The Social Network of US National Math Education

by

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Abstract

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This dissertation investigates the emerging US national math education, its curriculum and purpose, with respect to the individuals and organizations comprising its social network. National math education means two things: a circumstance in which all students across the US are offered primarily the same instruction from among mathematical topics, and a process whose outcome is in the national interest. The method of inquiry relies on a new perspective of governance in which social networks operate among official governing structures. Upon constructing a representative social network surrounding US national math education, the following interests were found: developing a national math education that enhances the productivity of US workers, advocacy for either a traditional or reform mathematics pedagogy, improving the content knowledge of US math teachers, and a national math education that fuels an education services industry. Taken together, these interests undermine each other and are argued to fail at national math education's purported objective, namely, to increase the knowledge and use of mathematics by persons living in the US.

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Chapter 1: Introducing National Math Education and its Historical Context

For the last half of the twentieth century, we witnessed an increase in the attempts to define and execute a national mathematics education for public schools in the United States. National math education means two things: a circumstance in which all students across the US are offered primarily the same instruction from among mathematical topics, and a process whose outcome is in the national interest. Efforts have swelled to a greater magnitude since 2000, culminating in 2010 with over 40 states adopting the same math education standards because such action increased a state's chances to win federal monies for use in schools. Such an emerging national math education warrants significant attention from those interested in education policy and math education. This dissertation presents one approach for inquiring into these developments, namely an analysis of the social network of the persons and organizations surrounding them.

Focusing on a social network surrounding a policy domain is different than, for example, looking at the text of specific policy documents, policies or other events related to the domain. My choice represents a perspective on contemporary governance in which new forms of governing allow significant influence of private interests via a social network of individuals, private organizations and their overlapping interests.[1] The individuals and organizations that comprise the network, what I will refer to as network actors, initially congregate over similar interests surrounding the policy's domain, yet subsequently the alliances and compromises contained therein sometimes undermine both

[1] Janine Wedel, *Shadow Elite: How the World's New Power Brokers Undermine Democracy, Government, and the Free Market* (New York: Basic Books, 2009), 1-21.

small scale interests in the network as well as the overarching explicit goals of policy and government.[2]

By using this perspective on governance, I have identified a social network surrounding national mathematics education that presents the following interrelated interests: a national math education that develops human capital (the characteristics of productive workers), debates over traditional and reform pedagogy, agreement on a content knowledge deficit of math teachers, and a math education that fuels an education services sector. In the chapters that follow I elaborate on these themes by presenting the network constituents that support them, as well as the variations within each theme that exist among these constituents. In the final chapter I also argue how these variations can undermine specific interests in the network as well as, when taken together, these themes work in concert to undermine the national math education's purported objective to increase the knowledge and use of mathematics by people living in the US.

Thus far, I have introduced this dissertation's primary subject matter and method of inquiry, an emerging national math education and the social network surrounding it, respectively. I continue this chapter by elaborating first on my approach and findings. Second, I sketch the historical developments in national math education from World War II to 2000 in order to develop a framework for investigating contemporary national math education. The end of this chapter also includes an outline of the contents contained in this dissertation.

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2 Ibid., 5.

Introducing the Social Network of National Math Education

In this brief section, I offer a glimpse of the approach I used in analyzing national math education. Primarily, I offer an example that illustrates how I analyzed the people, and their organizational affiliations, involved in national math education events. This opposes analyzing the contents of these events. The power of such analysis rests with the perspective I outlined above, one that is put forth by anthropologist Janine Wedel. In short, "Emergent forms of governing, power, and influence ... play out not in formal organizations or among stable elites, but in social networks that operate within and among organizations at the nexus of private and official power."[3]

For example, one of the recent national math education events was a group of people who came together to draft a set of curricular goals in mathematics for students in US public schools. The document that resulted is the *College and Career Readiness Standards for Mathematics*[4] and provided the blueprint for the *Common Core State Standards for Mathematics*[5] that over 40 states have adopted as their curricular framework. The list of people writing the *College and Career Readiness Standards* included a "development team" and a "feedback group." Delineation between the two groups is provided by the National Governors Association's press release which announced the two groups: "The role of this Feedback Group is to provide information backed by research to inform the standards development process by offering expert input

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3 Ibid., 20.

4 *College and Career Readiness Standards for Mathematics: Draft for Review and Comment*, September 21, 2009, accessed July 31, 2011, http://www.gatesfoundation.org/united-states/Documents/MathStandardsSources.pdf.

5 Common Core State Standards Initiative. *Common Core State Standards for Mathematics*. accessed July 31, 2011, http://www.corestandards.org/assets/CCSSI_Math%20Standards.pdf.

on draft documents. Final decisions regarding the common core standards document will be made by the Standards Development Work Group. The Feedback Group will play an advisory role, not a decision-making role in the process."[6] In other words, the development group is the primary author of these curricular goals. Since they determined the contents of the standards adopted by over 40 states, I argue this group as the most influential in the development of the new national math standards.

Of the 15 people on the Development Workgroup, several are employees in the educational testing industry, including ACT and College Board. One member, Phil Daro, works for America's Choice, a company that provides professional development for math teachers and was recently bought out by Pearson, an educational corporation. Thus the interest in national math education by educational business has already been made clear. Furthermore, America's Choice was initially founded by the National Center On Education and the Economy (NCEE), a research and policy institute that aims to shape public education towards the needs of business. Specifically, they seek an education that develops in students the intangible qualities required to be a productive worker, something I will refer to as human capital throughout this dissertation. In light of this, funding for NCEE comes from the likes of Apple, Kodak and Walmart. Another research and policy institute that is well represented in this national math education event is Achieve, Inc. They are funded by Gates, Boeing, Hewlett, GE, IBM, JP Morgan Chase, Intel, and Prudential, among others. Therefore, this event indicates another interest in

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6 National Governors Association. *Press Release: Common Core State Standards Development Team and Feedback Group Announced,* July 1, 2009, printed from the National Governors Association website, www.nga.org.

national math education, that of the corporations that find math education useful for developing the workers they need.

I offer this brief example to introduce how I looked at the organizations in the social network surrounding national math education. Ultimately, my construction of a representative social network surrounding national math education is more involved than what I describe here, but it does rest primarily on looking at the individuals involved in such national math education events and their links to other organizations. I will outline my methods in detail in chapter 2. This example also indicated the two primary interests in national math education, that of educational business and, more generally, businesses who seek to use math education as a means to develop the kinds of workers they need.

Introducing the Trends in National Math Education

As I outlined with the brief example above, math education "in the national interest" actually is in the interest of corporations, mostly for its role in developing human capital and providing a scenario for educational businesses to make their profits. National math education exists primarily to develop those intangible qualities of productive workers. This is the subject of chapter 3, where I detail the several network actors who hold the interest, those that represent the interest (mainly because they are funded by corporations that hold the interest), and the many academics who adopt the interest. I also include how the educational businesses adopt this purpose for math education to advance their own interest in providing services related to the development of human capital.

Adopting the development of human capital as the primary purpose of national math education is a phenomenon that corresponds to Wedel's understanding of the individuals in these social networks surrounding public policy. Terming them "flexians," she posits that actors adopt other interests to advance their own. The several academics in the network adopt the interest of human capital to advance their own interests, which I describe in chapters 4 and 5.

Chapter 4 discusses the academic debate between the mathematicians and math education researchers in the representative social network surrounding national math education that I constructed. Specifically, most of the involved mathematicians desire a traditional math education comprising teacher-directed learning that emphasizes the learning of math facts and computations. Most of the involved math education researchers desire a progressive math education comprising student-directed learning that emphasizes problem-solving and mathematical reasoning. In the chapter I argue how both align themselves with the development of human capital. For example, the progressivist position resonates quite strongly with the writings on education by economic institutions such as the Organization for Economic Cooperation and Development (OECD); each focuses on education for problem-solving, collaboration and independent learning. On the other hand, the traditionalist perspective emphasizes a moral of hard work, an intangible quality I argue as useful for corporations.

Chapter 5 discusses another interest that the academics in the network put forth: that US math teachers do not know enough mathematics to teach effectively. There I highlight evidence from this network trend to indicate that this point is dubious. I also argue that the myth is a necessary component to the goals of educating for human capital, because it can be used to re-educate practicing math teachers in this interest as well as focus the preparation of future math teachers on only those aspects helpful to the goal. Taken together, both chapter 4's "Math Wars" and chapter 5's teacher mythology align themselves with the primary purpose of national math education: educating for the development of human capital. The involved academics have adopted the business interest of educating for human capital and aligned their particular academic interests with this goal.

The auxiliary business interest in the social context of national math education comes from the educational businesses who attempt to provide the services to develop human capital. I introduce their alignment to human capital in chapter 3, but in chapter 6 attend to their activities which includes primarily the service to test students and then use these tests to evaluate teachers. Ultimately, the services in their current form indicate a striking example of disharmony in the social network surrounding national math education. The testing services do not fulfill all the components of educating for human capital, and specifically lack one of the most talked about: the problem-solving, collaboration and independent learning needed by the contemporary knowledge economy. I argue this occurs because educational businesses find this service too costly to provide. Therefore, while educational businesses answer the call to develop human capital, their own interest to efficiently provide educational services undermines the goal.

