THE ROLE OF MATHEMATICS EDUCATION IN PROMOTING FLOURISHING

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The thrust of this paper is to make the familiar strange. A typical child going through her or his country's public education system will take ten to twelve years of mathematics courses, yet despite this, very few students go on to use the skills gleaned from the latter years of such coursework in their future lives or careers. This lack of utility is not a problem in and of itself; however, if one examines mathematics education through the lens of a guiding aim for education as a whole—as we do here—issues with ten to twelve years of mandatory mathematics become salient. The conclusion we draw is that public school curricula should include compulsory mathematics in the early and middle years, but afterward only insofar as students' careers or interests demand it; at the same time, throughout students' schooling, classes in other subjects should integrate quantitative reasoning where appropriate, the goal being to foster quantitative literacy.

We recognize that deciding upon aims for public schooling is rightfully a complex political process, one which takes time and will vary from country to country; nonetheless, it is something that educators and policy-makers must do, as otherwise we run the risk of meandering through a curriculum aimlessly. The guiding aim that leads us to our conclusion is that the public school curriculum should foster students' present and future flourishing (Brighouse, 2006), a concept akin to Hilton's (1984) notion of a successful life. To Brighouse flourishing consists of realizing objectively valuable goods in a life that is lived from the inside. Objectively valuable goods are those that make life worthwhile and are worth pursuing for their own sake, with commonly agreed-upon goods including things like enjoyment, mutual friendship and intimacy, accomplishment, and personal autonomy. The goods Brighouse (2006) has in mind are achieved in activities like "raising children, mastering difficult and complex skills, giving enjoyment to others and enjoying their company, studying great literature, [and] devising great comic routines" (pp. 15-16) and not in activities like hoarding money or items. Such goods are realizable in a wide diversity of lifestyles, religious and non-religious, professionally ambitious or not professionally ambitious, heterosexual or LGBTQ, and so on. For this reason, attaining objectively valuable goods is only necessary and not sufficient for a flourishing life. A person can flourish within a way of life only if she can also identify with it or can live it from the inside.

So one can flourish through a spectrum of activities, ranging from having a career, to spending time with friends and enjoying hobbies or other interests. Importantly, flourishing embraces many of the dominant ideologies Ernest (2002) describes that have influenced mathematics education—notably humanists, developmentalists, social efficiency (or utilitarian) educators, and social meliorists. Flourishing aligns with humanist goals insofar as it encourages one to pursue a worthwhile (or liberal) education, but with developmentalist goals as it necessarily accounts for one's own desires—not just those viewed by others as intrinsically worthwhile. It aligns with social efficiency goals insofar as it encourages one to pursue autonomously chosen interests relevant to their future lives and careers; all the while, there is no assumption that there are pre-defined roles for students to fill in society. It is acceptable if scores of students become engineers, but there is no expectation that our society has such aims. Finally, flourishing aligns with social meliorist goals, as it aims for the flourishing of all, paying particular attention to the realities of systemic marginalization. We discuss the latter goal in depth later.

Mathematics for flourishing

Our work now is to consider the extent to which teaching for mathematics and teaching for quantitative literacy promote flourishing. To that end, we begin by distinguishing between mathematical and quantitative literacy. Mathematical literacy [1] involves, among other things, the skills necessary for doing traditional school mathematics, such as algebraic manipulation and computational dexterity; in many ways, it is encompassed by the notion of symbol sense (Arcavi, 2005). Large-scale attempts to measure mathematical achievement—such as the Programme for International Student Assessment—primarily examine students' mathematical literacy. On the other hand, with roots in Steen's (2001) *Mathematics and Democracy,* quantitative literacy is the ability and critical disposition to use and interpret numbers as they manifest in daily life. Very little formal mathematics beyond arithmetic and statistics is necessary for being quantitatively literate. Rather, quantitative literacy builds upon basic mathematical skills in tandem with critical thinking involving numbers, also incorporating the use of "mathematical knowledge as part of a process of social criticism and renewal" (Apple, 1992, p. 429). Notably, mathematical and quantitative literacy are related, but not equivalent, as having one does not imply having the other. For instance, one can understand how to factor quadratic equations, but not understand that a 50% increase in cancer risk could be insignificant—and vice-versa. Mathematical literacy develops over the span of mandatory schooling and through post-compulsory course-work, while the seeds of quantitative literacy—percentages, ratios, linear equations, and basic statistics, among other topics—are sewn in early years and grow (if at all) through interdisciplinary efforts and critical reasoning tasks at the late- and post-compulsory levels of schooling (Hughes-Hallett, 2003).

