COMMENTARY

DELTA-K IN THE 1990s

Learning Mathematics with Meaning

Elaine Simmt

The 1990s in Alberta have been described as "the restructuring nineties" because of the significant changes to education that were brought about by the Klein government over that period: New school ward boundaries, changes in the levying of school taxes and distribution of the funds, and the introduction of charter schools are some of the most significant changes to education since Alberta became a province (Ell, 2002). In North American research, constructivism emerged as the most common theory of learning in mathematics education (see *Journal for Research in Mathematics Education*, V. 25), and around the world educators called for mathematics education for all (e.g., UNESCO, 1984). Throughout the decade, *delta-K* offered readers a range of topics discussed by various people involved in mathematics education, from classroom and university teachers to educational researchers and policymakers. Article themes ranged from mathematics problems and solution strategies to teaching methods, learner characteristics, curriculum reform, and the use of technology.

Although in this paper I integrate ten papers selected from the 1990s *delta-K* issues, I spent some time leafing through all of the issues published

Selected Writings from the Journal of the Mathematics Council of the Alberta Teachers' Association, pages 323–334

in that decade. I found that scan uplifting because it suggested that the journal's editors were less interested in what mathematics wasn't doing or unable to do and more interested in possibilities for mathematics teaching and learning. For instance, we do not find reports of students' performance on provincial achievement tests, diploma examinations, or international comparisons of students, although such reports were beginning to attract more media attention. The collection of papers selected for this issue reflect a journal that in the 1990s was focused on enhancing the teaching and learning of mathematics. Those papers were written for teachers and discussed teaching mathematics, learning mathematics, teaching teachers of mathematics, curriculum reform, and innovations brought about by advances in research into learning and the rapid growth of information communication technology (ICT). These themes reflect the spirit of a decade when constructivism, the National Council of Teachers of Mathematics *Curriculum and Evaluation Standards for School Mathematics,* international comparisons of student achievement, and rapid advances in ICT were the dominant conversations in the mathematics education community in North America. Another theme was teaching all learners meaningful and relevant mathematics.

In this chapter I will discuss the papers selected for this monograph based on five themes: (1) attending to the learner, (2) mathematics lessons for diverse learners, (3) integrating ITC into mathematics education (4) the teacher as a learner, and (5) curriculum reform.

ATTENDING TO THE LEARNER

The 1990s refocused educators' attention on the needs of the learner in the mathematics classroom. The reasons for this are multifaceted and complex but three in particular stand out: (1) the neo-Piagetian movement and constructivist learning theory (see Steffe & Kieren, 1994), (2) international comparisons of learners' achievement in mathematics (e.g., Institute of Education Sciences National Centre for Education Statistics, TIMSS, 2012), and (3) a movement that called for mathematics for all (UNESCO, 1984). As I reflect on the articles, I see them in relation to themes that were present in the international discourse in mathematics education: learner diversity; reshaping mathematics lessons framed with a theory of constructivist learners; using technology to teach and learn mathematics; teachers teaching mathematics; and reforming mathematics curriculum for all.

In the late1980s and early 1990s, the neo-Piagetian movement, known as constructivism, had grown to dominate as a theoretical frame for mathematics education researchers in the United States and Canada. Constructivism provided a much more powerful theory of mathematics learning than behaviourism, and it focused researchers' attention on children's mathematics rather than on modes of transmitting and transforming pre-given (adult) mathematics into bite-sized pieces for children to learn:

> It is perhaps this [the constructivist researcher's] phenomenological consideration of children's mathematics arising in inter-action with a teacher in very particular spaces of mathematical possibilities that has led to whatever influence constructivist research has had on reformers in mathematics curriculum and teaching. Observing and listening to the mathematical activities of students is a powerful source and guide for teaching, for curriculum, and for ways in which growth in student understanding could be evaluated. (Steffe & Kieren, 1994, p. 723)

Constructivism had become so dominant in research that in the 1990s it began to enter teacher education (both preservice and inservice) and subsequently influenced teaching in K–12 schools. Curriculum developers and mathematics teachers rethought mathematics education from the perspective of the learner as a meaning-maker who constructs mathematical understanding on the basis of his or her history, experiences, and interaction in the world.