Here I also introduce a few other considerations regarding this particular tension in national math education. Viewing it another way, educational businesses are providing services that align closer to the traditional perspective on math education rather than the progressive. As I will argue in chapter 4, the human capital skills of problem-solving, collaboration and independent learning align with the progressivist perspective on math education. Economic organizations like the World Bank and Organization for Economic Cooperation and Development (OECD) find these skills necessary for contemporary workers. As I've mentioned, the primary interest in national math education is to develop productive workers, however, it seems that the traditional perspective holds greater power than the progressivist. This power is seen not from the fact that the educational business services align with the traditionalists. It is better evidenced by the *Common Core State Standards',* the new national math standards, shift towards the traditional. For example, these standards remove statistics from the elementary school curriculum, de-emphasize calculator use, emphasize basic math facts, and provide a rigid structure that progresses from one topic to the next (see chapter 4 for the basic differences between traditional and progressive pedagogy). Therefore, in discussing national math education, one question of interest becomes, if the primary goal is to use math education to develop human capital, and if progressivists articulate the means to do this, then why does traditional math education enjoy its current success?

As I have already suggested, one reason for the traditional triumph may be due to the educational businesses in the network. There, they may attempt to shape policy in ways that help to keep their own costs low. However, I will also introduce two other possibilities for now. The first is related to educational businesses. Not only do they have their particular profit motives driving them to shape policy, they are now entangling with the larger, more profitable and powerful information and communications technology (ICT) industry. This is clearly seen by educational business' shift to online instruction and assessment services. For example, Phil Daro, the member of the writing team I mentioned earlier, was recently announced to lead the research and development on a new package of digital instructional resources. Funding the project are the foundations of Bill Gates, founder of Microsoft, and Pearson, a large educational corporation. I am suggesting that educational business' might is increased by their coupling with ICT. This could impact the debate over traditional and progressive pedagogy, most likely in the former's favor.

As to a second possibility regarding the traditional triumph, Michael Apple suggests that the corporate push for developing human capital with math education is actually rhetorical, going unfunded but giving support to our belief in equal opportunity for all.[7] I argue that Apple is, in part, correct. As I have introduced, the progressivist aspects to developing human capital seem merely rhetorical. However, the traditionalist aspects of national math education are being executed and, as I will argue, do satisfy other needs for the development of human capital. These include a moral education of hard work and a means by which to sort workers into the producers and professionals in the economy. In other words, it could be that the tension I described earlier, between educational business and the interest to develop human capital, does not exist. As it stands, national math education contributes to human capital in certain, but not all, ways. Time will tell whether the human capital interest is satisfied with the educational business' emphasis on traditional math education.

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7 Michael W. Apple, "Do the Standards Go Far Enough? Power, Policy and Practice in Mathematics Education," *Journal for Research in Mathematics Education* 23, No. 5 (1992): 421.

Before concluding this section, I want to introduce the findings from my analysis in one other manner. Should the trends in national math education continue, we can imagine the future of national math education as follows: The teaching of math is a priority. In elementary school, math is the new “special,” the name for classes that elementary students used to have, like art, music, etc. There and across the grades, math is taught by “math specialists” and with software run on a computer. Instruction emphasizes the learning of math facts and procedures. All students are assessed by the same educational company at least three times a year from grades 3 to 11, and this happens online as well. The students' teachers are evaluated by how much value they add to each child, as determined by another company's analysis of student progress throughout the year. Teachers may or may not receive bonuses for this success, but generally math teachers with strong math backgrounds are paid more than teachers without such backgrounds. Since the instruction will be delivered online, teachers will primarily establish a moral of hard work while their students do their learning online. Teachers who do not educate using these materials or with the goal to develop human capital will be easily removed from their jobs, given the loss of teacher job security.

In this section, I have briefly introduced the trends in national math education I found by analyzing its social network. These include the primary and auxiliary interests of developing human capital and educational businesses, respectively. These interests have inherent contradictions, and I introduced some possible explanations for this. I have also brought up the academic interests, of math pedagogies and teacher content knowledge, in the network and how they correspond to the goal to develop human capital. While I argue that these business and academic interests have come to impact policy in ways not seen yet, the historical sketch of national math education in the 20th century that follows will indicate that these themes are not young.

Sketching the Historical Context of National Math Education

In what follows, I sketch the historical beginnings of a national mathematics education that occurred in the latter half of the twentieth century. This includes presenting famous and influential statements on national math education as well as specific actions taken by individuals, private organizations and groups of people in the interest of a national math education. Sketching these statements and actions from history reveals a concern with a national math education that will strengthen the US military and US economy and an emerging debate between progressive (student-centered, process-oriented) and traditional (teacher-directed, content-oriented) pedagogy.

As for the events in national math education, I cover the following statements and actions: a well-circulated statement on math education by Admiral Nimitz during World War II, the Soviet launch of Sputnik and subsequent National Defense Education Act (NDEA) that sponsored the "new math," the "Back to Basics" movement of the 1970s, *A Nation At Risk's* emphasis on math education and economic security, the National Council of Teachers of Mathematics (NCTM) 1989 *Standards*, sometimes referred to as the "new-new math," and opposition by parents and mathematicians to this new-new math.

The first national math education statement included in my historical sketch is a letter written by Admiral Nimitz regarding his concern that people joining the US Navy lacked mathematical knowledge useful for both basic and advanced Naval operations.[8] As I will explain, the letter represents a national math education in the interest of US military needs and a commitment to traditional math education. The latter commitment is also embedded in a broader backlash against the progressive era's reforms in education.

Citing specific deficiencies in arithmetic reasoning and trigonometry, Nimitz argued that those in Naval training programs are insufficiently prepared to learn the techniques of navigation, fire control and other aspects related to "vital branches of the naval officer's profession."[9] As a result of the letter, dialogue ensued among military officials and more of them began to openly criticize math education's faulty preparation for the needs of the military. Such letters were published in *National Association of Secondary School Principals Bulletin* and *Mathematics Teacher,*[10] aiming to affect changes in the orientations and practice of school administrators and teachers. The Nimitz letter clearly advocates the learning of mathematics for the needs of the US military.

In addition, at least one scholar situates complaints like that of Admiral Nimitz within a general response to the progressive era's influence on math education.[11] Progressive era goals for education included the development of those attitudes, skills and knowledge needed by large corporations; along these lines changes to school instruction included the introduction of group work and problem solving in the place of

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8 This letter can be found in "War Time Editorials," *Mathematics Teacher* 100 (Special issue: 100 Years of *Mathematics Teacher*): 24-25.

9 Ibid., 25.

10 Alan W. Garrett, "Teaching with 'Fanfare and Military Glamour': School Mathematics, the Federal Government, and World War II," *The Educational Forum* 67 (Spring 2003): 228.

11 Ibid., 226.

traditional drill and practice performed by individuals.[12] Such changes in this era specifically opposed why and how math education was taught before the progressive reform: for increasing "mental discipline" and by an individual's drilling and practice.[13] "Critics of school mathematics argued it was a relic that had outlived its usefulness and should play a significantly reduced role in the curriculum."[14] These changes were noticed by professors and military officials, who pointed to the low passing rates on entrance exams testing basic math computation. As with Admiral Nimitz, these observations were made public and prompted significant debate about the need for a specific math education in all public schools.

This first instance of national math education calls attention to a purpose for math education as well as differences in pedagogy, specifically distinctions between the progressive and traditional. As I continue the sketch, I intend my use of these latter terms to suggest the following. Progressive pedagogy, initially successful because it prepared students to meet the needs of large corporations, concerns problem-solving, group work and practical knowledge. Traditional pedagogy, born out of a desire to increase "mental discipline," attends to the drilling of math computation. Notably, the first instance in this historical sketch on math education suggests an alliance between a math education that serves the needs of the US military with a math education that is traditional. Ironically, the next instance I focus on shatters this alliance. The Cold War's influence on math education, namely something now referred to as the "new math," seemed to side with

12 Joel Spring, *Education and the Rise of the Corporate State*. Boston: Beacon, 1972.

13 David Klein, "A Brief History of American K-12 Mathematics Education in the 20th Century," in *Mathematical Cognition*, ed. James Royer (location: Information Age Publishing, 2003): 175-259.

14 Garrett, "Teaching with Fanfare," 226.

progressive pedagogy and would result in a backlash from those interested in maintaining traditional math education.

The Soviet launch of Sputnik resulted in federal education policy that again asserted math education's significance for the US military, but this time did not commit to traditional math education. Eisenhower's National Defense Education Act (NDEA) resulted in a group of mathematicians working under the National Science Foundation (NSF). Their work to develop a new high school curriculum was dubbed the "new math" and contained elements of the progressive era's education reforms, although not all of these. Ultimately, the new math was a failure when implemented and resulted in a return to traditional pedagogy.

"Immediately after the launching of Sputnik I, President Dwight D. Eisenhower ... outlined a relationship between education and the Cold War strategy."[15] Eisenhower's statement gives more accurate meaning to the National Defense Education Act (NDEA) of 1958, a piece of legislation that provided five avenues for increasing federal involvement in public schools. These avenues included increasing money for the research and development of innovative programs at NSF, as well as granting federal dollars to public schools that adopted these and other programs in the interest of national defense. "As a consequence, the NDEA became a means by which the federal government could control local educational policy simply by offering money for the establishment of specified educational programs."[16] [17] All aspects of NDEA thus

15 Joel Spring. *The American School: 1642-2000, Fifth Edition*. New York: McGraw-Hill, 2000: 369.

16 Ibid., 370.

17 This Federal action to enact policy outside its jurisdiction continued well beyond the NDEA, as for example with a state's increased competitiveness in the "Race to the Top" program with its adoption of the *Common Core State Standard.*

forcefully connected many public schools to an education that serves the US military, this time more strongly than the World War II rhetoric described above.