So how does quantitative literacy foster flourishing? An easy answer is that we live in a world "awash in numbers," and thus that quantitative literacy is necessary for full participation in it (Steen, 2001, p. 1). It then follows that—because flourishing is dependent upon participation in society—flourishing is dependent upon quantitative literacy. Given that we are inundated with numbers each day, quantitative literacy enables one to participate in democracy (numbers flood election cycles), to manage one's personal finances and personal health, as well as to recognize social injustices, among other things. This is not mere rhetoric. Research suggests that quantitative literacy fosters informed decision-making with respect to nutrition, medicine, risk situations, and financial matters (among other things), all of which can support one's attainment of objective goods like leading a healthy and prosperous life. To boot, it is increasingly clear that the skills of quantitative literacy are necessary for use in a host of jobs (e.g., administrative assistants, factory workers, nurses, etc.); that is, quantitative literacy brings about objective goods while allowing one to pursue their career interests.

To a large degree, the relationship between mathematical literacy and flourishing is less direct. We focus on (and problematize) three common reasons for supporting mathematical literacy, including that it can: (1) aid one in obtaining a job, (2) build one's capacity for critical thinking, and (3) be intrinsically rewarding for its own sake. With respect to (1), having a career certainly contributes to a flourishing life, as a career is an objective good that provides income security and can be intrinsically rewarding. There are a number of careers that make use of the mathematics learned in compulsory and post-compulsory schooling (e.g., engineering), and it is reasonable that students who want to engage in such work should have access to the coursework necessary for doing so. Problematic in this context, however, is that in our current society, a driving force in education is the goal of social mobility, wherein students compete for knowledge that they can later exchange for status and pay (i.e., objective goods) (Labaree, 1997). This is especially true in learning mathematics, where competency in the discipline often permits one to enter university (through one's SAT scores), exit university (through general education requirements), and even obtain a job (through one's grades), completing significant, status-earning tasks that—in and of themselves—often have no significant relation to the mathematics itself. Research readily confirms this advantage, as mathematical ability (as defined through grades or test scores) is connected to both wage increases and likelihood of full-time employment (Levy, Murnane & Willett, 1995; Rivera-Batiz, 1992). In response to this, some might note this advantage is simply a matter of economics; the laws of supply and demand dictate these patterns, not us—the problem is structural, not related to the mathematics itself. This is a fair point; however, it does not discount that for the majority of careers, whether high-paying or not, higher-level mathematics has little use value. Among other issues, exchanging mathematics credentials for status unrelated to the mathematics itself disadvantages students who have not had the privileges that foster mathematical achievement. Hence, simply arguing that mathematics is important for obtaining a job is a vexed defense.

Related to the issue of exchanging mathematics for status is the idea that the subject, when taught properly, fosters problem-solving and logical reasoning skills. That is, students can benefit from learning mathematics in ways that legitimately make them better workers and citizens, among other things (Gibson, 1986). This rhetoric is not new, as the subject has a long history in serving as a proxy for logic and rationality, as well as being viewed as a vehicle for developing one's problem-solving skills and metacognition. These are valuable objections, as mathematics and logic are inherently intertwined, and mathematics certainly can foster one's problem-solving ability. With that said, these objections are problematic when one considers the everyday importance of reasoning and problem-solving, and the lesser need for mathematical content knowledge for most people. It begs the question of why we use the largely unneeded subject as a proxy for the needed one, especially when there are more direct ways of focusing on the latter.