It is not surprising, then, that we find authors in the 1990s *delta-K* papers who wrote about the nature of the learner that teachers encounter in the classroom. Hubber (1990), in "It's All Greek to Me: Math Anxiety," writes about a phenomenon that Sheila Tobias (1995) identified in some of her university students. Tobias wondered how learners who were very competent in some areas could encounter such difficulty with mathematics. In Hubber's reflections on math anxiety, she attributes much of it to the teaching methods used in school, methods that suppress meaning for rote learning. She contends that such methods result in students struggling to make meaning of solutions to mathematics problems, which in turns leads to a perception that mathematics is an "incomprehensible mystery." Hubber also wonders about the impact on students when they are unable to make sense of mathematics in their day-to-day living or in communications that they encounter that are composed of difficult mathematical language and symbolism. In her paper she offers some advice to teachers for creating better environments for their learners: incorporate mathematics into the life of learners, reduce competition, encourage creative problem solving, pay attention to reading demands, systematically instruct problem solving, and most important, dispel the myth that mathematics involves a secret code that only the elite can know.

Mathematics classes have a great deal of diversity, some of which may be attributed to schooling itself (say, confidence and anxiety in mathematics or background knowledge of the content) but diversity comes in many other forms that a learner brings to the classroom: gender, ethnicity, cultural practices, language, and activity preferences are just a few examples. In the article by Liedtke (1999), "Multiculturalism and Equities Issues: Selected

Experiences and Reflections," we read a thoughtful reflection by a pedagogue who wonders about the impact his biases have on students in his mathematics classes. Although this paper was written in 1996, it points to issues that continue to be relevant today. Indeed, one of the great challenges of preservice teacher education in 2013 is to educate teachers and prepare them for the diversity their learners will bring to the classroom.

The Hubber and Leidtke articles reflect a concern for inclusive mathematics education. In 1984, UNESCO published the reports of the Mathematics for All working group of ICME 5. Calling for "mathematics for all" has meant different things in different parts of the world. In developing nations, the call was to provide mathematics as part of universal basic education, which, at that time, was not a basic right of every child in a number of countries. In nations like Canada, and in Alberta where basic education is a right, it was a call for mathematics education to be appropriate for meeting the needs of children and youth—gifted learners and students with cognitive disabilities; learners who favour abstraction, formalism and symbolism and learners who favour the concrete, informal and everyday language; city dwellers and country dwellers; First Nations and newcomers to Canada; English speakers and English learners. Leidtke points out that teachers need to be aware not only of the diversity of the learners in classrooms but also of strategies and approaches for mathematics lessons that cause no harm to students and that make learning mathematics meaningful and relevant. For such learners, Leidtke notes how teachers must be attentive to their turns of phrase, the examples they use, technical language, and classroom activities.

As our understanding of diversity grows, we start to see that the great potential of diversity: One student's way of seeing something is not a drawback so much as an opportunity for the student and others to make meaning of mathematics. There is a message in Hubber's and Leidtke's papers for today's mathematics teachers; that is, by reflecting on our own understandings, biases, and patterns of behaviour we can create opportunities for more inclusive lessons so that our classrooms are sites of mathematics for all.