The innovative programs coming from NDEA's money to NSF affecting math education in US schools was the work of the School Mathematics Study Group (SMSG). Under the direction of Edward S. Begle, this group's work to develop a replacement curriculum for secondary schools represents the new math of the 1960's. Their curriculum clearly orients math education away from the practical and towards pure mathematics, a branch of math attending only to abstract concepts. It included the additions of "set theory, modular arithmetic, and symbolic logic" into the high school content.[18] Critics addressed the curriculum's lack of practical mathematics, e.g. the complaints of physicists as mentioned in a letter addressed to Begle.[19] Some physicists and other scientists were concerned that such overemphasis on abstract mathematics would prevent students from being able to apply the mathematics useful in their domains. An example of this might have been using algebraic formulas to solve concrete physics problems.

The political context (NDEA) of the new math clearly suggests its commitment to math education for national defense. However, the specific contents of the new math react significantly against traditional math education, while simultaneously articulate alliance with and opposition to progressive math education pedagogy. Progressive pedagogy considered problem solving when faced with new circumstances as essential for the development of a talented workforce. The new math presented the training of such skill with its emphasis on prompting "students to discover mathematical principles on

[18] Alan Schoenfeld, "The Math Wars," *Educational Policy 18*, 1 (January and March 2004): 257.
[19] The letter from mathematician E.J. McShane can be found in *FOCUS* (December 2006): 7.

their own"[20] and then solve abstract problems. On the other hand, the new math's emphasis on pure mathematics completely lacks the progressive reform's attention to learning that continuously maintains a connection to the concrete.

Ultimately, this new math failed in implementation and heralded a return to a traditional math education in the 1970s[21]. Two scholars[22] both blame its failure on the excesses of pure mathematics in the curriculum as well as the inability of parents and teachers to teach a high level curriculum. Historical support for these claims are not present, and instead academic opposition to the new math is clear, including those like the physicists above and, perhaps surprisingly, other mathematicians. "In 1962, a letter entitled *On The Mathematics Curriculum Of The High School*, signed by 64 prominent mathematicians, was published in the *American Mathematical Monthly* and *The Mathematics Teacher*. The letter criticized New Math and offered some general guidelines and principles for future curricula."[23] This moment in history demonstrates that mathematicians do not always agree on what is best for math education. The new math failed at least in part for its lack of broad-based support by the mathematical community. In the years to come, this debate between progressive and traditional pedagogy would continue, but next as prompted by the needs of the US economy, rather than US military.

The publication and dissemination of *A Nation at Risk* once again prompted a conversation on national math education, this time with an interest in the national economy. Such conversation resulted in the National Council of Teachers of

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20 Kristy Sorenson, "The School Mathematics Study Group Records" Mathematical Association of America, July 12, 2010, http://www.maa.org/spotlight/smsg.html.
21 Schoenfeld, "The Math Wars," 258.
22 Klein, "A Brief History" and Schoenfeld, "The Math Wars."
23 Klein, "A Brief History," 185.

Mathematics' (NCTM) attempt to draft national standards to increase the US economy's success in the global market. Additionally these standards represented an opposition to traditional math education and increased attention towards an emerging perspective regarding mathematical cognition. Reactions to these standards once again point to disagreements within the mathematical community, as was the case with the new math of the Cold War.

Distinct from the earlier concerns with military intervention against fascism and Communism, the 1980s national concern primarily addressed the US competition "with Japan and West Germany in world markets."[24] Such economic concern prompted the administration under President Reagan to write and disseminate *A Nation at Risk*, a document that flags US schools, and specifically math education, as key to improving the US economy's competitiveness. As proof of this failure, the document highlights that students in the US scored lower than other countries on the Second International Mathematics Study. Despite Reagan and Republican efforts to decrease federal involvement in schools, "the net effect of Republican actions was to ensure that education would remain a national issue."[25] Thus, *A Nation at Risk* implied the need for a national math education.

Thus ensued conversations for math education in the economic national interest and specific national math education curricular standards. One private organization, the National Council of Teachers of Mathematics (NCTM) took up the call to improve such

[24] Spring, *American School,* 431.
[25] Ibid., 431.

math education[26] and drafted national math education standards six years after *A Nation at Risk*. The 1989 *Curriculum and Evaluation Standards for School Mathematics* ("*Standards*")[27] aligned with math education for the US economy and a progressive pedagogy. As noted by Gutstein,[28] the *Standards* are framed by the societal goal to create "mathematically literate workers." In the following quote from the document, this goal is elaborated and connected to an opposition to traditional math education:

> Today, economic survival and growth are dependent on new factories established to produce complex products and services with very short market cycles...Traditional notions of basic mathematical competence have been outstripped by ever-higher expectations of the skills and knowledge of workers; new methods of production demand a technologically competent work force...Businesses no longer seek workers with strong backs, clever hands, and 'shopkeeper' arithmetic skills.[29]

In this first societal goal, the *Standards* preserve progressive education's original commitments to business, as outlined above and by Spring.[30] This preservation continues with a consideration of two of the *Standards'* other societal goals. First, the *Standards* describes the societal goal of "lifelong learning" as the need for a flexible workforce as required by modern business.[31] Second, "opportunity for all" means that these *Standards* will eradicate math education's role as a "filter" that prevents "women and various ethnic groups" from gaining employment.[32] To the latter point, the *Standards* do not suggest that

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26 Schoenfeld, "Math Wars," 259-262.
27 National Council of Teachers of Mathematics (NCTM). *Curriculum and Evaluation Standards for School Mathematics*. (Reston: VA, National Council of Teachers of Mathematics, 1989).
28 Eric Gutstein. *Reading and Writing the World With Mathematics: Toward a Pedagogy for Social Justice. (*New York: Routledge, 2006), 7-8.
29 NCTM, *Standards,* p. 3
30 Spring, *Education and Corporate State.*
31 NCTM, *Standards*, p. 4
32 NCTM, *Standards*, p. 4

the playing field will be leveled amongst women, various ethnic groups and white males, but instead that *all* educated will be employable in the workforce. This represents business interests by increasing the number of able employees.[33] Such a goal does not necessarily imply that employment would eradicate the economic oppression of certain groups because "while workers and business leaders share a common interest in an improved economy, there is an inherent conflict between the desire of workers for increased wages and the desire of business leaders to reduce wages."[34] In other words, increasing the employment of persons would not guarantee reasonable remunerations in return for work or the eradication of pay differentials between different groups, especially if these reforms are motivated primarily by the businesses themselves. Spring points out that during the 1980s, an increasing alliance between businesses and schools coexisted with a greater stratification of wealth between high and low income groups.[35]

The 1989 recapitulation of progressive education and the business interest made more impact because much academic work in mathematical cognition further justified the pedagogies of progressive education.[36] In the 1970s and 1980s, research on mathematical thinking, including that of expert mathematicians, asserted the centrality of problem-solving and innovation in mathematics:

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33 To be clear, the *Standards* "opportunity for all" societal goal also signifies ideas pertaining to various notions of social justice, such as redistributing resources to eradicate continual oppression of certain groups of persons. My presentation of the *Standards* resonates with the following contribution from Michael Apple(1992. Do the standards go far enough? Power, policy, and practice in mathematics education. Journal for Research in Mathematics Education, 23(5), 412-431) : The *Standards* use a "slogan system" in order to bring together a variety of ideas under one umbrella. Yet the most present and formidable interests, as I argue in this case those of business, are the primary motivations behind the "opportunity for all" societal goal.

34 Spring, *American School*, 433.

35 Ibid., 433.

36 Schoenfeld, "Math Wars", 262.

> In short, mathematical competence was shown to depend on a number of factors: having a strong knowledge base; having access to productive problem-solving strategies; making effective use of the knowledge one has (this is known as meta- cognition); and having a set of productive beliefs about oneself and the mathematical enterprise (which position the individual to act in mathematically appropriate ways).[37]

With this knowledge the goal became to make the math education experience similar to the work of mathematicians. Students should problem solve and develop mathematics, all the while remaining confident in their ability to do so. These descriptions of mathematical cognition and a math education informed by such resonate with the needs of business. Whether business interests clouded the research findings or that the research findings merely aligned with them is a question beyond the scope of this historical sketch. However, I highlight this alliance between these academic findings and the increasingly powerful business interests (as suggested by Spring) because it strikes resemblance to the kind of synergy that takes place in the social network surrounding present day national math education, the object of study in this dissertation.

Such significant backing by the academic community, coupled with the attention to math education for the US economy and increasing business interest in schools, propelled the *Standards* to greater success in implementation than its preceding attempt to reform traditional education (the new math of the Cold War). The National Science Foundation (NSF), a federal government agency, "issued requests for proposals for the development of curricula consistent with the *Standards*. It went on to fund four centers devoted to the support of standards-based curricula ."[38] Financial support from NSF,

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[37] Ibid., 263.
[38] Schoenfeld, 2004, 269.

private foundations and corporations aided in local districts' implementation of these new curricula.[39]

By its critics, these developments in schools were often dubbed the "new-new math" primarily to suggest the *Standards'* attempt to reform traditional math education. Reaction included the new-new math's de-emphasizing of memorizing multiplication tables or learning of the division algorithm.[40] As with historical accounts of the new math, parents and teachers are included in this reaction against the new-new math, but I argue their significance to be shadowed by that of the mathematicians and mathematician/engineer parents who reacted strongly against the new-new math.

