowledge a benefit in Lampert's more student-related teaching, however we feel it is only a marginal improvement to ask the student for "a story" related to a computation than for the teacher to provide the story. The story the student provides is not a story from the student's life experience (what student has 12 jars, not to mention 48 butterflies?). The multiplication problem remains a "school problem", and the teacher remains in control of the lesson. The student has become enculturated to schools and is supplying the same type of problems that s/he has read in textbooks or heard from teachers.

A more contextualized example can be found in the works of Mellin-Olsen [1987] from a classroom in Norway, a country where fishing is popular and in some cases a way of life. During the second week at school, when the children were just getting acquainted with the routine, one student said to the teacher: "Miss, we went fishing yesterday. We got hundreds." The teacher then asked if anyone else had gone fishing, and the children told how many fish they and members of their families recently caught. Twenty stories involving thousands of fish were told before the teacher proceeded with the lesson, asking the children to make drawings of when they went fishing.

When the drawings were shown, the children related their stories in such ways as this:

> "First we got these two, then three, and then another two. We got seven altogether." "I got three, my sister four. She had one more than me, but that big cod, that was mine. Oh, we had many dinners from that one—15 kilos it was."

Children wrote the sum of their catches on their drawings, and the teacher then posed problems based on fish and dinners.

Anchored instruction

Anchored instruction situates classroom instruction in videodisc-based, problem-solving environments. Proponents of anchored instruction claim that it "provides a way to recreate some of the advantages of apprenticeship training in formal education settings" and "may make it possible to create learning experiences that are more effective than are many that occur in traditional apprenticeship training" [Cognition and Technology Group at Vanderbilt, 1990, p. 2].

Although the use of video as motivation for discussion and writing is an improvement over the routine of drill and practice, we contend that the issue of apprenticeships is more complex than the authors acknowledge.

We maintain that a successful apprenticeship program is more than seeing and hearing, as in anchored instruction. It is even more than "learning by doing," as in cognitive and craft apprenticeships. A key and vital factor in acquiring knowledge through cognitive apprenticeships is situating the learning experience in an environment that is real to the student.

One learning experience is not necessarily transferable to other problem-solving exercises. We concur with Brown, *et al.*, that in situated cognition, "knowing is inextricably situated in the physical and social context of its acquisition and use. It cannot be extracted from these without being irretrievably transformed" [Brown, *et al.*, 1988, p. 1].

However, whether knowledge acquired in situated cognition or cognitive apprenticeships is transformed or perhaps not applicable from one situation to another, we contend that acquiring knowledge in a real-life situation or cognitive apprenticeship enhances a student's self-confidence and stimulates initiative in acquiring knowledge in other cognitive apprenticeships, especially those that are meaningful to his/her environment and lifestyle.

Selecting the context

If authentic activity is paramount for learning [Brown, Collins, & Duguid, 1989], then deciding what is authentic activity is an enormous responsibility for educators. If we are to change instruction so as to "enculturate students into authentic practices through activity and social interaction" [Brown, *et al.*, p. 37] similar to a craft apprenticeship, then selection of the apprenticing context is a curricular and ethical choice.

The Vanderbilt group's example [Cognition and Technology Group, 1990] of anchored instruction in a language arts/social studies project for fifth-graders uses the movie, "The young Sherlock," to motivate students to write stories and analyze the historical accuracy of the movie. "One of the goals was to help students develop rich mental models of what it was like to live at certain important times in history" [p. 4].

Would it not be better to study periods in U.S. history during which decisions were made and policies set that contributed to the controversial social issues that we are struggling with today? A more student-related movie might have been "Mississippi Burning," "Matawan," or "Hester Street."

The Vanderbilt group's example of anchored instruction in mathematical problem-solving depicts the adventures of a person named Jasper, who travels by boat from his home to another city to look at an old cruiser that he is interested in buying. At the end of the episode, Jasper is asking himself when he needs to leave and whether he can make it home before dark without running out of gasoline. Students are then challenged to solve the problem, which requires identifying the sub-problems to which they have been exposed while viewing the movie (e.g. a map, the time of sunset).

