The Development of Mathematics Education as an Academic Field

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I trace the development of mathematics education as a field of study and practice distinct from mathematics. After 1908, but especially after 1969, ICMI has been both a mirror of that development and a stimulus for new directions. As the community of people who identify themselves as mathematics educators has grown, it has increased in diversity, in part because of the growing multi-disciplinarity of the field. There is also diversity across countries in the way mathematics education is institutionalized and how it is related to mathematics. How has ICMI dealt with these issues?

The International Commission on Mathematical Instruction (ICMI) was established as a commission of the International Mathematical Union (IMU) at the 1952 meeting of the IMU general assembly in Rome. Both organizations were reincarnations: The ICMI was the successor to the Commission internationale de l’enseignement mathématique (CIEM, anglicized as the International Commission on the Teaching of Mathematics), which had been organized at the 1908 international congress in Rome, functioned between congresses until the First World War, was revived in 1928, and then was dissolved in 1939 (although its secretary general, Henri Fehr, claimed it was technically still in existence in 1952, when it became officially attached to the IMU; Lehto, 1998, p. 316). The IMU had been founded in 1920, was suspended in 1932, and then was reconstituted in 1952 (see Figure 1). Before 1952, “the Commission was connected not with the IMU, but with the International Congresses. Each Congress gave it a mandate for the period between two Congresses, i.e., for four years, and appointed a Committee to coordinate its activities” (p. 65). In other words, the subordinate (ICMI) antedated the superordinate (IMU).
The idea for an international commission on mathematics education had first been put forward by David Eugene Smith (1905) in an article in *L’Enseignement Mathématique*. He was one of five respondents to a request expressed at the Third International Congress of Mathematicians in Heidelberg the preceding year for opinions regarding needed reforms in the teaching of mathematics in higher education. Addressing the question of how the teaching of pure mathematics might be improved, Smith argued for the creation of a commission to be named by an international congress to study the problem. At the Fourth International Congress in Rome in April 1908, he made a formal proposal that a commission be established to conduct “a comparative study on the methods and plans of teaching mathematics at secondary schools” (quoted in Lehto, 1998, p. 13). The scope of the study was eventually expanded to all types of schools, including primary schools, vocational schools, and universities.

The proposal for a commission was adopted by the Congress, and Felix Klein was appointed the founding president of the CIEM, serving until 1920 and beginning a tradition in which presidents of the commission were research mathematicians with an interest in mathematics education. The one exception was David Eugene Smith, president from the CIEM’s revival in 1928 until 1932. Although a distinguished historian of mathematics and holder of a chair in mathematics education at Teachers College, Columbia University, Smith had studied mathematics only as an undergraduate, obtaining his doctorate in art history. He had studied to become a lawyer before beginning his teaching career (Swetz, 1987, pp. 299–304; Travers, 1983, pp. 381–382). He is credited (Jones & Coxford, 1970, p. 42)
with being one of the two principal founders of mathematics education as an academic field in the United States (the other was Jacob William Albert Young of the University of Chicago).

Both 1908 and 1952 marked periods when the school mathematics curriculum was being faced with new demands, countries were attempting or about to attempt efforts to reform that curriculum, and an international exchange of views seemed appropriate (Howson, 1984). Before both periods, the gap between the mathematics taught in schools and mathematics as a scientific discipline had widened, and the views of mathematicians on how to close the gap seemed to set the terms of debate (Wheeler, 1989; Wojciechowska, 1989). In each case, activities undertaken by the ICMI were to be decisive, not only in addressing issues of reform but also in shaping the field of mathematics education.

In what follows, I discuss the development of mathematics as an academic field over the past century or so, taking the ICMI as both a barometer of that development and a spur to greater change.