Avoiding the predicament above altogether, still others argue that mathematics is a beautiful discipline—an art to be shared with the world, and an essential component of any liberal education (Mumford, 2006). There is no need to justify the subject's utility, as the ends and means are one in the same. Brighouse (2006) notes that paternalism is necessary to some extent among educators in supporting flourishing, and naturally this would involve deciding that teaching some subjects (e.g., writing, history) is more important than teaching others (e.g., Latin). Hence, there is certainly some merit in mandating a liberal education for all students. All the while, the humanist tendency to continue marching through mathematics courses in public schooling (after developing quantitative literacy skills)—albeit well-intended—runs counter to the notion of flourishing if it clashes with students' interests. Indeed, the second component of Brighouse's (2006) framework, living a life aligned with one's inner desires, dictates that one be able to pursue their passions. With or without access to mathematics courses in schools, students are less likely to be able to focus on coursework in subjects such as art, geography, or sociology, among many others, should they desire to do so. We leave it to the reader to gander at what might replace four years of mandatory late-compulsory mathematics for students; they might engage in discovering psychology, sociology, human geography, and philosophy, among a host of other disciplines, all of which would aid in directly developing students' reasoning and communication skills—skills many equate as an inherent reason for learning mathematics.

Implications for curricula

Based on the discussion above, it appears that while mathematics is absolutely useful for some—be it of intrinsic interest, or necessary for one's career—it is unclear if that means all students should be forced to take courses in the subject in each grade until graduation. We believe that if taken seriously, our analysis has profound consequences for the compulsory mathematics curriculum (and that of other subjects, though a discussion of that is beyond the scope of this paper).

What are we to do? We believe that through year nine (approximately, depending on the country's context), all students should participate in a challenging mathematics curriculum that promotes both mathematical literacy and quantitative literacy; this should take place in non-tracked classrooms, meaning students are not placed in classrooms with others who have similar achievement scores on exams. This would prepare students for the mathematics they would encounter in higher levels, should they choose to enroll in such, as well as sow the seeds for critical thinking using numbers outside of school. Curricula for the early school years that support both of these goals in a genuine fashion (i.e., where real-world contexts are not contrived) are difficult to find, though *Investigations* is a promising start (Russell & Economopoulos, 2016); for the middle years of compulsory schooling, the *Connected Mathematics* curriculum is also promising (Lappan, Phillips, Fey & Friel, 2016).

Beyond year nine, we argue that it should be up to students—not test scores or advisers—to decide whether they desire to take further courses in mathematics. At the same time, courses in other disciplines (e.g., biology, history) would take up the nontrivial task of reinforcing the skills and critical reasoning of quantitative literacy as they manifest within the respective discipline, following a spiraling approach akin to that suggested by Bruner (1977) or Whitehead (1929). This means the endeavor should be interdisciplinary, in that we integrate quantitative skills and critical thinking across the disciplines, regardless of whether the student is taking further mathematics courses. As a concrete example, although students may develop a basic conception of percentages in primary school, in a curriculum like the one we have proposed, they could revisit the concept often in various years, discussing concepts like percent change (in any discipline), the distinction between relative and absolute change (in a health course), how the stock market works (in an economics or civics course), or even the disproportionate rise in incarceration rates among certain races (in a sociology course). Notably, mathematics would never leave the curriculum; students simply would not be forced to take it directly. The freedom from mathematics courses in the late-compulsory years would permit student flexibility in taking courses that promote their flourishing. Moreover, important to additionally note, the curriculum would be set up so that students may opt back in to take mathematics courses, should they be interested in doing so at a later time.

Issues and rebuttal

Even readers sympathetic to our reasoning thus far are likely to be wary of the proposals, as indeed, there are a number of reasons to be. First, we focus on qualms concerning implementation, then we discuss the proposed curriculum's relationship to current efforts. One potential concern is that we should be careful not conflate curriculum with its enactment in the classroom. Fostering quantitative literacy in this interdisciplinary manner is no simple matter, as it would require development efforts from both major curricular voices and textbook publishers, as well as significant work on the part of teachers and college instructors without a heavy mathematics background. The result is that in a curriculum where mathematics is not directly allotted time, the skills of quantitative literacy may be taught hardly at all (Brighouse, 2006, p. 53). At the same time, it would also require work among the mathematics teachers up to year eight, because as Cranfield (2012) notes, a curriculum that fosters quantitative literacy "challenges the beliefs and understandings of mathematics teachers who were trained under very different assumptions regarding the teaching of mathematics" (p. 209). We are sympathetic to these concerns. With that said, we argue that these are not tenable reasons to avoid a quantitative literacy curriculum in the long-term. Indeed, they are concerns about the practicality of implementation, which should not serve as excuses for the status quo.

