Mathematics: Going Beyond the Academic Discipline

Jennifer Hoyte
Florida International University, USA

Abstract: Mathematics is rigidly classified as an academic discipline. This determines curriculum content and teaching and evaluation methods. These methods can give rise to negative views of mathematics, resulting in increased math anxiety. Educators, therefore, need to look beyond the discipline to provide a classroom environment that meets students' needs.

Mathematics is considered an academic discipline (Favero, 2006). As such, it can be described, analyzed, impersonalized, and memorized (Schiro, 2008). Inherent within its status as a discipline is the methodology for teaching and learning. Such a methodology dictates that the teacher be the source of all mathematical values, skills, and meanings (King & Brownell, 1966) —the transmitter to the receiving learner (Schiro, 2008). Locke (1693/1970) made reference to young children as "white Paper, or Wax, to be moulded and fashioned as one pleases" (p. 261), giving rise to viewing a learner as a *tabula rasa* (blank slate) (Burns & Brooks, 1970). While some educators take delight in filling the *tabula rasa*, learners are objecting to being positioned as information receivers (Erickson, et al., 2008). As receivers, learners are forced to set aside their own mathematical thinking and accept "teacher-imposed methods of getting to the correct answer" (Geist, 2010, p. 25). With added focus on repetition, memorization, and timed tests for skill building, learners may, therefore, not perform well. This focus gives rise to an overall perception of mathematics as a high-risk activity, leading to higher levels of math anxiety (Geist, 2010; Popham, 2008). Krantz (1999) defines math anxiety as "an inability by an otherwise intelligent person to cope with quantification" (p. 100). Various studies found that positive attitudes towards math decline as students age, with as many as 63% of a college level math class expressing anxiety over math tests (Betz, 1978; Stodolsky, 1985). The purpose of this paper is, therefore, to discuss the negative effects that mathematics positioned as an academic discipline is having on learners, and the need to go beyond such a rigid classification in order to counter math anxiety. The paper opens by discussing mathematics as an academic discipline, followed by the effects of mathematics as an academic discipline on learners. It closes with a call to go beyond the academic discipline confines to reshape mathematics curricula and how mathematics is perceived.

Mathematics as an Academic Discipline

A discipline is defined as "a field of study" [or] "a rule or system of rules governing conduct or activity" (Merriam-Webster, 2010, n.p.). An academic discipline is, therefore, defined as the "knowledge, ways of working and perspectives of the world" (Favero, 2006, p. 1) manifested by scholars of that community. Five aspects of an academic discipline typified by mathematics are how it (1) is classified, (2) views knowledge, (3) views the learner, (4) is taught, and (5) is evaluated.

How Mathematics is Classified

A discipline can be classified as hard or soft, depending on how clearly defined its laws are with regard to "defining, ordering and investigating knowledge" (Favero, 2006, p. 2). As such, mathematics or physics would be considered hard disciplines. Social sciences or education would be considered soft disciplines as there is great debate over what constitutes new

Hoyte, J. (2011). Mathematics: Going beyond the academic discipline. In M. S. Plakhotnik, S. M. Nielsen, & D. M. Pane (Eds.), *Proceedings of the Tenth Annual College of Education & GSN Research Conference* (pp. 87-94). Miami: Florida International University. http://coeweb.fiu.edu/research_conference/

This research is made possible by a Presidential Fellowship from the Florida International University.

knowledge or appropriate methods of inquiry in these subjects. Disciplines are further divided into pure and applied: "pure fields are those that are viewed as less concerned with practical application, such as mathematics, history, and philosophy" (p. 3), whereas applied disciplines would include law, education, or engineering. Indeed, Biglan (1973b) found that for small colleges, mathematics content is determined empirically while a more creative approach is used for subjects like Philosophy or English. Thus, mathematics would be considered a pure, hard discipline.