We believe that this is a significant improvement over textbook drill practice. However, the mathematics is situated in a fictional situation set up by educators rather than in the context of students' lives. Although some students will relate to this situation, others might see it as uninteresting. It does not involve them in real-world activities with personal goals.

Educators and contextual teaching

If situated cognition and cognitive apprenticeships are to be anything else than one more continued school activity, educators need to consider how their present values affect their choices of classroom experience and be open to the consideration of new values and practices. What values, for example, underlie the Vanderbilt group's decision to choose Victorian England as an "important time" for U S students to study today?

When educators select educational materials or when they attempt to situate cognition in cognitive apprenticeships, they always are expressing their values about the subject being taught. No material or situation is free from the educator's judgmental decisions about what is good and worthwhile in and for society. To effectively teach and effectively learn in situated cognition and/or cognitive apprenticeships, many traditional values and beliefs must make way for more democratic concepts in which assumptions of the dominant culture are questioned and cultures of the students are respected.

In the past, attempts to change education have often focused on developing new actions and structures in schools without attention to what individuals believe or feel about the old and new practices [Weissglass, 1991]. Asking questions is necessary to uncover implicit beliefs. For example: What does it mean to learn mathematics? Who creates mathematics curriculum? Is it relevant to the needs of all young people or is it taught in a way that predisposes affluent children to succeed and poor children to fail?

In our view, mathematics can be learned in situations that acknowledge the values of the students as well as the educators and can at the same time encourage responsible democratic citizenship among the learners.

ECC Project: mathematics and societal values

Mathematics can have relevancy and be used to question *societal values* as well [Frankenstein, 1989], especially, we think, if pursued within the context of the student's real life. One way to do so is to situate mathematics problem-solving and apprenticeships in the context of the students' neighbourhood or community

For example, in the Educational and Community Change project in South Tucson, AZ [Heckman, 1990], the fourth-, fifth- and sixth-grade students of one local elementary school and their teachers became involved in a community problem: vacant lots littered with garbage, such as used syringes, empty liquor bottles, human waste, and dumped motor oil.

They began their search for a local community problem by walking through their lower-income neighborhood; they returned and counted the number of houses and examined the patterns of where the vacant houses and lots were located—on what streets, near what intersections. They questioned how long the houses had been vacant. Who used to live there? What stories existed in the community about how the houses became vacant? Who were the present owners?

At this same time, a group of parents and other community members working with a local interfaith group were pursuing the problem of the littered vacant lots and houses. Through the efforts of one of the teachers, the children and adults joined together in what was to become a novice/expert or apprenticeship learning process in the context of their everyday lives.

According to Rucker [1987, p. 3], "Mathematics is the study of pure pattern, and everything in the cosmos is a kind of pattern." These patterns are represented in various ways and constitute the language of mathematics. In this regard, the teachers, students, parents and community members looked for patterns, counting and portraying in graphs, photos, and maps where vacant houses and lots were located. Children and adults often alternated roles between novice and expert, with the children often more expert than the teachers in areas of community culture and history.

In the classroom, the children estimated the amount of trash on vacant lots and compared that to lots with occupied houses. They wrote papers about the issue and presented them to their city council person and later to a community meeting that was attended by more than 1,000 persons.

The end result was one of the nearby, neglected, city-owned lots was donated to the school, and through independently awarded funds, a habitat for use by the entire community is being constructed on it

Classroom instruction of mathematics has continued throughout the project. The children measured the perimeter of the acquired lot; a fence company was called in, and students arrived at the final dimensions of the to-be-fenced habitat by subtracting from the total lot dimension the footage from the street required by city building codes.

Height of the fence became a study for the classroom as students related different heights for different purposes (e.g. six feet to keep out people, four or five feet to keep out dogs and other animals). Size of the fence wire was considered and size of the holes in the fence webbing were placed in context with the cost of the fence and the degree of sturdiness required.

The habitat's landscaping, especially the selection of trees in the desert environment, integrated easily with the teaching of mathematics. When students found it difficult to relate tree heights on paper to actual tree heights, they went outdoors and did actual measurements. They also took into consideration the direction of the sun's rays at various times of the day.