The so-called "math wars"[41] centered on the progressive pedagogic aspects of the new-new math, rather than attending to the business interests embedded in them. The following presents one account of an initial act of such opposition:

> The first significant parental rebellion in California occurred in Palo Alto, a highly educated community that included Stanford University faculty and business leaders. In May 1994, more than 600 parents signed a petition asking that the school district retain a traditional pre-algebra curriculum at one of the middle schools in the Palo Alto Unified School District. The district was about to replace the remaining traditional courses with a math program aligned to California's 1992 math framework. Finding the district uncooperative, 25 parents in Palo Alto formed "Honest and Open Logical Debate," or HOLD in February 1995, put up a website the next month, and within a short period of time there were nearly 500 households on the HOLD mailing list. The already considerable math credentials of HOLD members were increased by the support and participation of Henry Alder, a professor of mathematics at UC Davis, a former president of the Mathematical Association of America, and a former member of the California State Board of Education. Alder had long been advocating themes similar to those of HOLD.[42]

[39] Klein, "A Brief History."
[40] An example of this de-emphasis can be found on page 71 of *Standards, 1989*.
[41] e.g., Schoenfeld, "Math Wars" and Klein, "A Brief History."
[42] Klein, "A Brief History," 204.

Such account signals attention to the mathematicians and engineering parents that converged forces to oppose the new-new math. Primarily, this opposition asserted superior math knowledge to that of the math educators who had written the *Standards*, or so groups like HOLD were to suggest.

To the contrary, writers and advocates of the *Standards* included some mathematicians well respected in their field, such as Lynn Steen (a *Standards* author) and Hyman Bass (an advocate for the *Standards*-based California state standards[43]). These efforts of opposing mathematician groups like HOLD made significant impact on math education policy in states, such as the 1999 rewriting of California state standards. As with the new math of the Cold War era, opposition to the new-new math and its failure in widespread implementation primarily focused on disagreements among mathematicians and/or math educators.

In discussing the math wars, Schoenfeld suggests an ideological split between these advocates of reform and traditional math education. He contends that the *Standards* resonate with a social mobility perspective on education, in which “schools should serve the needs of individuals by providing the means of gaining advantage in competitions for social mobility.” On the other hand, the opposition to the new-new math represents a social efficiency perspective, where the goal is “that schools should serve the needs of the social and economic order by training students to occupy different positions in society and the economy.”[44] While these two variations have different pedagogical implications, I

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[43] Schoenfeld, “Math Wars,” 275.
[44] Ibid., 255.

offer that both can serve the concerns for US economic competitiveness as expressed in *A Nation At Risk*. As I will explain in chapter 4, representatives of the federal government recognized the contributions to business from both sides of the math wars, and pleaded with each side to compromise and "reach common ground."

Thus concludes my historical sketch of the seeds of a national math education. I began with motivations from the military in World War II and ended with the shift away from the new-new math, as evidenced by California's state standards revision in 1999. Throughout this sketch I have called attention to the primary motivations for a national math education and the debates as to whether this education should align with progressive or traditional pedagogies. The first half of this time period math education was argued to serve the US military and in the second half to strengthen the US economy. At different times in history, both of these interests have aligned with either traditional or progressive pedagogy, and both of these camps have increased their political power through cooperation and research to justify their cause.

In the chapters to follow I present my analysis of the social context behind contemporary national math education. Many of the themes presented in this historical sketch will come up again, including education in the business and military interest (in chapter 2, where I elaborate on education for human capital) as well as the progressive and traditional perspectives that both situate within these interests. The two other primary themes in math education, the content knowledge deficits of teachers and a math education that fuels an education services sector, will also grow out of the previous events I have outlined here.

Additionally, this historical sketch has presented at least one example of the agreement between academic work and other interests, in that case the interest of businesses. Instances of such accordance present significant advantage for the individuals and organizations involved to affect policy change. This trend of accordances has been argued by Wedel to increasingly determine policy outcomes, and it is for this reason that the social network surrounding contemporary national math education is the unit of analysis in studying national math education.

Chapter Outline

My dissertation uses a unique approach to analyze the social network surrounding national math education. In this chapter I introduced my approach centering on the individuals and their links to the interests of private organizations. I also indicated the predominant interests in national math education as the development of human capital and the interest of educational businesses. Similarly, my historical sketch of the beginnings of national math education centered on significant interest in math education for the national military and economy as well as a debate over traditional versus progressive pedagogy. As I will elaborate on in greater detail, these themes increase their strength in today's efforts towards national math education. I now present brief sketches of the chapters that follow.

In the next chapter, I elaborate on my method for constructing and analyzing the social network surrounding national math education. This includes a review of the field of social network analysis and more elaboration on Wedel and other work influential to my unique approach. I then present the process of constructing my representative social network surrounding national math education. I also introduce the way in which I read the network for its primary interests and themes.

In chapter 3, I discuss the primary interest I found in my analysis of the social network: math education for human capital. This interest continues the themes of military and economy concerns that were presented in the historical sketch. There I elaborate on the notion of human capital, introducing the relevant theorists who are not in my network but whose ideas are contained in it. I next present the surprising variety and number of actors in the social network who align themselves with this interest. This includes academics who claim math education's role in the US economy and those whose research compares US math education to that of other countries. A push for a "coherent national math curriculum" is born out of the network's commitment to human capital; notably the result rests on this country's appropriation of methods from authoritarian Capitalist countries.

Chapter 4's theme also concerns matters from the historical sketch, this time the debate over traditional and progressive pedagogy. The social network includes many actors advocating for either traditional or progressive pedagogy in national math education. However, I use instances of this debates' explicit connections to human capital to suggest that more generally, both sides of the debate contribute to the needs of human capital. The progressivists' pedagogic stance contributes to educating for human capital with its resonance to the knowledge economy and its notion of equity, which increases the number of people able to be employed. The traditionalist perspective offers a means to sort students into professionals and producers in the economy and also includes a moral education centered on hard work.

Chapter 5 attends to the point on which the academics in the network agree: the content knowledge deficits of math teachers. Among those who agree that teachers of math do not know (enough) math are math teacher educators, mathematicians and policy institutes seeking to blame teachers for the problems of education. Interestingly, some academics in the network who support this idea happened to produce research that does not support the claim that US math teachers have deficiencies in knowledge. However, math teacher knowledge deficits is still placed on the national math education stage for the ways the idea can contribute to the primary interests in national math education, developing human capital. There I argue the ways that promoting the myth that math teachers do not know math enables the shifting of teaching policy and practice towards the goals of human capital.

Chapter 6 attends to the auxiliary interest in national math education, that of educational businesses. Of these, testing is the predominant industry in my social network and I detail how private organizations and the federal government encouraged the creation of testing megacontracts for educational businesses in my network. I also cover the academics in my network who support this industry, including those working in the field of psychometrics. Lastly, I elaborate on the contradictions between educating for human capital and the educational business interest.

I begin my concluding chapter with examples of the variety of tensions existing among the interests in national math education. These tensions suggest that some stated interests in national math education will go unsatisfied. I use these circumstances to put forth that, indeed, the purported objective of national math education, to increase the knowledge and use of mathematics by people living in the US, will fail. I argue the limitations of a national math education with human capital and educational businesses as its primary interests, with specific attention to the limitations to content and teaching. These lead to a brief articulation of alternatives to national math education as well as my personal appeal to fellow math enthusiasts and those with a specific interest in math education.

Chapter 2: Social Network Analysis and National Math Education

In this chapter I review particular perspectives on contemporary governance and methods in social network analysis that inspired my unique inquiry into national math education. The historical sketch in the first chapter focused on the economic and militaristic interests, as well as academic debates over traditional and progressive pedagogy, that began to present themselves in conversations about math education. These interests have grown and, in particular, their usefulness to corporate profit has increased the chances for policies relating to national math education policy. Primarily, I use Janine Wedel's[45] description of new “forms of governing”[46] as the means by which these interests have gained a greater hold in both the conversations regarding math education within the US and policy actions that begin to establish a nascent national math education. These structures function as “nexus of private and official power,” where “social networks ... operate within and among organizations.”[47] Accordingly, I identified an example from each structure relevant to national math education and then constructed the social network for that event. Taken together, the three events offer a representative social network surrounding national math education. With the consideration of methods in social network analysis as I include here, the complete social network surrounding national math education is difficult or impossible to obtain. In light of this, my representative network indicates the types of organizations and people and their interests and actions that exist in the complete social network surrounding national math education

45 Janine Wedel, *Shadow Elite: How the World's New Power Brokers Undermine Democracy, Government, and the Free Market* (New York: Basic Books, 2009).
46 Wedel, *Shadow Elite,* 20.
47 Ibid., 20.

I begin with more detail about Wedel's perspective on the newly emerging "forms of governing." I next review examples from among the active world of social network analysis, indicating how each might contribute to my methods for inquiry. This ultimately leads to an articulation of my exact approach in identifying the network and next the details of the network that I found. There I detail both the nature of the national math education "events" that correspond to Wedel's "forms of governing" and my reasons for selecting them instead of other options. In this chapter's final section, I describe my process of "reading the network" that allowed me to make the conclusions presented in chapters 3 through 6.