ATTENTION ON MATHEMATICS LESSONS FOR DIVERSE LEARNERS

With constructivism and the calls for mathematics for all learners in the 1990s, mathematics teachers were encouraged to think differently about their classroom instruction. Creating meaningful mathematics lessons was a challenge for teachers who had previously placed a great deal of emphasis on direct instruction that involved definitions, worked examples, and guided practice followed by independent practice. Kieren (1995) labels such teacher-centric instruction as TIRE (Tell, Interrogate, Respond, and Evaluate) and suggests that such modes of instruction do not help learners make meaning. To make meaning, rather than preparing lecture notes and practice questions, teachers should prepare lessons in which learners experience mathematics in the form of patterns and relations, change and constancy, shape and space, number and measure (see Sanders & Vivone-Vernon, this volume). Loewen (1990), in "Implementing Manipulatives in Mathematics Teaching," shows how to create alternative lessons: that is, how teachers could move from telling to selecting and setting up experiences in which learners manipulate materials from which they are expected to construct their mathematics. Though the notion of using manipulatives to teach mathematics has become part of the teacher's repertoire today, in 1990 it was quite novel, so much so that Loewen begins his article by defining a manipulative. A manipulative "must embody or physically represent specific mathematical concepts" (1990, p. 4). He suggests that there are three purposes for manipulatives: (1) introducing concepts through experimentation with manipulatives, (2) applying mathematical principles by using manipulatives, and (3) integrating manipulatives of different complexity throughout a lesson to help students achieve multiple layers of understanding. A preservice teacher reading Loewen's paper today will likely find it just as informative as teachers did in the 1990s.

Working with manipulatives is one form of problem solving. Problem solving continued to be stressed in mathematics education into the 1990s but came to include a discussion of what constituted a problem and why we solve problems. Preceding this discussion was a common view in the United States and Canada that word problems and applications were content for problem solving after students developed concepts and skills. But closer examination of problem solving and international comparisons of student achievement triggered comparative classroom studies that illustrated how differently problem solving could be used in instruction. Stevenson and Stigler (1992) and Sawada and Stevenson studied Japanese mathematics lessons. In Sawada's (1996) article, "Mathematics as Problem Solving—a Japanese Way," we see a classroom-based example of a typical Japanese lesson in which a class of learners work with a teacher on a problem set in a realistic context. With the introduction to Japanese lessons, a model of extended class time spent on a single problem to develop mathematics concepts became another possibility for Alberta teachers to modify their instruction to create more learner-centred lessons that encourage meaning making. The Japanese case illustrated how a teacher could work with learners on a complex problem, interpret it as a set of smaller problems, develop multiple solution strategies with the students, use manipulative aids, and focus on interpreting problems, not simply practising problems similar to ones previously demonstrated by the teacher. Mathematics teaching in Japanese schools continues to be of interest to Canadian teachers, and recent interest in lesson study has become a form of professional development.

INTEGRATING ICT INTO MATHEMATICS EDUCATION

One of the most striking possibilities for mathematics classrooms in the 1990s was the introduction of information and communication technology (ICT) in the form of personal computers (microcomputers) and graphing calculators (in essence, a handheld computer decades before the iPad). Interestingly, of the 17 issues of *delta-K* from 1990–1999 that I scanned, 11 had articles about using computers and (after 1995) graphing calculators for doing mathematics. Most of the articles provided activities that used computers or graphing calculators and provided illustrations of how computers could be used for mathematical problem solving in a number of different areas. The decade was an interesting time with respect to ICT since there were calls for integrating computers and calculators into the teaching and learning of mathematics (see, for example, the *NCTM Standards* and the *Common Curriculum Framework for K–12 Mathematics: Western Canada Protocol for Collaboration in Basic Education (WCP)*) and educators were providing illustrations of how computers could be integrated in mathematics. However, there was a stumbling block—computers were often housed in business labs, so mathematics students did not have a great deal of access to them.

Given that the 1990s was a beginning point in the integration of ICT in school mathematics, it is not surprising that the technologically based mathematics lessons presented in *delta-K* from that time do not reflect contemporary conversations as much as the articles on the use of manipulatives or the nature of the learner. The two articles selected for this volume provide reflections on the anticipated use of computers in mathematics, but neither mentions the role of the graphing calculator in high school mathematics. Instead, authors discuss the use of computers in the mathematics classroom. In "Learning about Computers and Mathematics: A Student Perspective," Findlay asks himself, "How can I integrate this technology into my profession so that it can aid in my teaching endeavours?" (1993, p. 8). He begins with a thought experiment, asking who among his students might benefit and what kind of resources would be of value. He saw an opportunity for special-needs learners, both those who are challenged by mathematics as it is currently taught and those who need to be challenged. But his review of the research uncovered impediments to using technology in the ways he anticipated, some of which continue to be expressed today; for example, computers rapidly change and obsolescence is an ongoing concern; computer technology is expensive; and computers pose a threat of the unknown (pp. 10–11). Dickie (1996), in "Computers in