How Mathematics Views Knowledge

A hard discipline would "specify the appropriate problems for study and the appropriate methods to be used" (Biglan, 1973b, p. 195). New knowledge for the discipline has to be discovered and sanctioned by members of the community of discourse, then tested against how well it "reflects the essence of the discipline" (Schiro, 2008, p. 40). Thus, research plays a critical role in sanctioning and testing new knowledge. As found in Biglan's (1973a) study, faculty in hard-discipline areas are more involved in research but less committed to teaching than those in the soft-discipline areas. This approach to mathematics as a subject with clearly defined theorems, proofs, content, and pedagogy would exclude consideration of ethnomathematics, the study of cultural adaptations of problem solving (Kilpatrick, 2008). Phenix (1962) definitively states that "there are kinds of knowledge which … [are] unsuitable for teaching and learning. . . . psychological needs, social problems . . . are not appropriate to the determination of what is taught" (p. 58).

How Mathematics Views the Learner

Such didactic knowledge is "repeatable and impersonal . . . can be repeated without losing its point and special circumstances are not needed for its transmission" (Schiro, 2008, p. 40). Thus, all that is needed for this knowledge to be received is the mind of the learner—"man's schooled power of knowing, of understanding" (King & Brownell, 1966, p. 20)—with no consideration for the cultural diversity, emotions, identity nor language of the learner (Fang He, Phillion, Chan, and Xu, 2008; Schiro, 2008). "The child is thus viewed as a mind, the important aspects of mind being those 'powers' that are capable of being 'schooled' within the academic disciplines" (Schiro, 2008, p. 41). This mind lodges the facility for storage and reason. Thus, the storage can be filled, and the reason can be shaped by the knowledge of the discipline to manipulate that which is received. Learners are seen as *neophytes* who must be groomed to maturity in the discipline. The methods for such grooming are also dictated by the discipline as learners perform similar activities to the *scholar* who is seen as the top of the mastery hierarchy.

How Mathematics is Taught

As Schiro (2008) states, "the very nature of the discipline dictates the way in which it is to be learned and taught" (p. 43) with didactic instruction being used to "help students acquire organized knowledge sanctioned by a discipline" (p. 45). Indeed, Gardner (1998) voices that precious class time is better spent having a good teacher explain on the blackboard than having students work with manipulatives. Thus, the teacher plays a key role as scholar, who embodies the discipline by being uniquely qualified to transmit this most sacred cultural tradition to waiting ears.

Other methods of the discipline include supervised practice and Socratic discussion. Supervised practice is aimed at learners acquiring "intellectual skills associated with a discipline" (Schiro, 2008, p. 45), such as when they practice multiplication. Learners can also test previously acquired intellectual skills by using Socratic discussions with the teacher and other learned members of the community to analyze what they have learned. In a Socratic

discussion, information is systematically questioned "to elicit a clear expression of a truth supposed to be knowable by all rational beings" (Merriam-Webster, 2011, n.p.). The aim is to provide disciplined conversation similar to how scholars communicate with each other (Schiro, 2008). As Phenix (1962) shares, "Education should be conceived as a guided recapitulation of the processes of inquiry which gave rise to the fruitful bodies of organized knowledge comprising the established disciplines" (p. 64).

Since the mind is the receptacle, the methods of the discipline encourage grouping learners of similar ability to make it easier for instruction tailored to each level. Thus, learners at any age can be considered "ready to learn" (Schiro, 2008, p. 44) once material has been simplified to their level and concepts are broken down into a set of rules and operations that are taught in sequence. For example, the Saxon Math curriculum is structured information that is presented in incremental, explicit chunks. Students continually review previously learned concepts, and assessment is frequent and cumulative (Resendez, 2008).

How Mathematics is Evaluated

Frequent, cumulative assessments are possible since the objective view of an academic discipline enables mathematics to be evaluated in an objective fashion. Students are tested on their ability to "re-present to members of the discipline that which has been transmitted to them through the curriculum" (Schiro, 2008, p. 48). Data collected from such tests can then be used to make comparisons as a measure of academic performance for promotion or graduation. Data aggregates are also used for comparing schools and school districts and for holding students and schools accountable (American Educational Research Association, 2004). Thus, the focus is more performance- than improvement-oriented. This rigid view of mathematics affects learners in different ways and can give rise to a negative view of math.