An additional concern (indeed, the elephant in the room) concerns the inequities that might manifest from a proposal like ours. Given the inequities typically associated with tracking—the practice of placing students in classes with students of similar prior academic achievement—it is certainly logical that one might view our argument with caution. Indeed, as it has become increasingly apparent that mathematical knowledge permits social mobility, we are likely to view any subtraction of the discipline from the curriculum (for any student) as blasphemous. To boot, given the recent push to make STEM careers available to all students—especially those in historically marginalized groups—it would appear backward to propose any option that might hinder progress toward equitable outcomes in education. The response that some tend to have in pushing for equity in mathematics education is curricula like criticalmathematics and mathematics for social justice. All the while, such pedagogies seem useful only insofar as they involve the use of statistics and basic mathematics to heighten students' awareness of injustice. They give no advice on how to imbue, for example, trigonometry or precalculus, with any meaning for students. The implication of this is that they are not completely transformative curricula—after a certain point, students return to traditional mathematics. Given that quantitative literacy involves a critical awareness of mathematics and its role in society, it appears that one can weave critical-mathematics and mathematics for social justice throughout our proposed curriculum.

Still yet, others might observe that curricula for quantitative literacy are not new, and might question what differentiates our proposed one from those that already exist. Unfortunately in the U.S., despite the fact that Steen (2001) and others have argued for quantitative literacy at both the compulsory and post-compulsory levels, their work has wielded little influence over the former, which—primarily driven by the Common Core State Standards for Mathematics—focuses on mathematical literacy. South Africa has fared rather similarly, having a compulsory curriculum that focuses on mathematical literacy (as defined in the U.S. context), and a post-compulsory curriculum including quantitative literacy as a less rigorous option for individuals interested in careers non-quantitative in nature (Venkatakrishnan & Graven, 2006). The purpose of having such an option is sound, as it attempts to increase access to higher education while also equipping students with quantitative skills for daily life; however, the curriculum operationalizes quantitative literacy as simply traditional mathematics but with an applied focus. That is, in the post-compulsory quantitative literacy curriculum, the content drives the context, rather than the converse (Venkatakrishnan & Graven, 2006)—an important distinction (Steen, 2001). As a more promising example, in England, where the last year of compulsory schooling is year eleven, there have been pilots of a curriculum where quantitative literacy (in this context, called Functional Mathematics) is woven throughout the compulsory program of study—similar to what we have argued for here. However, the results from the pilots have not filtered into the country's National Curriculum (Department of Education, 2014), where the current focus is primarily on mathematical literacy in a manner similar to that found in the U.S. and in South Africa. Thus, despite significant efforts among groups in various countries to push for greater attention to quantitative literacy in compulsory curricula, there is much room to grow, from the perspective of both operationalization and implementation.

Conclusion

It has long been suggested that in order to improve mathematics education, we need to—among other things—disrupt traditional ways of teaching, make the content better connected, and make available the benefits of mathematical knowledge to everyone. These are laudable aims; however, in this paper, we have argued that to a large extent, none of these changes disrupts the root of the problem—that most students do not need twelve years of mathematics in order to flourish. As Pais (2013) eloquently notes, "If the purpose is the high ideals of peace, democracy, social justice and equality, the route via mathematical thinking, in which we currently invest so much, is a dead end" (p. 5). Our thesis—that the curriculum in most countries requires too much mathematics of students—rests on the assumption that the primary aim of schools should be to help students to acquire objective goods and to lead lives on their own terms. The latter, as we have argued, suggests that students take as much or as little mathematics as they desire to—at least after year nine. The former component—the acquisition of objective goods such as friends, material items, or love—requires mathematics only insofar as one's career does. Time spent learning mathematics is necessarily less time spent learning material of one's interest.

With all of this written, we recognize the inherent complexities and issues embedded within the argument. All the while, the current practices we see are fundamentally incongruous with empowering students to flourish. We encourage educators and policy-makers to critically reflect on our complicity in the matter, as—albeit we are often well-intended—by allowing the current *quantity* of mathematics content in schools to remain constant, we ignore a significant component of the problems we purport to mollify. And of course, given that the lens of flourishing is not limited to analysis of the mathematics curriculum, we invite individuals of all disciplines to scrutinize the influence their work may have on students.

Notes

[1] An important note here is that in South Africa, the term mathematical literacy has a connotation similar to the US's quantitative literacy; the term mathematics (in isolated usage) is similar to the US's mathematical literacy (Venkatakrishnan & Graven, 2006).

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