Classrooms, Essential Learning Too or Program Disaster?," highlights the threat of the unknown. The article, a reprint from *Home & School* magazine, expresses the author's deep concern with the integration of computers in the mathematics classroom. She worries that fill-in-the-blank and drill-and-rote programs are far too common and they stifle creative learning, that the ability to work from the concrete to the abstract will be lost, that children are already bombarded with visual information from television, and that children who receive computers too early will grow up without a critical perspective on them.

Even though many *delta-K* articles in the 1990s focused on computers in mathematics classes (though only Dickie mentions the concerns just listed), it was calculators and graphing calculators that made their way onto students' desks. Indeed, Smith (in this volume) points to the graphing calculator as one of the most significant changes in high school mathematics.

THE TEACHER AS A LEARNER

The introduction of constructivism as a theory of learning, new manipulative materials, teaching aids, computers, and calculators affected teachers' professional development because they had to rethink their instructional practices. Given that constructing one's own knowledge is not restricted to students of mathematics and that the same learning theory applies to all of us in all domains of knowing, teachers had some learning to do. It is not surprising that in the articles selected for this decade we find one that illustrates teacher meaning making and another that points to the need for teachers to transform their mathematics knowing into pedagogical content knowledge so that they can create educative experiences for their learners. In Hauk and Quinn's (1992) article, "Moving Out of the Comfort Zone," we read about a teacher's experience of trying to transform his mathematics instruction. We learn how he modified his instruction to include manipulatives, small-group discussions, and student journalling to create a classroom where students would have "opportunities to be involved responsibly and actively in their own learning" and where they could have "concrete experiences in personally meaningful problem solving contexts" (p. 4). This modification of practice was principled and deliberate, and based on educational research. But it was not easy. In this case study, teachers can learn from an innovator brave enough to talk about the difficulties and the rewards he encountered when making change. On one hand, teachers reading the article today may be surprised to learn how novel working in small groups was for the learners and how exciting they found it; on the other, teachers will surely empathise with the challenge Quinn faced trying to fit the manipulative-based activities, small-group work, and journalling into the time allocated for math class. Another interesting aspect about this article is its contemporary tone. It is much more common today than it was when this article was published to use student voices (qualitative research) to provide insights into what students value, what they believed impeded their learning, and what meaning they made of the mathematics they were learning.

The Hauk and Quinn paper is the kind of work called for by Onslow and Geddis (1995) in "Building a Professional Memory: Articulating Knowledge about Teaching Mathematics." They argue that "effective mathematics teaching demands that subject matter be transformed to allow it to be learned meaningfully by novices" (p. 21) and that case studies are needed for that learning. They point to the need for resources for teaching pedagogical content knowledge (Shulman, 1986) to new teachers. Since the 1990s, a large community of scholars interested in what mathematics teachers need to know and how can that be taught (e.g., Lowenberg Ball, Thames, & Phelps, 2008) has arisen. Today, it is much more common to see strategies described by Hauk and Quinn used in the mathematics classroom, though there continues to be a need for case studies that illustrate pedagogical content knowledge for teaching mathematics, especially given the demand for mathematics teaching that has emerged out of curriculum reform over the last twenty years.