The Effect of Mathematics as an Academic Discipline on Learners

According to the Chorpita (1998) model of the development of vulnerability for anxiety and depression, low-perceived control in children leads to inhibitions and, as the children continue to experience situations over which they have little control, becomes feelings of uncontrollability leading to anxiety and depression with age. Feelings of vulnerability and loss of control are heightened when core needs are violated (Fiske, Morling, & Stevens, 1996). Core needs have to be satisfied in order for individuals to feel socially accepted. Three such core needs that are affected by the view of mathematics as an academic discipline include the need to: (1) make meaning of the world or to be able to understand what is going on and why; (2) see the world as being benevolent, as being a safe place where needs can be fulfilled and efforts rewarded; and (3) develop high self-esteem, to feel worthy of being a part of the group and to be able to contribute competently and effectively to the welfare of the group (Fiske et al., 1996). When in a place of powerlessness, individuals no longer feel in control of the outcome of their actions, lose their confidence to contribute, and, since their worth to the group is measured by their ability to contribute, thereby, lose their self-esteem. As individuals lose faith in themselves, they also lose faith in being rewarded for their efforts and the world is no longer seen as a safe, benevolent place.

Effect of How Mathematics is Classified

Treating mathematics as a pure discipline with no concern for application widens the gap between what is studied in the classroom and what is experienced in daily life. This dichotomy created between theory and practice is considered an obvious pitfall in teaching that causes schooling to seem unrelated to world affairs (Kliebard, 1965), thereby, violating the core need to make meaning of the world. Indeed, as Trujillo and Hadfield (1999) found, passive classrooms

and students' inability to see the relevance of mathematical topics are contributors to math anxiety. Adult learners, in particular, who are more proactive about their learning and seek education as solutions to daily life's problems (Betz, 1978) would be alienated by this environment.

Effect of How Mathematics Views Knowledge

To qualify as knowledge, mathematical information has to be repeatable and impersonal. Thus ethnomathematics is decried as ". . . rain forest math . . . practiced by cultures other than Western especially among primitive African tribes" (Gardner, 1998, p. 1). This violates the need to "develop a curriculum of shared interests . . . that values the cultural and linguistic heritages of students" (Fang He et al., 2008, p. 231). Mathematics' classification as an academic discipline also positions it as a core subject, making it a required course for many degree programs. Thus, when students fail at math, the door is closed to further advancement, affecting an individual's ability to contribute to the group's welfare. Mathematics therefore serves as a gatekeeper to determine who achieves economic access, full citizenship, or a higher education (Stinson, 2004).

Effect of How Mathematics Views the Learner

A student's comfort is also affected by the way the academic discipline approach focuses on the mind of the learner. Turner and colleagues (2002) found that "students may also need motivational and affective support through interaction with their teachers and peers" (p. 91). Students will notice if the teacher is not highly motivated and this too can cause math anxiety. As students detect their teachers' negative attitudes they may be discouraged from seeking the help they need (Turner et al., 2002), lowering their performance further, leaving their core need of competence and effectiveness unsatisfied, and fulfilling teachers' low expectations.

Viewing the mind as a clean slate enables the thought that "by repeating the same action, till it be grown habitual in them, the Performance . . . will be natural in them" (Locke, 1693/1970, p. 64). This "learn-by-repetition" (Erickson et al., 2008, p. 208) dictate of the discipline has become a "drill-and-kill" (p. 208) pedagogy acerbated by low scores on the frequent assessments. In addition, the grouping system which was meant by the discipline to maximize learning by placing like-ability students together is now being used to stream already unmotivated students into holding pens with even lower opportunity for learning.

Effect of How Mathematics is Taught

Children are already constructing structures needed for mathematical operations before they reach age five (Geist, 2010). However, as they enter school, the focus shifts from the learners to the teacher or the textbook as expert. Such is the case with academic disciplines where the teacher is the expert and the transmission method is used for teaching. Turner and colleagues (2002) associate the transmission model of learning with a *low-mastery-oriented* classroom—more concerned with students' ability to outperform each other and less focused on understanding. Low-mastery-oriented classroom teachers showed "little enthusiasm about learning and did not convey high expectations for all" (p. 90). This could be attributed to the academic discipline scholar's view of learners as neophytes with differing abilities, some of whom would make it to the apex of academia and others who would not.

Having a teacher established as the authority, with minimal scaffolding and a controlling instructional discourse, was found to create a classroom environment focused on evaluation for performance, causing students to be avoid situations that made them seem unknowing (Turner et al., 2002). Students felt forced to become passive receivers of knowledge which caused them to consider both mathematics to be a non-thinking subject with no room for creativity and themselves to be willing subjects (Boaler, 2000). If they are not willing to be passive receivers,

students who may be capable of excelling in mathematics consider mathematics to be contrary to their identities.