**Mathematics Education Enters the Academy**

Although mathematics itself as an academic subject can trace its lineage back at least to the *quadrivium* of Plato’s academy and even to the Sumerian and Babylonian scribal schools (Davis & Hersh, 1981; Høyrup, 1994), the subject of mathematics education is both more recently and less firmly established in the academy. Throughout the 19th century, the modern scientific disciplines were emerging in higher education, beginning with the reforms of the Protestant universities of Prussia (Kilpatrick, 1992, p. 4). During the second half of the 19th century, mathematics succeeded in becoming an autonomous discipline in German universities although not yet in the technical colleges (Schubring, 1989, p. 175).

As teacher education began to move into institutions of higher education in various countries during the last decades of the 19th century and early decades of the 20th, education, too, began to be
treated as a separate academic field. The first seminary for teachers had been established at Halle in 1704 and the first chair of education there in 1779 (Fleming, 1954), but as of 1910, there were only 13 staff members at German universities with teaching responsibilities in education (Husén, 1983). Other pioneering chairs in education were those established at the University of Iowa in 1873, at the University of Edinburgh in 1876, and at the University of Uppsala in 1910. At about the same time, school mathematics was gradually becoming an object of scholarly study and not just a field of practice (Jahnke, 1986; Schubring, 1988).

The Reform Program of Felix Klein

By the end of the 19th century, secondary teachers of mathematics were being prepared in universities, pedagogical seminars, and normal schools, but their preparation typically consisted almost entirely of lectures in mathematics with little or no instruction in teaching. Felix Klein, by devising and conducting courses on teaching methods at several universities in Germany, took the lead in addressing that problem. He wanted to establish applied mathematics in the university as a means of reorienting pure mathematics there, with his ultimate goal to make mathematics a foundational discipline in the universities and technical colleges. To achieve that goal, he initiated a reform of secondary mathematics education so that it would include the calculus, thereby raising the level of mathematics in secondary and higher education (Schubring, 1989). In the process, Klein

began . . . to interest himself in the improvement of teacher education. By so doing, he hoped to reverse the trend toward one-sidedly formal, abstract approaches to mathematics instruction by promoting practical instruction and the development of spatial intuition. (p. 184)

He started to address issues that concerned secondary mathematics teachers and hit upon “the key phrase that would hereinafter serve as the slogan for his reform program” (p. 188): functional reasoning.
Klein’s strategy for change “was clearly to forge an extraordinarily broad and powerful alliance of teachers, scientists and engineers that would advocate a series of reforms for mathematics and science curricula” (Schubring, 1989, p. 188). He enlisted the international commission in his efforts, “and the organization began to function as an agent for curricular change” (p. 189). He saw that if secondary and higher education curricula were to be brought closer, a new approach to teacher education would be needed, and he continued to push for reforms in teacher education. During his lifetime, Klein published over 30 books and articles on mathematics education (Rowe, 1983).

Meanwhile, primary school teachers were being prepared in institutions at the secondary school level, whether those institutions were termed colleges, institutes, seminaries, or normal schools (Kilpatrick, 1992, p. 4). In general, we tend to know less about the mathematics taught and learned in those varied institutions than we do about the preparation of secondary school mathematics teachers. Although prospective primary school teachers were likely to receive some practice-teaching experience and attention to teaching methods as part of their preparation, most of it was apparently devoted to studying the primary school subjects (Butts, 1947, p. 424).

Professional Education for Teachers

As countries began to establish national school systems from the end of the 19th century through the beginning of the 20th, they began to require a larger supply of teachers with a professional education, and that need stimulated both the evolution of institutions at the secondary level into institutions of higher education and the establishment of academic units concerned with education within those evolving institutions. Those changes prompted the gradual development of mathematics education as a university subject. In the 1912 survey conducted in response to the mandate given the CIEM in Rome in 1908, four countries—Belgium, Germany, Great Britain, and the United States—reported that university lectures in mathematics education were being offered to supplement mathematics lectures (Schubring, 1988).
Throughout the 20th century, many of the special schools for training elementary or secondary teachers either became part of a university or attained university status for themselves, which has led to great differences across countries in the way teacher preparation is handled. By the 1930s in the United States, for example, most former public normal schools had become teachers colleges, and by the 1950s they had become departments, schools, or colleges of education in universities. Today, in some less economically developed countries, prospective teachers still receive only a short training course at the level of secondary education to prepare them to teach large classes of young children. In more economically developed countries, in contrast, most teachers are university graduates who began their teacher preparation after finishing secondary school. And between those extremes are many other arrangements.