CURRICULUM REFORM

Whereas constructivism and ICT informed the shape of mathematics lessons in the 1990s, the National Council of Teacher of Mathematics' *Curriculum and Evaluation Standards for School Mathematics* in 1989 (commonly known as the *NCTM Standards*)[1] affected mathematics education more generally and informed curriculum reform in the United States and Canada. The *NCTM Standards* offered a vision of mathematics education based on research and expert opinion of the content, methods, and nature of mathematics, and argued that children and youth needed an appreciation of mathematics as well as mathematical skills and content for full participation in contemporary society. In "Enhancing Mathematics Teaching in the Context of the Curriculum and Professional Standards of the NCTM," Puhlmann (1995) introduces Alberta teachers to the *NCTM Standards*. The "Curriculum *Standards* for school mathematics are value judgements based on a broad coherent vision of schooling derived from several factors: societal goals, student goals, research on teaching and learning, and professional experience" (p. 21). With this statement we learn that the *NCTM Standards* are as much a political document as they are an educational resource. The document is divided into sections based on grade levels. Each section delineates the mathematics content that students should learn and a set of core standards across all grade levels: problem solving, communication, reasoning, and mathematical connections. Further, in the *NCTM Standards*, it is asserted that technology should be integrated throughout all school mathematics. A close read of Puhlmann's article against current curriculum and instruction locally will lead the reader of this volume to see how the *NCTM Standards* have permeated the consciousness of the mathematics education community in Alberta and Canada in the decades that followed their publication. Although the *NCTM Standards* documents have been revised over the past twenty years and are now known as the *Principals and Standards for School Mathematics*, they continue to influence mathematics education across the world.

The influence of the NCTM Standards is most evident in the curriculum reform of the 1990s in Alberta in mathematics education. In "The Western Canadian Protocol (WCP): The Common Curriculum Framework (K–12 Mathematics) (CCF)," Sanders and Vivone-Vernon (1998) elaborate on the WCP and the process by which the new program of studies for Alberta came about. That curriculum led to one of the most significant reforms of high school mathematics education in Alberta in decades. The authors discuss how the ministers of education from the four western Canadian provinces and two territories agreed to develop a common curriculum of general and specific outcomes for mathematics. Although the intention was for the six signatories to the protocol to implement the new framework for mathematics education K–12 in their jurisdictions, only the K–9 curriculum was implemented by all. In the end, only a couple of jurisdictions developed high school programs of studies from the CCF. Alberta, as the lead province of this initiative, did use the framework in developing pure and applied math courses, which replaced Math 10-20-30 and Math 13-23-33.

The CCF included four strands within which all content outcomes were organized: number, shape and space, patterns and relations, and statistics and probability. It also referenced seven mathematical processes outcomes that were intended to permeate all strands: (1) communicate mathematically, (2) connect mathematical ideas, (3) use estimation and mental mathematics, (4) relate and apply new knowledge through problem solving, (5) reason and justify thinking, (6) select and use appropriate technology, and (7) use visualization in mathematics (p. 26). Not surprisingly, the WCP framework, a product work of the 1990s, was compatible with the other movements we have read about in this paper. For example, the use of manipulatives and ICT was promoted as valuable for problem solving, reasoning, visualization and making connections. Even today teachers will point to the *CCF for K–12 Mathematics* as a significant curriculum reform that has affected mathematics in Alberta over the past two decades.

THE RESTRUCTURING 1990s

Although today's mathematics classrooms may appear on the surface similar to those of the 1990s, there are contexts and practices we take for granted today that were just being introduced twenty years ago. Constructivism as a theory of learning continues to inform mathematics teaching; however, the constructivism of today has been elaborated to include the role of the social. Manipulatives, multiple representations, problem posing, and problem solving all continue to be used in Alberta classrooms as teachers create opportunities for students to engage in meaningful and relevant mathematics. Technology introduced to the 1990s mathematics classrooms, especially graphing calculators, has changed mathematics in high schools. Children and youth of the 2010s don't need to purchase expensive software packages to access mathematics lessons, practice exercises, problem-solving activities, simulations, or games. Such things are all available on the Internet and come in a variety of forms that the teachers of the 1990s couldn't even imagine. In large cities and smaller towns throughout the province, a booming economy has continued to make Alberta a province of newcomers, and the ethnocultural makeup of our classrooms continues to diversify. As well, policies to integrate all students in the classroom have resulted in classes in which the mathematics instruction is differentiated through the use of small groups, manipulatives, and variable-entry problem solving. *Delta-K* in the 1990s published plenty of articles that are as relevant today as they were 20 years ago. The 1990s was a pivotal decade for mathematics education. Of all of the innovations and trends of the 1990s, there is no doubt that constructivism, the call for mathematics for all, the *NCTM Standards,* and graphing calculators were the most significant factors in the restructuring of mathematics education in Alberta.