Teachers' lack of mathematical knowledge can also adversely affect students' level of comfort. After being presented as the experts, if teachers are unable to maintain control of the learning environment or to provide prompt and sure feedback, students become apprehensive (Jackson & Leffingwell, 1999; Turner et al., 2002). The less emphasis placed on teaching by the academic discipline adherents may appear to be lack of interest to the students. This lack of interest is interpreted by the students as a reflection of their capabilities (Jackson and Leffingwell, 1999), resulting in lower performance since their self-esteem is affected.

Effect of How Mathematics is Evaluated

Timed tests are considered to be artificial and cause a negative attitude towards mathematics when students do not excel (Popham, 2008). Indeed, replacing the child's inherent constructivist approach to learning with emphasis on correct answers instead of concept development, speed instead of understanding, and rote repetition instead of critical thinking has been shown to increase anxiety in children and adults (Geist, 2010). Boaler (2000) argues:

> The idea that learning mathematics requires no or little thought, as students are only required to reproduce procedures, suggests that students are engaging in ritualistic acts of knowledge reproduction rather than thinking about the nature of the procedures and the reasons why and when they may be applied. (p. 179)

Beyond the Academic Discipline

Viewing mathematics as an academic discipline has given rise to certain misconceptions about education, which have resulted in mathematics instruction being implemented in ways that are not beneficial to all students. By freeing mathematics from such rigid classification and tradition, it could be made more accessible to all.

Beyond How Mathematics is Classified

Despite the commonly exalted status of disciplines, no "field of study must present an approved pedigree in order to be admitted to membership as a discipline" (Kliebar, 1965, p. 338). Furthermore, teaching the discipline was not meant to be "searching for *the* structure and then transmitting it in *toto*" (p. 338). Rather, applicable principles and concepts were to be adapted for learning. This opens the door to adapting mathematical topics to the needs of the students, adapting the way mathematics is presented to the learning styles of the students, and most importantly, satisfying students' core needs so that anxiety is averted.

Beyond How Mathematics Views Knowledge

On the one hand, Phenix (1962) urges a coming-together of the academic scholar and the professional educator. The academic scholar, is more concerned with erudition and less with pedagogy, while the educator is more concerned with teaching and learning "with little understanding or concern for the standards of rigorous scholarship" (p. 59). Phenix's view of educators stems from his view of mathematics as a discipline that should be based on teachable content and not psychological needs, as shown earlier. Kilpatrick (2008), on the other hand, sees the mathematics educator as "concerned with how mathematics is learned, understood and used, as well as what it is" (p. 7). To this end, the educator goes beyond applied mathematics to how people think about mathematics, how learners can make use of mathematics on a daily basis, and how these uses and school learning can be connected. While some educators consider ethnomathematics to be fuzzy math, others "understand the value of taking into account the mathematical systems of the cultures from which students come" (p. 8), without sacrificing understanding of mathematical concepts.

Beyond How Mathematics Views the Learner

Though the academic discipline recognizes that learners have varying abilities, the intention was that the same level of education was to be given to all (Adler, 1982). Thus, even though some students may branch off to vocational education, they would still have the opportunity of acquiring an academic education (Schiro, 2008). The whole student must be considered for mathematics to be effectively understood. Turner and colleagues (2002) speak of the need to create a classroom environment that is high-mastery/low-avoidance by not only providing cognitive support but also focusing on motivational and affective support. This is because all students are "educable—not just trainable for jobs!" (Adler, 1982, p. 7).

Beyond How Mathematics Is Taught

Due to limited time in the classroom, it is necessary to determine which information should be taught and which is not as essential, but how that information is taught and how students learn have to be considered in achieving understanding. Erickson et al. (2008) speak of the "need to look much more closely and thoroughly at the conditions within school life itself, in which students affiliate and disaffiliate with the project of school learning" (p. 207). Geist (2010) shares that "we must look for environmental variables to explain the intertwining outcomes of poor achievement and negative attitude toward mathematics" (p. 27).