The Shadow Elite and New Forms of Governing

In this section, I elaborate on Wedel's perspective on contemporary governance, including new structures that afford greater and less obvious influence by the private on public-policy, and her focus on the individuals that move between these structures and official government. The "shadow elite" denotes her perspective regarding a more nebulous, shifting and unstable, and thereby more formidable, power elite than previous theorists describe, such as C. Wright Mills. Specifically, she details the new forms of governing, such as Federal Advisory Committees, as ways for this shadow elite to enact policy in their interests, rather than those of the public. Her contributions resonate with other approaches in social network analysis that I will review in the section following this one. These considerations will lead to my process for identifying the social network surrounding national math education.

Wedel argues that a "shadow elite" of individuals and organizations increasingly determine policy, rather than a transparent governmental process with direct oversight by the public. Her idea builds off earlier contributions from Mills, specifically his "power elite"[48] comprised of groups of powerful individuals like celebrities, CEOs and military leadership. Mills argued these groups as stable, cooperative and thereby powerful, as opposed to the "mass society" that is "politically fragmented ... and increasingly powerless."[49] Now, Wedel describes the powerful as "less stable, less visible, and more global in reach...Emergent forms of governing, power, and influence thus play out not in formal organizations or among stable elites, but in social networks that operate within and among organizations at the nexus of official and private power."[50] My inquiry into the emerging United States' national math education focuses on identifying and studying the social network that moves its creation forward.

As Wedel indicates in the quotes above, the success of social networks surrounding public-policy relies on blending official, public government with private organizations. This blending occurs via what Wedel calls "new forms of governing." Examples of these include an increase in the number of and influence by quasi-governmental organizations and federal advisory committees, the contracting out of government work to private organizations, and a shifting focus of policy and research institutes away from objective study and towards ideological or industry motivations. I elaborate on each of these state-private hybrid structures in the subsequent paragraphs

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[48] C. Wright Mills, *Power Elite,* (New York: Oxford University Press, 1956).
[49] Ibid., 324.
[50] Wedel, *Shadow Elite,* 20.

and provide examples in the context of national math education.

The first of these new forms of governing, quasi-governmental organizations, describes those organizations with both private and public legal characteristics. Wedel writes, “In recent years, both Congress and the President have increasingly used hybrid organizations for the implementation of public policy functions traditionally assigned to executive departments and agencies.”[51] Quasi-governmental organizations have been further categorized by Kevin Kosar, who indicates a spectrum of organizations from those that are mostly state to those that are mostly private. Moving along this spectrum are “Government-Sponsored Enterprises,” “Federally Funded Research and Development Centers (FFRDC)” “Agency-Related Nonprofit Organizations, (ARNOs)” “Venture Capital Funds,” and “Congressionally Chartered Nonprofit Organizations. (CCNO)” The variations in these organizations include more and less oversight from government agencies and more and less funding from government agencies. Many, though not all, of these categories apply to the national math education arena. Examples in national math education include: 1) the inclusion of FFRDC Sandia National Laboratory in my representative network surrounding national math education, 2) math education research centers dependent on federal funding, e.g. the “Instructional Research Group,” an Agency-Related Nonprofit, and 3) the Mathematical Sciences Education Board (MSEB) of the National Academy of Sciences' National Research Council, a Congressionally Chartered Nonprofit Corporation, which has produced several statements on national

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[51] Kosar, Kevin R, *The Quasi Government: Hybrid Organizations with Both Government and Private Sector Legal Characteristics*, CRS Report for Congress, Washington, DC: Congressional Research Service, 1.

math education since the 1980s.

By their very nature, quasi-governmental organizations increase the opportunity for private interests to impact government. For example, many FFRDC's are managed by private companies, as is the case with Sandia National Laboratory whose work is outsourced to Lockheed Martin. Sandia develops nuclear weapons and other technology related to US defense systems and homeland security.[52] As Wedel points out, such blending of public and private presents significant problems for a government that purports to act on behalf of its citizens. In Sandia's case, private companies have unlimited access to confidential US military information that even its citizens cannot access. In many cases, these types of activities result in a situation where the US government merely “rubber stamps” the work of its contractors.[53] Furthermore, quasi-government organizations even “draft official documents,” thereby actually writing policy that most likely supports the private interests present in the organization.[54] Upon my creation of a representative social network surrounding nation math education, I found Sandia to be linked in the network. As I argue in more detail in chapter 3, this indicates that military industrial corporations hold an interest in national math education.

One center dependent on federal funding, an Agency-Related Nonprofit (ARN) related to national math education and also in my network, is the Instructional Research Group. Much of this organization's research are contracts from the US Department of Education's (USDOE) Institute of Education Sciences (IES), therefore I categorized it as

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52 Sandia National Laboratory, “About Sandia,” Accessed April 29, 2011, http://www.sandia.gov/about/index.html

53 Wedel, *Shadow Elite,* 86.

54 Ibid., 85.

a quasi-governmental organization because it is dependent on government agencies. The connection to private interests is made clearer upon reading the type of research that IRG promotes, which includes “randomized controlled trials,”[55] or experimental studies in education research. In chapter 6 I argue how the trend in national math education emphasizing experimental studies in education reflects the interest of educational businesses, specifically the testing industry.

An example of an influential Congressionally Chartered Nonprofit Organization (CCNO) on national math education is the National Academy of Sciences. CCNO's are mainly private organizations, with only one public characteristic: they were chartered by Congress and “honored” with the claim that the organization's activity acts in the national or patriotic interest.[56] Accordingly, CCNO's sometimes enjoy more of an “official government” status than they deserve. For instance, the National Academy of Sciences (NAS) receives general funding primarily from private sources. In addition, several of its activities are co-sponsored by private corporations and can include representatives from these. One NAS document related to national math education is *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*.[57] The committee writing this document included academics, as to be expected for a committee of the National *Academy of Sciences*; however, it also included corporate representatives from corporations, such as Craig Barrett, of Intel, Lee Raymond of

55 “Instructional Research Group” Accessed December 1, 2011, http://www.inresg.org. Note that this phrase has been removed in the website's current version.

56 Kosar, *Quasi Government,* 29.

57 National Academy of Sciences. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future Committee on Prospering in the Global Economy of the 21st Century:An Agenda for American Science and Technology,* (Washington, DC: National Academy Press, 2007) PDF available at http://www.nap.edu/catalog/11463.html.

ExxonMobil, and P. Roy Vagelos of Merck. In this case, representatives from the information and communications technology and pharmaceuticals industries indicate these private interests' concern with national math education. In chapter 3, I outline how these and other industries are well represented in the social network surrounding national math education.

Additionally, quasi-governmental organizations, especially CCNO's, can mislead the public into thinking that an organization is a part of the democratic government and acting in the public interest. This is true in the case of NAS, which houses the National Research Council's (NRC) Mathematical Sciences Education Board (MSEB). Upon my reading of the social network, I found one academic who served on MSEB and yet referred to his/her participation as on the "US Mathematical Education Sciences Board."[58] However, as I have indicated, the MSEB is in fact a subsidiary of a Congressionally Chartered Nonprofit and bears little oversight from federal agencies and significant funding from sources other than federal agencies. Instead, this actor's participation should read something like, "Served on the National Academy of Sciences' (or its subsidiary, National Research Council's) Mathematical Sciences Education Board." I do not suggest that this academic intentionally misrepresented the quality of his/her work. Instead, I use this to indicate that even the participants are confused by the nature of quasi-governmental organizations.

I have just reviewed three types of quasi-government organizations, or those groups that have both private and public legal characteristics. I also provided examples of

[58] To avoid possible public embarrassment to this individual, instead of citation I've asked the reader to take my word on this.

these organizations within the context of national math education, and indicated how each example introduces a private interest that might use national math education as a means to an end. These interests are connected to corporations that provide information and communications technology, military, and pharmaceutical services. As well, the interest of educational businesses, specifically the testing industry, are introduced. Upon my reading of the representative social network, these and other corporate interests hold the primary power in conversations on national math education. Next I turn to another of Janine Wedel's "form of governing."

Besides the increasing presence of quasi-government agencies, there are other "new forms of governing" that provide opportunities for social networks to encourage public policy to adopt private interests. One, Federal Advisory Committees (FACs), are comprised of individuals that have made contributions to a specific policy domain and are then appointed by government officials. The increasing significance of FAC's is signaled by providing "guidance to more than fifty government agencies" and havig been called the "fifth arm of government."[59] Wedel suggests that these committees are steeped in "might-be-private, might-be-public ambiguity,"[60] especially since the Federal Advisory Committee Act (FACA) allows portions of their meetings to be held in private. A famous federal advisory committee concerning national math education was the National Math Advisory Panel (NMAP) that was appointed by Secretary of Education Spellings in 2006 and concluded with their published document in 2008. The authoring of this document included the corporate interest, such as with the inclusion of the world's 80th richest man

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59 Wedel, *Shadow Elite,* 77.
60 Ibid., 101.

and financial executive James Simons.