Money was an issue in the construction of the habitat. While the school put $500 toward the project, $5,000 had been provided by philanthropic organizations. Under direction of one of the teachers, students went to a bank and opened an account for the habitat project. They organized a finance committee and devised procedures for keeping track of the money, providing receipts, and determining what amounts of money could be reasonably requested.

The vacant lot issue took the children into the area of mathematics, as well as history, sociology, literature and civics. The combined activities of this project constitute a curriculum in real-life contextual teaching.

The sociological aspects of this project are on-going. The children, parents, and neighbors have organized themselves to identify and address other community problems and issues in the hope that, over time, they can change the texture of the community.

Conclusion

Before the educational community adopts situated cognition as a guiding epistemology, it would be wise to discuss criteria for where and how to situate or anchor it. The following three recommendations are adapted from *The politics of mathematics education* [Mellin-Olsen, 1987]:

1. Classroom experiences are selected both with regard to the individual history of the student and the history of the culture (social, racial, economic) from which the student comes. This selection is negotiated between teacher and the learner.
2. Learning a skill occurs in the context of a wider project of interest to the learner.
3. Learning occurs within the context of cooperation. The gains of the individual feed the gains of the group.

Additional criteria are presented in Weissglass [in preparation]:

1. The teacher plays a role as a leader, facilitator, and colleague rather than an authority figure or importer of knowledge.
2. There is a complete respect for students' thinking and feelings.
3. Students see knowledge of a discipline (e.g., mathematics, history, biology, or literature) as part of a complex web of values and activities that affect the environment and society.
4. The teacher does not blame the student for inadequate knowledge, but rather recognizes that difficulties in learning are a result of past experiences of educational failure, distressing experiences such as ridicule or criticism that have disempowered the learner, lack of experience in a situated environment, or a lack of support in the mostly middle-class Anglo environment of a school.

In summary, the teaching of mathematics in the context of real-life situations avoids giving students the message that mathematics does not have to be concerned about the world and that mathematicians can create mathematics without being concerned about whether or how it is used. Contextual teaching and cognitive apprenticeships situated in a student's real world lend substance to the premise behind public education: Education—even mathematics—is for everyone.

Notes

[1] *Situated cognition and the culture of learning* [Brown, Collins, & Duguid, 1989]. *Situated cognition* describes a mathematics investigation for college students, conducted by Alan Schoenfeld [1985], and a math lesson taught to fourth graders by Magdalene Lampert [1986], stating that these examples of mathematics teaching elucidate how some of the characteristics of learning we discuss here can be honored in the classroom.

[2] *Anchored instruction and its relationship to situated cognition* [Cognition and Technology Group at Vanderbilt, 1990]. The authors of *Anchored instruction* describe two projects developed by their group, one in a language arts/social studies context and another in a mathematical problem-solving context. From these examples, readers can determine how their understanding of the theory of situated cognition compares with the authors'.

References

Amabile, T.M. [1983] *The social psychology of creativity*. New York: Springer-Verlag

Brown, J.S., Collins, A., & Duguid, P. [Dec., 1988] *Situated cognition and the culture of learning*. Institute for Research on Learning Report, IRL 88-0008, Palo Alto, CA

Brown, J.S., Collins, A., & Duguid, P. [1989] Situated cognition and the culture of learning. *Educational Researcher*, 18 (1), 32-41

Cognition and Technology Group at Vanderbilt [1990] Anchored instruction and its relationship to situated cognition. *Educational Researcher*, 19(6), 2-10

Collins, A., Brown, J.S., & Newman, S.E. [1989] Cognitive apprenticeship: Teaching the craft of reading, writing and mathematics. In L.B. Resnick (Ed.), *Knowing, learning and instruction: essays in honor of Robert Glaser*. Hillsdale, NJ: Erlbaum