Mathematics education as a practice has developed, therefore, within a variety of academic structures, whereas its major development as a field of study has been within universities. As practice and as field of study it is different from mathematics:

Mathematics education and mathematics, though obviously linked, are fundamentally different as domains of practice and scholarship. Their main historical intersection has been the induction and advanced mathematical preparation of mathematical researchers and scientists, a small but now growing fraction of the population served by school education, and this primarily at postsecondary levels. While most mathematicians teach, mathematics education treats teaching much more seriously as a professional practice, requiring dedicated training and certification. (Bass & Hodgson, 2004, p. 640)

To see some of the differences, it is useful to consider how mathematics and education are to be understood in the phrase mathematics education.


**What Is Mathematics?**

A major difference between mathematicians and mathematics educators lies in the way they look at mathematics. To the mathematician, it is clear: Mathematics is the body of knowledge and the academic discipline that studies such concepts as quantity, structure, space, and change. It has been defined as the science of quantity and space, the science of relations, the science that draws necessary conclusions, and the science of patterns. Regardless of the definition they prefer, mathematicians have few doubts as to what their subject is, whether they follow Courant and Robbins (1941) or Davis and Hersh (1981).

Mathematics educators are less sure. As Lynn Steen (1999) observes:

Mathematics educators cannot even agree on the nature of mathematics. Although mathematics is at the heart of mathematics education, it turns out that educators’ mathematics is not mathematicians’ mathematics. . . . To a mathematician, mathematics is singular—a Platonic paradigm in which there are simple, unquestionable criteria for distinguishing right from wrong and true from false. But to mathematics educators, mathematics is plural. Mathematics, among other things, offers a lens through which one can look at the world. In mathematics education the direction is reversed—one looks at mathematics through the lens of learners (and teachers). (pp. 236–237)

Mathematics educators see mathematics not simply as a body of knowledge or an academic discipline but also as a field of practice. Because they are concerned with how mathematics is learned, understood, and used as well as what it is, they take a comprehensive view. A mathematician might concede that, yes, applied mathematics is a branch of mathematics, but a mathematics educator looks beyond applications to ways in which people think about mathematics, how they use it in their occupations and daily lives, and how learners can be brought to connect the mathematics they see in school with the mathematics in the world around them.
A good example of the disparity in views is provided by ethnomathematics. To the mathematician, ethnomathematics is not mathematics at all. If anything, it is anthropology. What are the axioms or theorems of ethnomathematics? Martin Gardner (1998) reviewing books and videotapes reflecting efforts to reform U.S. school mathematics that he dubs “the new new math, whole math, fuzzy math, standards math, and rain forest math” (p. 9) defines ethnomathematics as “math as practiced by cultures other than Western, especially among primitive African tribes” (p. 9). He goes on to disparage attention to non-Western mathematics:

Knowing how pre-industrial cultures, both ancient and modern, handled mathematical concepts may be of historical interest, but one must keep in mind that mathematics, like science, is a cumulative process that advances steadily by uncovering truths that are everywhere the same. (p. 9)

To the mathematics educator, in contrast, ethnomathematics is a highly popular subject for discussion and research even if it is not a branch of academic mathematics. There have been lectures, sessions, and working groups at International Congresses of Mathematics Education on ethnomathematics ever since Ubiritan D’Ambrosio (1986) gave his memorable plenary address in 1984 at ICME-5 in Adelaide. The field has spawned newsletters, study groups, journals, doctoral dissertations, and books. International conferences on ethnomathematics have been held in Spain, Brazil, and New Zealand. Ethnomathematics may not be part of the mathematician’s mathematics, but it is an important part of school mathematics because teachers understand the value of taking into account the mathematical systems of the cultures from which students come or in which they are interested (Gerdes, 1966; Skovsmose, 2006).