The last of Wedel's “new form of governing” that I highlight is the shifting nature of research and policy institutes, something that further represents the increased presence of private interest in public policy. These think tanks “once enjoyed a greater reputation for scholarly distance from politics ... [but now] are more often partisan than neutral...Part of the usefulness of think tanks, from the point of view of their affiliates, is that they provide a veneer of neutrality and objective study.”[61] In other words, think tanks continue to project an image of objective policy analysis, however their research often promotes private interests, such as research leading to policies that enhance an industry's means for making profit. Examples of think tanks relevant to math education include the Fordham Institute's policy statements on math standards and math teachers and the Mathematical Sciences Research Institute's (MSRI) conference series titled “Critical Issues in Math Education.” The example that I use for the identification of a representative social network is the collaboration of three think tanks on the new *Common Core State Standards* in math. These are the National Governors Associations' Center for Best Practices, the Council of Chiefs of School State Offices and Achieve, Inc. Their collaboration resulted in a draft of math curricular standards that were adopted by almost all US states. This occurred because the federal government encouraged adoption by incentivizing such via the Race to the Top program of 2010. Such activity indicates the power of think tanks and their connection to both official government and policy.

Three of Wedel's “new forms of governing” informed the choices I made in

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61 Ibid., 102.

investigating national math education. I chose a math education event from the following nexus where social networks operate within and among official and private institutions: quasi-governmental organizations, Federal Advisory Committees and think tanks. I will discuss these selections in more detail when I reveal my representative social network surrounding national math education later in the chapter. Before moving to a discussion on social networks, I want to review one more phenomenon in contemporary governance that Wedel highlights. This is not an "emerging form of governing" per se, but proves relevant in my analysis of educational business in chapter 6.

This phenomenon, the contracting out of government work, has increased in recent years and furthers private sector influence on public policy in a particular way. "Upwards of three-quarters of the work of the federal government, measured in terms of jobs, is contracted out."[62] This extends not just to the services government provides, but to government actions leading to the creation of policy, such as policy research. Examples from the national math education arena include the contracting out of several Department of Education's research reports to private organizations, such as analysis of US students results on the PISA international assessment in 2009 that was executed by Windwalker Corporation and a Regional Education Laboratory report on the preparation of teachers.[63] Perhaps the most lucrative example comes with the awarding of testing

62 Ibid., 77.

63 Respectively, these are H.L. Fleischman, P.J. Hopstock, M.P. Pelczar, and B.E. Shelley, *Highlights From PISA 2009: Performance of U.S. 15-Year- Old Students in Reading, Mathematics, and Science Literacy in an International Context* (NCES 2011-004). (Washington, DC: U.S. Government Printing Office, U.S. Department of Education, National Center for Education Statistics, 2010) and A. Burke, *How well prepared and supported are new teachers? Results for the Northwest Region from the 2003/04 Schools and Staffing Survey. Results from the 2003/04 Schools and Staffing Survey.* (Issues & Answers Report, REL 2010–No. 097). (Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Northwest, 2010). Both available at http://ies.ed.gov/ncee/edlabs.

megacontracts to educational businesses, which I consider in more detail in chapter 6. Current and future contracts provide single corporations with the business of providing math testing of most students in the country. Furthermore, the services will increase in the number of times given to as much as 4 times per year and each year a student is in grades 3 through 11. These megacontracts are enabled by support from privately funded think tanks, like Achieve, Inc., and the federal government. Although I do not use outsourcing as a means to identify the social network surrounding national math education, Wedel's attention to this matter exists throughout the process of identifying and reading the network.

In this section, I have reviewed Wedel's perspective on quasi-government organizations, federal advisory committees, outsourcing of government work and think tank influences, that when taken together represent a new architecture of governance. They provide private interests with significant windows of opportunity into the public domain and thereby "[fray] the whole system of accountability."[64] What's more, these "private actors" influence all aspects of governance, including "policy making, implementation and enforcement"[65] and "encourage privatizations of heretofore officially available information and processes."[66] As she suggests, these "new forms of governing" provide the nexus where social networks of organizations influence the public policy process with private interests. Next, I turn to considerations relevant to creating a network.

64 Wedel, *Shadow Elite,* 76.
65 Ibid., 77.
66 Ibid., 10.

Social Network Analysis, Flexians and Interlocks

In the previous section, I presented how Janine Wedel's "new forms of governing" suggest three places in which to identify the social networks that introduce private interests in conversations about public policy. This led me to identify, accordingly, three national math education events for which I would construct a social network. Wedel's work presents a bit more thought on what is meant by "social network" and I include that here. However, her work did not provide significant inspiration for a method to identify social networks, and so I also review a handful of methodologies from social network analysis, including interlocks and complete network theory, that inspired my unique approach to constructing my representative network surrounding national math education.

To begin, I review the burgeoning field of social network analysis. This field is situated within a focus on networks that occurs across academic disciplines. Physicist Albert Laszlo Barabasi's *Linked: The New Science of Networks* introduces theories of networks and its variety of applications. The history of network theory originates with mathematicians, as Barabasi reminds us of Euler's famous Konigsburg Bridge Problem. Euler's proof that no path on the network can traverse each bridge exactly once (a quality known as a network's traversability) launched the branch of mathematics known as graph theory.[67] This theory, which names the elements of networks, formed much of the modern usage of networks including their ability to describe social phenomena. Mathematics' role in the further development of network theory has remained strong, including several aims

[67] Albert-László Barabási, *Linked: The New Science of Networks,* (Cambridge, MA: Perseus, 2002), 10-11.

at quantifying the elements within a given network.

Network theory has gained a foothold in the analysis of social phenomena and work in this area is typically denoted Social Network Analysis (SNA). SNA describes a broad range of theoretical and methodological variants as well as a variety of applications, among these are industry (especially applications to management practices) and policy studies. Introducing this particular field of network theory are John Scott's *Social Network Analysis: A Handbook*[68] as well as the website of the International Network of Social Network Analysis,[69] an online professional organization of academics using these or related methods. Common among users of SNA is an attempt to identify a network of actors (e.g. organizations and/or people) and the social links between them (e.g., occasions the two actors have interacted). Some use this network for investigating the structural relationships between actors; others use the method as a means to identify a social network, and then use other means to analyze it. Ultimately, my project fell into the latter category, mostly because my aims conflicted with any attempts to identify a complete social network.

One example of a method from among SNA's variants that I considered for its application to policy studies is "complete network analysis." Alejandra Real and Nicolas Hasanagas[70] attempted to identify the complete social network of policy related to environmentalist concerns in Canada. In attempting to find all actors in the network, they first compiled a list of possible actors from public sources, such as membership lists of

68 John Scott, *Social Network Analysis: A Handbook,* (Thousand Oaks, CA: Sage Publications, 2000).
69 The website of the International Network of Social Network Analysis is http://www.insna.org/.
70 Alejandra Real T. and Nicolas D. Hasanagas, "Complete Network Analysis in Research of Organized Interests and Policy Analysis: Indicators, Methodical Aspects and Challenges" *CONNECTIONS* 26, No. 2 (2005): 89-106.

environmentalist organizations. They then contacted those on the list and asked them for the names of other people with whom they discussed relevant policy, only including those that were active in the policy domain (e.g. ignoring friends and family). They continued in this fashion until no new names were identified. Once all actors were identified, they then surveyed all names on their list. Questions of the actors included the frequency of contact with other names on the list as well as individual stances within the policy arena. Results to these questions were analyzed in looking for trends in these stances and isolation of particular actors. In particular, they developed an algorithm that used the frequency of contact (the strength of a link between two actors) to determine who in the network exerted the most influence.

This method of analysis is particularly powerful with its use of quantitative methods, but I found it inappropriate for my aims in studying US national math education. Primarily, the initial sample of people with a publicly stated interest in national math education is far too large to begin this inquiry. Indeed, Real and Hasanagas point out that complete network analysis may not be appropriate for studies of large policy domains, such as the domain of interest in my dissertation. As I have already indicated, I used Janine Wedel's “new forms of governing” as places to identify the people involved in the social network, and then researched publicly available information to identify the links these individuals had with organizations. Because my network is not complete, I call it a *representative* social network surrounding national math education. For this reason, quantitative methods seemed inappropriate. Instead, I analyzed my network in a qualitative manner that I describe in the last section of this chapter.

I now describe more specifically the ideas that did contribute to the method I used. To begin, Janine Wedel's perspective on governance sheds a bit more light on the power of analyzing the social network that occurs at the nexus of private and official power. She refers to the individuals within this nexus as “flexians.” They flex in their role, as academics, policy-makers, and/or consultants or executives in think tanks or corporations. They also flex in their position, often adopting others' interests in the social network so as to advance their own. Flexians occur in my representative social network surrounding national math education. For example, a corporate executive from Exxon served on a quasi-government committee on national math education[71] and a researcher at the Brookings Institution worked on the National Math Advisory Panel. At these events, each individual presents their own interests in national math education, as well as those from the other organizations she represents.

More on Wedel's flexians, she writes that “Performing overlapping roles can be -- and often is -- not only benign, but can serve the interests of all the organizations involved, as well as the public's.” However, the activities of such an individual “on behalf of one organization can be at odds with those on behalf of another -- even to the point of undermining the goals of either, or both.”[72] Such compromise led Wedel to name these individuals “flexians;” their objectives are flexible. A flexian might act “as a political scientist in one context... and a lawyer in another; a spokesperson for nationalistic values

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71 I am referring to Edgar Robinson, former Vice President and Treasurer of Exxon Corporation and coauthor of the National Research Council's *Adding It Up*, 2001. The National Research Council is a subsidiary of the National Academy of Sciences, a Congressionally Chartered Corporation. *Adding It Up* was initially conceived of by two Federal Agencies: the Department of Education's Office of Educational Research and Improvement and the National Science Foundation's Directorate for Education and Human Resources.