D'Ambrosio, U. [1983] Successes and failures of mathematics curricula in the past two decades: a developing society viewpoint in a holistic framework. In M. Zweng, T. Green, J. Kilpatrick, H. Pillak, M. Suydam (Eds.), *Proceedings of the Fourth International Congress of Mathematical Education*. Boston: Birkhauser

Frankenstein, M. [1989] *Relearning mathematics: a different third R—radical maths*. London: Free Association Books (distributed in U.S. by Columbia University Press)

Gazzaniza, M. [1988] *Mind matters: how the mind and brain interact to create our conscious lives*. Boston: Houghton Mifflin

Guilford, J.P. [1967] *The nature of human intelligence*. New York: McGraw-Hill

Guilford, J.P. [1971] *The analysis of intelligence*. New York: McGraw-Hill

Heckman, P.E. [1990]. *Altering patterns of success for at-risk children*. Tucson, AZ: College of Education, University of Arizona.

Johnson-Laird, P.N. [1988] Freedom and constraint in creativity. In R.J. Sternberg (Ed.), *The nature of creativity: contemporary psychological perspectives* (pp. 202-219). New York: Cambridge University Press

Lampert, M. [1986] Knowing, doing, and teaching multiplication. *Cognition and Instruction*, 3(4), 305-342

Lave, J. [1988] *Cognition in practice: mind, mathematics and culture in everyday life*. New York: Cambridge University Press

May, R. [1975] *The courage to create*. New York: W.W. Norton

Mellin-Olsen, S. [1987] *The politics of mathematics education*. Dordrecht: Reidel

Perkins, D N [1988] The possibility of invention In R J Sternberg (Ed.), *The nature of creativity: contemporary psychological perspectives* (pp 202-219). New York: Cambridge University Press
Rogoff, B., & Lave, J. (Eds.) (1984) *Everyday cognition: its development in social contexts.* Cambridge, MA: Harvard University Press
Rucker, R [1987] *Mind tools: the five levels of mathematical reality* Boston: Houghton Mifflin
Schoenfeld, A.H [1985] *Mathematical problem solving* Orlando, FL; Academic Press
Stanic, G M A [1987] Mathematics education in the United States at the beginning of the twentieth century In T S Popkewitz (Ed), *The formation of school subjects: the struggle for creating an American institution* (pp 145-171) New York: Falmer Press
Taylor, C.W [1988] Various approaches to and definitions of creativity In R J Sternberg (Ed.), *The nature of creativity: contemporary psychological perspectives* (pp 202-219) New York: Cambridge University Press
Wallace, D B., & Gruber, H E. (1989) *Creative people at work: twelve cognitive case studies* New York: Oxford University Press
Weissglass, J. [1991] Teachers have feelings: What can we do about it? *Journal of Staff Development,* 12(1), pp 28-33)
Weissglass, J [1992] Changing the culture of mathematics instruction *Journal of Mathematical Behavior,* 11 (pp 195-203)
Weissglass, J. [in preparation] Humanizing mathematics instruction: Criteria and challenges

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It was the distinguished archaeologist, Gordon Childe, who gave to one of his influential books the striking title *Man makes himself* This embodies the concept I am tangling with, and trying to unravel in terms of the role of education Human beings, Childe argues, make themselves—have made themselves through their growing understanding of, control and so transformation of nature; people's actions on nature being the product of socialised labour on the one hand (the determining form of activity), and their growing knowledge, or what slowly came to be science, on the other The crucial aspect of human activity in this context is that it increasingly takes place in a humanised world; a world in which people's knowledge, and abilities, as they develop, are crystallised, as it were, in a transformed external world, existing independently of them and so forming for him or her a humanised environment The modern computer is a good example, but, as Childe showed, the earlier and crudest tools in their time played the same formative role So, through new forms of activity, the senses themselves are refined, new skills and new abilities are developed. [...] Through language, culture and knowledge are, as it were, crystallised and may be handed on, or made available to each new generation "Language, mathematics, or other theoretical ways of structuring knowledge," writes Jerome Bruner, "capitalise upon innate capacities But these skills, although they depend on innate capacities, originate *outside* the organism and memorialise generations of encounters by members of the culture "

Brian Simon