Providing learning in a developmentally appropriate fashion is certainly critical, but it need not be the repetitive step-by-step method of the Saxon curriculum (Resendez, 2008). Unlike those who feel that interesting activities detract from true learning (Geist, 2010), Williams (2000) found that students who practiced with a computer program were better prepared for a multiplication fact assessment. Indeed, technology is being used more widely in the classroom today. Not only does it boost efficiency of class time, but it also enables distance learning, access to online resources, and deeper, more interactive, experiences for students (Means, 2008). With a change in how mathematics is acquired and understood comes the need to change how it is evaluated.

Beyond How Mathematics is Evaluated

Multiple choice tests give credit for arriving at the correct answer, not for the process involved. Yet, multiple choice tests provide the only viable means of frequent assessments. As a result, either time has to be invested in grading meaningful assignments, or the need for such frequent assessments has to be rethought. The whole approach to teaching and learning mathematics needs to be re-examined if mathematics is to be transformed from an "ideal of the gods reproduced by a few students, into a human endeavor produced [and accessible] by all students" (Stinson, 2004, p. 16). Jackson and Leffingwell (1999) encourage teachers to step off the scholar pedestal and openly discuss with students how they overcame math anxiety and specific strategies that students can use. Teachers can also take the following steps: (a) consciously share their enthusiasm with the students; (b) provide constant reinforcement; (c) make the classroom environment a safe haven instead of one in which students feel embarrassed and can lose face; and (d) make the subject matter meaningful, relevant and interesting. To this end, the curriculum needs to be reshaped into one that (a) can be used to solve everyday problems, not by applying empty formulas, but by students understanding enough to know when to use ethnomathematics, and when to use the academic discipline; and (b) fits the "customary way of thinking and acting of working class [and other] students" (Erickson et al., 2008, p. 207). The need for meaning and safety are core needs that must be satisfied to reduce students' anxiety and increase their ability to learn math.

References

Adler, M. J. (1982). *The paideia proposal: An educational manifesto*. New York: Macmillan.

American Educational Research Association. (2004). AERA position statement on high-stakes testing in pre-K–12 education. Retrieved from http://www.aera.net/?id=378

Betz, N. E. (1978). Prevalence, distribution and correlates of math anxiety in college students. *Journal of Counseling Psychology, 25*(5), 441-448.

Biglan, A. (1973a). Relationships between subject matter characteristics and the structure and output of university departments. *Journal of Applied Psychology, 57*(3), 204-213. doi: 10.1037/h0034699

Biglan, A. (1973b). The characteristics of subject matter in different academic areas. *Journal of Applied Psychology, 57*(3), 195-203. doi: 10.1037/h0034701

Boaler, J. (2000). *Multiple perspectives on mathematics teaching and learning*. International perspectives on mathematics education. Westport, CT: Ablex.

Burns, R. W., & Brooks, G. D. (1970). *Curriculum design in a changing society*. Englewood cliffs, NJ. Educational Technology Publications. Retrieved from http://books.google.com/books?id=_QfLLips6LoC&printsec=frontcover&dq=curriculum+design+changing+society&source=bl&ots=XGG-nO7PgJ&sig=kxpWk26d0qoX14qvjy6kkCDl4n8&hl=en&ei=L7kOTZbELMP38Abrp_zCDg&sa=X&oi=book_result&ct=result&resnum=1&ved=0CCIQ6AEwAA#v=onepage&q&f=false

Chorpita, B. F., & Barlow, D. H. (1998). The development of anxiety: The role of control in the early environment. *Psychological Bulletin, 124*, 3-21.

Erickson, F., Bagrodia, R., Cook-Sather, A., Espinoza, M., Jurow, S., Shultz, J. J., & Spencer, J. (2008). Students' experience of school curriculum. In F. M. Connelly (Ed.), *The SAGE handbook of curriculum and instruction* (pp. 198-218). Los Angeles, CA: Sage.

Fang He, M., Phillion, J., Chan, E., & Xu, S. (2008). Immigrant students' experience of curriculum. In F. M. Connelly (Ed.), *The SAGE handbook of curriculum and instruction* (pp. 219-239). Los Angeles, CA: Sage.