72 Wedel, *Shadow Elite,* 5.

in one context, a booster of the international rule of law in another."[73]

For now, I provide two examples of how individuals in the network adopt others' interests at the expense of their own. In my reading of the representative social network surrounding national math education, there are two business interests: the development of human capital and educational businesses. As I elaborate on in chapter 3, many corporations in the network suggest that national math education plays a role in developing in people the intangible qualities that make them productive workers. In chapter 6, I discuss that educational businesses, primarily the testing industry, adopt the interest to develop human capital by aiming to provide educational services that satisfy the goal to develop human capital. However, the products they provide actually undermine this goal, at least in part, because educational businesses find it too costly to provide services that test a students' comprehension of skills related to the contemporary knowledge economy, such as collaboration, independent learning and problem-solving. Therefore, educational businesses adopt the human capital interest but the activities of educational businesses actually undermine the human capital interest.

Another example of such conflict in the network comes with a look at the interests of academics and corporations in the network. Many academics in the network are concerned with the mathematical knowledge of teachers, a topic which I address in chapter 5. Many of these academics also express a commitment to educating for the development of human capital, as I mentioned above. I consider this as an example of Wedel's "flexians" because the academics adopt the human capital interest rather than

73 Ibid., 5.

hold it as the corporations do. Some of these academics consider that the best way to address the mathematical knowledge of teachers is with stronger university preparation. However, as I describe in chapter 5, the human capital interest in education is tied to the aims of removing teacher education from the university. Because the human capital interest dominates the network, I argue that these academics who aim to increase the power of university teacher education are undermined by the more powerful human capital interest.

Wedel's flexians concept is similar to other work that terms these overlapping roles "organizational interlocks." Initial work in this area focused on the interlocks among corporate boards,[74] and generally provided the quantity of interlocks as justifying the existence of cohesive, formidable power amongst corporations and their interests. Domhoff and Salzman continued this work to examine the quantity of interlocks between the corporate community and nonprofit organizations, thereby implying a powerful, tight-knit community surrounding both groups.[75] My analysis will begin by similarly identifying these interlocks, but I continue by identifying the interests involved and how they flex and compromise, as Wedel suggests. In my case, the interlocks exist between the national math education events and other organizations. For example, in the case of the National Math Advisory Panel, a Federal Advisory Committee, I researched all of the organizations to which each panelist was interlocked. This included the organizations that each person worked for or in which she held a leadership position.

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74 For example, see Mark S. Mizruchi and David Bunting, "Influence in Corporate Networks: An Examination of Four Measures," *Administrative Science Quarterly,* 26, No. 3 (Sep., 1981), 475-489.

75 Harold Salzman and William Domhoff, "Nonprofit Organizations and the Corporate Community," *Social Science History* 7, No. 2 (Spring 1983): 205-216.

This section has reviewed social network analysis (SNA) for its relevance to my method of analyzing national math education. I have reviewed its origins in the branch of mathematics known as graph theory as well as the variety of applications and methods aiming to describe social phenomena. I outlined the work in SNA that proved relevant to my project's identification of a representative social network surrounding national math education. I began with sampling from among math education events that fit within Wedel's “new forms of governing” and then identified the interlocks that these events had to other organizations. It is important to note that, given my sampling approach, the resulting network does not represent a complete network and instead indicates the types of interlocks, and interests, that occur in the (unobtainable) complete network of national math education. The details of my particular choices are revealed in the following section.

Constructing a Representative Social Network Surrounding National Math Education

In this section I detail the process that led me to construct a representative social network surrounding national math education. I begin by introducing the three national math education events that I used, and the process I used to make a social network for each. I then present each social network, accompanied by background information about the national math education event. Finally, I consolidated these three networks into one network, revealed at the end of this section. There I also outline my reasoning for categorizing the individuals and organizations in the way I did. Throughout this section, I point to examples in these diagrams that led me to draw the conclusions made in chapters

3 through 6.

Three national math education events began my identification process of the social network surrounding national math education. Each corresponded to one of Janine Wedel's “new form of governing.” They were

1) a Federal Advisory Committee: the National Math Advisory Panel (2008)

2) a document authored by a quasi-governmental organization: *Adding It Up* (2001), and

3) a document authored by private think tanks: the joint efforts of the National Governors Association and Council of Chief of School State Officers *Common Core State Standards in Mathematics* (2010).

For each event, I examined the professional biographies of individual committee members to determine all interlocks the event had with other organizations. Interlocks I identified included when an individual worked for, was a member of an advisory board or committee of, or was in another position of leadership at the organization. For further clarification, here are a few examples and non examples of my version of interlocks. In the case of affiliations with the National Science Foundation (NSF), being an employee of the organization or working on a project conceived by NSF represented an interlock, whereas an individual who received grant money from NSF for their research project did not represent an interlock. And for further clarity, as in the case with professional organizations such as the National Council of Teachers of Mathematics (NCTM), simply being a paying dues member of an organization did not count as an affiliation whereas being an elected board member did. In a few cases, I named interlocks for the contribution an individual made to a work published by an organization. These cases included significant publications by professional organizations, such as NCTM, and policy institutes, such as Fordham Institute, but excluded any individual's having published a document with a publishing company. Generally, interlocks found before 1990 were considered less influential and thus ignored.

Lastly with regard to naming interlocks, while I did intend to provide an exhaustive list of all interlocks, my method in identifying affiliations allows the possibility that many have been missed. I relied only on information that was made publicly available, starting first with the professional biographies that were published for each event and included the individuals' professional websites and/or other websites containing professional biographies of the panelists. I did not contact individuals to ask them these interlocks directly. This choice was made because contacting individuals may also not have resulted in a truly exhaustive list of all organizations due to nonresponse and/or hesitancy to share information. Additionally, as these individuals commit to the public eye by partaking in the making of public-policy, I assumed that the accuracy of information contained in each professional biography on the web is both strong and not offensive to the individual. I did not, for instance, seek biographical information from sources that criticize these individuals. The potential for missed interlocks still exists, and again I suggest that the social network I present merely is indicative of the qualities of the complete social network. Again, this is why my network *represents* the complete social network surrounding national math education.

The individuals and organizations identified by these interlocks thus comprise the social network for each event. These networks are presented in the sociograms that follow, where interlocks are represented by the lines connecting an individual to an organization. In each sociogram, I also grouped the individuals and organizations into categories, which I will elaborate upon in the section following this one. My presentation of each sociogram begins with some background information about the event.

Because of the abundance of panelists and organizations comprising each social network, I was forced to code them on the sociograms rather than use the panelists names and organization's full titles. To prevent confusion, all sociograms use the same codes. For example, “P2” represents the American Educational Research Association for any sociogram contained here. A full list of all individuals and institutional codes appears on pages 73-75, after I present the sociogram comprising all three national math education events.

The National Math Advisory Panel, 2006-2008

The National Math Advisory Panel (NMAP) was a Federal Advisory Committee enacted by President Bush II through Executive Order 13398. Among all the events I selected, this panel's conception and execution was more firmly rooted in “official government” with greater transparency. Comments on the appointment process were made by Secretary Spellings and the majority, though not all, of their meetings were held in public. As noted earlier, federal advisory committees present new opportunities for private interests in public policy-making. For one, NMAP received external funding from five private organizations. Before I reveal this event's sociogram, which visually expresses the social network surrounding NMAP, I provide a bit more of the background to the event.

NMAP's birth took place on April 18, 2006, when George W. Bush signed Executive Order 13398 with the following policy: “To help keep America competitive, support American talent and creativity, encourage innovation throughout the American economy, and help State, local, territorial, and tribal governments give the Nation's children and youth the education they need to succeed, it shall be the policy of the United States to foster greater knowledge of and improved performance in mathematics among American students.”[76] This policy references math education's role in strengthening the economy and the development of a talented workforce. About a year after the creation of the panel and a year before NMAP published their final document, Congress signed into law the America COMPETES Act,[77] which includes $95 million in FY 08 to help states implement the National Math Panel's recommendations”.[78] The Act's full title, America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act, in conjunction with its abbreviation, the America COMPETES Act, puts forth once more the connection made between math education and a strong national economy.

Eric Gutstein, a math education researcher, argues that this Act supports a perspective presented by several national reports, such as *Rising Above the Gathering Storm*.[79] Their “consensus position ... is that technological innovation is, and has been

[76] “Executive Order 13398 by President of the United States: National Math Advisory Panel,” (April 21, 2006), http://en.wikisource.org/wiki/Executive_Order_13398.
[77] “Bill Summary Status, S.761, Latest Title: America COMPETES Act,” (August 9, 2007), http://thomas.loc.gov/cgi-bin/bdquery/z?d110:SN00761:@@@D&summ2=m&.
[78] “National Math Advisory Panel,” accessed December 1, 2010, http://www2.ed.gov/about/bdscomm/list/mathpanel/factsheet.html.
[79] National Academy of Sciences, *Rising Above the Gathering Storm.*

historically, the engine for US economic growth and global position. However, while the US has not stood still, other countries are working overtime to catch and surpass the US."[80] Therefore, both NMAP's origin and the legislation that provides its funding for implementation primarily present the connection between a strong math education and a strong national economy.