What Is Education?

Mathematics education has a blurred identity in the university. Across countries and institutions, it is not located in any one place.
As universities took on the education of teachers of mathematics, mathematics education became a field that straddled the liberal arts and the professions. In some universities, the faculty members responsible for teacher education in mathematics tend to be in a mathematics department; in others, they tend to be in a department, school, or college of education. Either way, much of the education of mathematics teachers is seen as professional education.

A Profession?

A profession is ordinarily understood to be an occupation that requires extensive specialized study, and its practitioners are viewed as possessing a body of arcane knowledge. Although “there is no authoritative set of criteria by means of which we can distinguish professions from other occupations” (Lieberman, 1956, p. 1), it is possible to identify some generally accepted characteristics (Figure 2).

Education’s status as a profession suffers by comparison with that of established professions such as medicine, law, and engineering. In particular, teachers have little of the autonomy, independence, and power suggested by the characteristics listed in Figure 2. Teachers have relatively slight control over such matters as selecting their clients, determining their working conditions, and deciding who is allowed to practice their trade (Lieberman, 1956). As Lortie (1975) observed, “Teaching is only partly professionalized” (p. 23).
1. A unique, definite, and essential social service.
2. An emphasis upon intellectual techniques in performing its service.
3. A long period of specialized training.
4. A broad range of autonomy for both the individual practitioners and for the occupational group as a whole.
5. An acceptance by the practitioners of broad personal responsibility for judgments made and acts performed within the scope of professional autonomy.
6. An emphasis upon the service to be rendered, rather than the economic gain to the practitioners, as the basis for the organization and performance of the social service delegated to the occupational group.
8. A code of ethics which has been clarified and interpreted at ambiguous and doubtful points by concrete cases.

Figure 2. Characteristics of a profession (from Lieberman, 1956, pp. 2–6).

Didactics, Pedagogy, or Education?

In countries such as France and Germany, education is a term not much used by mathematics educators. They prefer to speak of didactic or subject-matter didactics. “In French, the term «didactique» does not mean the art or science of teaching. Its purpose is far more comprehensive: it includes teaching AND learning AND school as a System, and so on” (Douady & Mercier, 1992, p. 5). In many countries, including the Nordic countries, there is a long history of using pedagogy to designate education in the university, and mathematics educators have had to struggle to get subject-matter didactics recognized as a field of study in its own right—a part of pedagogy.

In English, both didactics and pedagogy have acquired negative—even pejorative—connotations, and neither is much used in educational discourse (Andrews, 2007; Kilpatrick, 2003). Didactic teaching is understood to be moralistic and somewhat rigid; the pedagogue is one who teaches in a pedantic or dogmatic fashion.
Consequently, English-speaking countries tend to use *education*, and other countries use the other terms.

Although it can be argued that the avoidance of *didactics* (as well as *pedagogy*) may stem from an aversion to theory (Andrews, 2007), I see it as undermining the struggle to validate education as an academic field. Adopting the term *didactics of mathematics* has been very beneficial to mathematics educators in some countries who seek recognition for the field as a science—in fact, as one of the mathematical sciences.

Distinctions among *education*, *didactics*, and *pedagogy* are far from clear, however, even to insiders. Bertrand and Houssaye (1999) argue that in the Francophone world, researchers and theorists in didactics and pedagogy “operate in the same territory and use the same epistemological tools” (p. 34). However,

most Francophone didacticians are eager to differentiate themselves from pedagogists, theorists and practitioners of pedagogy. This differentiation is generally made as follows: Pedagogy is more general than didactics, less scientific, and therefore less status-enhancing. It’s more attractive to define oneself as a didactician than a pedagogist, say the didacticians. (p. 41)

After reviewing the literature, Bertrand and Houssaye conclude that didacticians tend to rely more on cognitive psychology than pedagogues do but that

when they leave behind research and take up classroom work, they inevitably face day-to-day pedagogical reality and find the learner is much more than a cognitive subject. Educational reality being highly complex, they are often led to take a larger variety of variables into account and do research that can be called pedagogical. (p. 49)

It appears that the terminology we use may be chosen as much for political reasons as for academic ones. And it also appears, as one
looks at patterns of usage, that *mathematics education* tends to be a broader, fuzzier term than *didactics of mathematics*.