Favero, M. (2006). Academic disciplines. *The Gale Group*. Retrieved from http://www.education.com/print/academic-disciplines/

Fiske, S. T., Morling, B., & Stevens, L. E. (1996). Controlling self and others: A theory of anxiety, mental control and social control. *Personality and Social Psychology Bulletin, 22*, 115-123. Retrieved from http://psp.sagepub.com/content/22/2/115

Gardner, M. (1998, September 24). The new new math. *The New York review of books.* Retrieved from http://www.nybooks.com/articles/archives/1998/sep/24/the-new-new-math/

Geist, E. (2010). The anti-anxiety curriculum: Combating math anxiety in the classroom. *Journal of Instructional Psychology, 37*, 24-31. Retrieved from http://vnweb.hwwilsonweb.com.ezproxy.fiu.edu/hww/results/external_link_maincontentframe.jhtml?_DARGS=/hww/results/results_common.jhtml.44

Jackson, C. D., & Leffingwell, R. J. (1999). The role of instructors in creating math anxiety in students from kindergarten through college. *Mathematics Teacher 92*(7), 583-586.

Kilpatrick, J. (2008). The development of mathematics education as an academic field. *Plenary Lecture 1 at the Symposium on the Occasion of the 100th Anniversary of ICMI.* Retrieved from

http://math.coe.uga.edu/olive/EMAT8990FYDS08/Math%20educ%20as%20academic%20field%20final.pdf

King, A. R., & Brownell, J. A. (1966). *The curriculum and the disciplines of knowledge: A theory of curriculum practice.* New York: Wiley.

Kliebard, H. M. (1965). Structure of the disciplines as an educational slogan. *Teachers College Record, LXVI*(7), 598 - 603.

Krantz, S. G. (1999). *How to teach mathematics* (2nd ed). Providence, RI: American Mathematical Society.

Locke, J. (1693/1970). *Some thoughts concerning education*. Menston, England: Scolar Press.

Means, B. (2008). Technology's role in curriculum and instruction. In F. M. Connelly (Ed.), *The SAGE handbook of curriculum and instruction* (pp. 123-144). Los Angeles, CA: Sage.

Merriam-Webster (2010). *Discipline.* Retrieved from http://www.merriam-webster.com/dictionary/discipline

Merriam-Webster. (2011). *Socratic.* Retrieved from http://www.merriam-webster.com/dictionary/socratic?show=0&t=1300371743

Phenix, P. H. (1962). The disciplines as curriculum content. In A. H. Passow (Ed.), *Curriculum crossroads* (pp. 57–65). New York: Bureau of Publications, Teachers College, Columbia University.

Popham, W. J. (2008). Timed test for tykes? *Educational Leadership, 65*(8), 86–87.

Resendez, M. (2008). *The relationship between using Saxon Math at the elementary and middle school levels and student performance on the North Carolina statewide assessment.* Retrieved from http://saxonpublishers.hmhco.com/HA/correlations/pdf/s/Saxon_Math_Archival_Report_NC_GR_3-8_2008.pdf

Schiro, M. S. (2008). *Curriculum theory: Conflicting visions and enduring concerns*. CA. Sage.

Stinson, D. W. (2004). Mathematics as "gate-keeper"(?): Three theoretical perspectives that aim toward empowering all children with a key to the gate. *The Mathematics Educator, 14*, 8–18. Retrieved from http://math.coe.uga.edu/tme/issues/v14n1/v14n1.stinson.pdf

Stodolsky, S. S. (1985). Telling math: Origins of math aversion and anxiety. *Educational Psychologist, 20*(3), 125-133. doi: 10.1207/s15326985ep2003_2

Trujillo, K. M., & Hadfield, O. D. (1999). Tracing the roots of mathematics anxiety through in-depth interviews with preservice elementary teachers. *College Student Journal, 33*(2) 219-232.

Turner, J. C., Midgley, C., Meyer, D. K., Gheen, M., Anderman, E. M., Kang, Y., & Patrick, H. (2002). The classroom environment and students' reports of avoidance strategies in mathematics: A multimethod study. *Journal of Educational Psychology, 94*, 88-106. doi: 10.1037/0022-0663.94.1.88

Williams, L. P. (2000). *The effect of drill and practice software on multiplication skills: "multiplication puzzles" versus "the mad minute."* (Master of Arts Action Research Project, Johnson Bible College). Retrieved from http://www.eric.ed.gov/PDFS/ED443706.pdf