NOTE

1. Dr. Thomas Kieren, currently Professor Emeritus of the University of Alberta was the only Canadian consultant on the working group that created the document.

Elaine Simmt is a professor of secondary mathematics education at the University of Alberta. She completed her doctoral studies in the 1990s under the direction of Tom Kieren. A former mathematics and physical sciences teacher, Elaine has embraced the call for meaningful mathematics for all in the preservice and inservice teacher education in which she is involved.

REFERENCES

Damerow, P., Dunkley, M., Nebres, F., & Werry, W. (Eds.). (1985). *Mathematics for All: Problems of cultural selectivity and unequal distribution of mathematical education and future perspectives on mathematics teaching for the majority.* Report and papers presented in theme group 1, at the 5th International Congress on Mathematical Education. Paris, France: Division of Science Technical and Environmental Education UNESCO.

Dickie, A. (1996). Computers in classrooms: essential learning tool... or program for disaster? *Delta-K 33*(2), 18–20.

Ell, J. (2002). History of education. Alberta Teachers Association: Edmonton, Alberta. Retrieved from www.teachers.ab.ca/Teaching%20in%20Alberta/History%20of%20Public%20Education/Pages/Index.aspx.

Findlay, C. (1993). Learning about computers and mathematics: a student perspective. *Delta-K, 31*(3), 8–11.

Hauk, M., & Quinn, B. (1992). Moving out of the comfort zone. *Delta-K, 30*(2), 4–9.

Hubber, D. (1990). It's all Greek to me: math anxiety. *Delta-K, 28*(2), 13–15.

Institute of Education Sciences National Center for Education Statistics. (n.d). *Trends in international mathematics and science study (TIMSS): Overview.* Electronic Retrieval September 23, 2012 from http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2013009rev

Kieren, T. (1995). *Teaching in the middle.* Paper presented at the Gage Educational Conference, Queens University, Kingston, ON.

Liedtke, W. (1999). Multiculturalism and equities issues: selected experiences and reflections. *Delta-K, 36*(1), 63–66.

Loewen, C. (1990). Implementing manipulatives in mathematics teaching. *Delta-K, 28*(1), 4–11.

Lowenberg Ball, D., Thames, M., & Phelps, G. (2008). Content knowledge for teaching: What makes it so special? *Journal of Teacher Education 59*(5), 389–407.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (1994). *Journal for Research in Mathematics Education,* vol. 25. Reston, VA: Author.

Onslow, B., & Geddis, A. (1995). Building a professional memory: articulating knowledge about teaching mathematics. *Delta-K, 32*(3), 21–23.

Puhlmann, K. (1995). 33(1) Enhancing mathematics teaching in the context of the curriculum and professional standards of the NCTM. *Delta-K, 33*(1), 21–27.

Sanders, H., & Vivone-Vernon, G. (1998). Western Canadian Protocol: The common curriculum framework (K–12 mathematics). *Delta-K, 35*(1), 25–28.

Sawada, D. (1996). Mathematics as problem solving—A Japanese way. *Delta-K, 33*(2), 44–47.

Shulman, L. (1986). Those who understand: Knowledge Growth in Teaching. *Educational Researcher, 15*(2), 4–14.

Steffe, L. P., & Kieren, T. (1994). Radical constructivism and mathematics education. *Journal for Research in Mathematics Education, 25,* 711–733.

Stevenson, H., & Stigler, J. (1992). *The learning gap: why our schools are failing and what we can learn from Japanese and Chinese education.* New York, NY: Summit.

Tobias, S. (1995). *Overcoming math anxiety.* New York, NY: W.W. Norton.
Von Glasersfeld, E. (1983). Learning as a constructive activity. In J. C. Bergeron & N. Herscovics (Eds.), *Proceedings of the Fifth Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 41–69). Montreal, QC: University of Montreal.