**A Discipline?**

Mathematics is a well-established discipline. It is a branch of knowledge with clearly defined objects of study and accepted methods for studying them. Whether education is a discipline is a more open question. Didactics of mathematics appears to have acquired disciplinary status, at least in the eyes of some of its practitioners (Adda, 1998; Biehler, Scholz, Sträßer, & Winkelmann, 1994), but mathematics education more broadly understood may be a different matter (Conant, 1963; Walton & Kuethe, 1963; although see King & McLeod, 1999, for a contrasting view). Norma Presmeg (1998) describes mathematics education as “an emergent discipline,” but Lynn Steen (1999) observes

Mathematicians tend to believe that only when mathematics education research produces a “theory of mathematical thinking that convincingly explains observed phenomena” . . . will it become a true academic discipline on a par with other sciences that produce robust theories with broad explanatory power (e.g., evolution in biology, thermodynamics in chemistry, relativity in physics). (p. 238)

**A Science?**

Steen’s (1999) observation raises the related question of whether education in general, and mathematics education in particular, can be considered a science. According to James Bryant Conant (1963), there is no science of education; it is at best a practical art. After examining the history of education research in the United States, Ellen Lagemann (2000) claims that education research remains “an elusive science” and points out that late in his life John Dewey (1929/1984) called education a new science that was just beginning to achieve scientific status. Controversy over that status continues to rage (National Research Council, 2002) and has spilled over to mathematics education (Steen, 1999). The consensus seems to be that
mathematics education is not itself a science but that at least some of its research fits the social sciences’ criteria for being scientific.

**A Field of Study and Practice**

A fair description might be that whereas mathematics is both a discipline and a profession, mathematics education is a field of study and practice whether or not it qualifies as a discipline or a profession. The terminology is less important than the recognition that each field has one side concerned with knowledge and another concerned with practice. Schubring (1989) observes,

> The autonomy of an academic discipline depends upon the existence of specialized professional careers for the discipline’s graduates. As a consequence, discipline and profession are functionally related. Changes that take place at one of these two poles will induce changes in the other. (p. 174)

At the disciplinary pole, the 20th century saw an abundance of mathematics education research studies, whether they were conducted within the pedagogue tradition, the empirical scientist tradition, or the scholastic philosopher tradition (Bishop, 1992). The field has constantly struggled to define the research it conducts (McLeod & King, 1999; Sierpinska & Kilpatrick, 1998; Steen, 1999), and the ICMI has responded with sections at its International Congresses on Mathematics Education and regional meetings, its affiliated study groups (especially the International Group for the Psychology of Mathematics Education), and its ICMI Studies.

In a lecture at the first ICME in Lyons, E. G. Begle (1969) cited some findings from empirical research that contradicted the received wisdom of the field and pointed out that neither teachers, nor mathematicians, nor mathematics educators had “been in a position to gather, during the course of our ordinary activities, the kind of broad knowledge about mathematics education that we need” (p. 239). He called for mathematics education to be made an experimental science in which mathematics educators would “abandon our reliance on
philosophical discussion based on dubious assumptions and instead follow a carefully correlated pattern of observation and speculation, the pattern so successfully employed by the physical and natural scientists” (p. 239). Although Begle’s vision has not been realized, progress has been made in the empirical observations and theory building he called for.

At the other pole, mathematics education developed greatly throughout the century as a field of practice, and again, ICMI played a role. Its regional meetings have allowed countries in which mathematics education is institutionalized in a similar fashion to build a community and share ideas regarding curriculum, teaching, and learning. Each ICMI Study has created, through the study conference, a forum where approaches to practice can be identified, and through the resulting study report, a platform for sharing those approaches. The affiliated study groups, through their own meetings and publications and at the ICMEs, have helped build communities of practice within the larger organization.

Skovsmose (2006) observes that mathematics educators need a broad view of practice, one that goes beyond the classroom to include out-of-school practice. Such a view inevitably raises socio-political issues:

When the different school-sites for learning mathematics as well as the many different practices that include mathematics are related, for instance by considering possible transitions between such practices, we enter the socio-political dimension of mathematics education. The principal issues are: Could a socio-political discrimination be acted out through mathematics education? How could mathematics education ensure an empowerment? (p. 268)

A hallmark of recent discussions of mathematics education, within ICMI activities and outside, has been the attention that increasing numbers of mathematics educators are giving to the socio-political dimension of our practice.
Teaching as Vehicle and Constituter

Jens Høyrup (1994) argues that “one aspect of mathematics as an activity . . . is to be a reasoned discourse; . . . as an organized body of knowledge [it is] the product of communication by argument” (p. 3). Consequently, “teaching is not only the vehicle by which mathematical knowledge and skill is transmitted from one generation to the next; it belongs to the essential characteristics of mathematics to be constituted through teaching” (p. 3). Just as certain algebraic techniques did not exist until the ancient Babylonians developed them in schools for training scribes, so the mathematics of the recent proof of Fermat’s last theorem by Andrew Wiles did not exist until it had been “taught” to others by appearing in print.

In a similar fashion, one can argue that an essential characteristic of mathematics education is to be constituted through teaching—in this case, through teaching teachers as well as students, and through teaching teachers to teach as well as to understand and do mathematics.

Domains of Knowledge and Communities of Practice

Bass and Hodgson (2004) raise and partly answer two important questions regarding these academic fields:

How are mathematics and mathematics education, as domains of knowledge and as communities of practice, now linked, and what could be the most natural and productive kinds of connections? The ICMI represents one historical, and still evolving, response to those questions at the international level. (p. 640)

It is tempting to treat the relation between mathematics and mathematics education as resembling that of parent and child (although, as noted at the outset, the child’s international organization predates the parent’s). The status of mathematics in the academy is both higher and more secure than that of mathematics education, and it seems natural to think of mathematics as the more mature,
responsible endeavor. Nonetheless, I think a better metaphor than parent and child lies in the concept of yin and yang (Figure 3). Mathematics and mathematics education have a synergistic relation, and neither can exist without the other.

![Figure 3. The yin yang symbol.](image)

In my view, mathematics education has not attained the status of a discipline, and it is not completely a profession. But as an academic field, it is linked to mathematics through a mutual concern with teaching (Figure 4). That mutual concern has been reflected in the many activities of the ICMI.
Nineteen countries participated in the first international commission meeting in Cologne in September 1908, together with another 14 “associated countries” (Howson, 1984, p. 76). Few could have predicted that a century later, there would be 72 member states of ICMI or that in each of those member states a distinctive community of mathematics education would have developed, comprising people from schools, universities, government ministries and agencies, and other organizations and associations. Today an astonishing profusion of books, handbooks, proceedings, articles, research reports, newsletters, journals, meetings, and organizations is devoted to
mathematics education in all its aspects. A search of the scholarly literature on the Web for the phrase *mathematics education* yields 125,000 hits; a search of the entire Web yields almost 9 times that number.

Mathematics education currently occupies a substantial if somewhat unclear position in the academy thanks to the many people, including mathematicians, who have devoted some or all of their careers to its furtherance. During the next century of ICMI’s existence, mathematics and mathematics education will continue to require each other’s support and assistance if mathematics education is to develop further as a field of study and practice.

**Note**

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**References**