As I present analysis of my network in the chapters that follow, this theme will come up often. As I indicate in chapter 3, this describes math education's role in the development of human capital, or those intangible qualities that make stronger workers for corporations. Given the language in Executive Order 13398 and NMAP's fiscal connection to the America COMPETES Act, the legislative events surrounding NMAP, then, sharply situate math education within investments in human capital assets.

Other of NMAP's background continue the theme of math education for human capital, especially the private funding provided for the publication of NMAP's final report: *Foundations for Success*.[81] Extra funding for NMAP came from Exxon Mobil Corporation, Houston Endowment, Inc., Math for America, Northrop Grumman and Texas Instruments. When an organization provides money for a project, it does not necessarily indicate that the organization's interests are well represented by the project, but I will assume that such funding indicates that an organization finds no conflict

80 Eric Gutstein, "The Political Context of the National Mathematics Advisory Panel," *The Montana Mathematical Enthusiast* 5, Nos. 2 & 3, 416.

81 US Department of Education, *Foundations for Success: The Final Report of the National Mathematics Advisory Panel,* (2008), http://www2.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf. Here, the rationale for funding is explained on page *ix*: "The budget dedicated to this project by the U.S. Department of Education was augmented by funds from donors who are also recognized below. Their generosity enabled work that was more thorough and more expertly supported than would ever have been otherwise possible. " The list of funders is on page *x*.

between the project's objectives and its own. It also remains possible that the project specifically supports the funding organization's objectives. Thus, the NMAP private funders can present the interests at play in NMAP and it is worth a look at these organization's objectives. In other words, NMAP's funders hint at the interests at play. The analysis in the remainder of this dissertation provides stronger evidence that this corporate funding indeed influences national math education.

Three of the organizations funding NMAP, Exxon Mobil, Houston Endowment, Inc., and Math for America, are also affiliated with NMAP for the associations that individual panelists had to each organization. As will be explained in chapter 3, all three present the need of math education for human capital. Northrop Grumman also furthers this theme because this corporation depends on the human capital necessary to invent technologies for military innovation. It also affirms a commitment to math education's role in significant government spending for military operations, one of the industrial sectors that finds an interest in math education. Lastly, Texas Instruments, who produces calculators for use in the math classroom, indicates the possibility that educational businesses have an interest in national math education. As I explain in chapter 5, however, the calculator business is far less powerful in the network than is the testing industry.

The political context and funding of NMAP indicate the possibility that national math education contains the interest of developing human capital and those related to educational businesses. These initial considerations are greatly supported with a more detailed account of NMAP's network, together with the network surrounding the remaining two math events that I included in my sampling.

The following sociogram (Figure 1) further presents how this committee is significantly embedded with private organizations via interlocks. The bottom half of the network oval are the individuals who participated in NMAP, and the top half are the organizations to which these people are linked. Here are a few examples. A line is drawn between NMAP's mathematician Roger Howe, M7, and the Institute of Mathematics and Education, RP9, because Howe is a member of the Institute's Advisory Board. Another example, NMAP's mathematician and corporate executive James Simons, CE2/M13, is connected to hedge fund management company Renaissance Technologies, GS18, because he is the company's founder and chief executive.

Figure 2-1: National Math Advisory Panel's Social Network

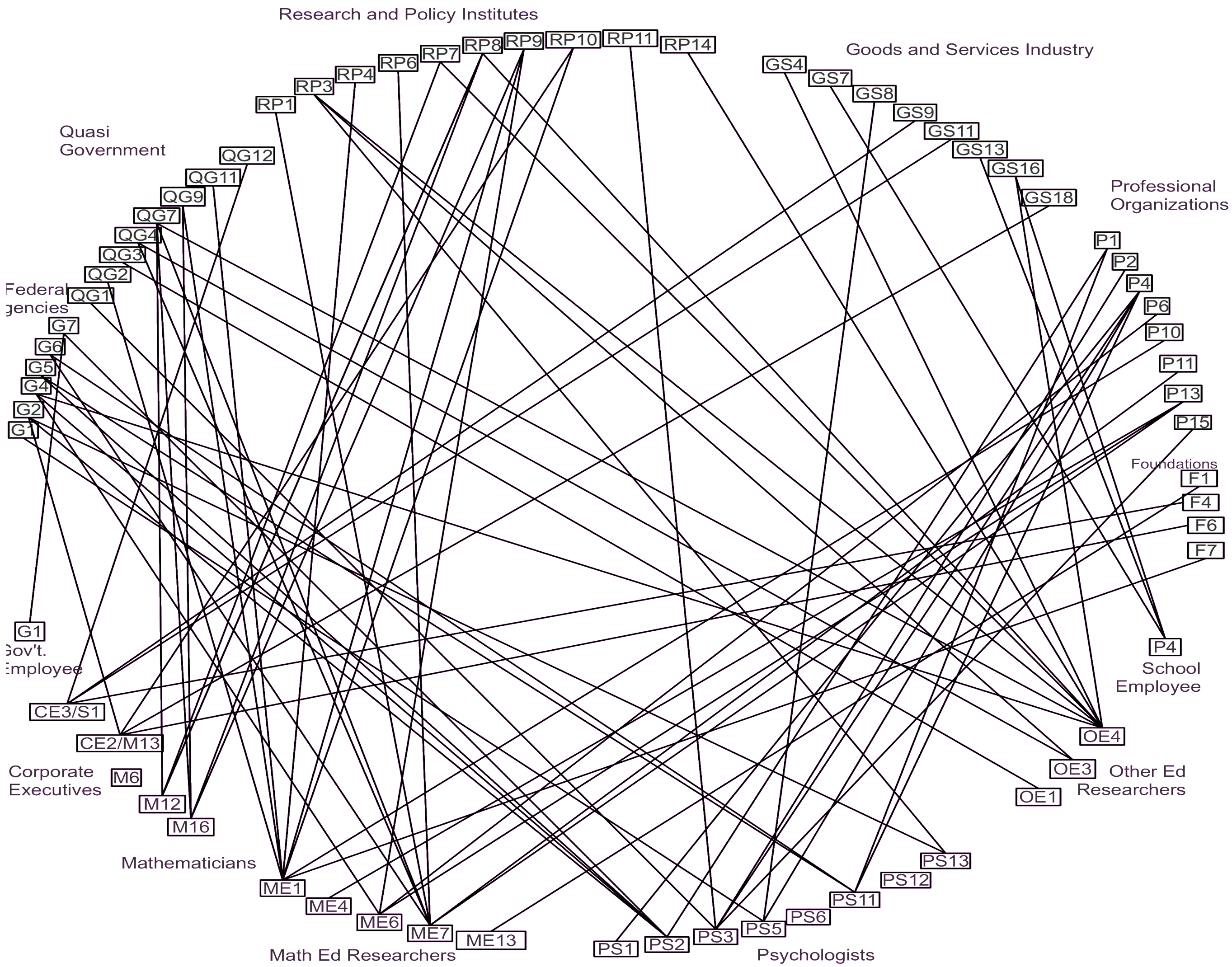

Table 2-1a: NMAP's Network Individuals

G1	Irma Arispe
CE3/S1	Larry Faulkner
CE2/M13	James Simons
M6	Bert Fristedt
M12	Wilfried Schmid
M16	Hung-Hsi Wu
ME1	Deborah Ball
ME4	Douglas Clements
ME6	Francis (Skip) Fennell
ME7	Joan Ferrini-Mundy
ME13	Karen Fuson
PS1	Camilla Benbow
PS2	Daniel Berch
PS3	Wade Boykin
PS5	Susan Embretson
PS6	David Geary
PS11	Valerie Reyna
PS12	Robert Siegler
PS13	Grover “Russ” Whitehurst
OE1	Russell Gersten
OE3	Tom Loveless
OE4	Sandra Stotsky
P4	Vern Williams

Table 2-1b: NMAP's Network Organizations

G1	Department of Defense
G2	Department of Education
G4	National Aeronautics and Space Administration
G5	National Institutes of Health
G6	National Science Foundation
G7	Office of Science and Technology Policy
QG1	Capstone Research
QG2	Center for Proficiency in Mathematics Teaching
QG3	Instructional Research Group
QG4	International Educational Assessment
QG7	National Assessment Governing Board
QG9	National Academy of Sciences (and NRC and MSEB)
QG11	RAND
QG12	Sandia National Laboratory
RP1	Achieve, Inc.
RP3	Brookings Institute
RP4	RAND
RP6	CT Academy for Ed in Math, Sci, Tech
RP7	Fordham Institute
RP8	Honest Open Logical Debate
RP9	Institute of Math and Education
RP10	Mathematical Sciences Research Institute
RP11	Minority Student Achievement Network
RP14	Pioneer Institute
GS4	Carus Publishing
GS7	CTY, JHU
GS8	Educational Testing Service
GS9	ExxonMobil
GS11	Guaranty Bank
GS13	MathCounts
GS16	Oxford-Sadlier
GS18	Renaissance Technologies
P1	American Association for the Advancement of Science
P2	American Educational Research Association
P4	American Psychology Association
P6	Association for Mathematics Teacher Educators
P10	International Commission on Math Instruction
P11	Mathematics Association of America
P13	National Council of Teachers of Mathematics
P15	National Education Association
F1	Carnegie Foundation for the Advancement of Teaching
F4	Houston Endowment
F6	Simons Foundation
F7	Spencer Foundation

Adding It Up, 2001

Adding It Up (AIU),[82] a book published in 2001 by the National Research Council (NRC) of the National Academy of Sciences (NAS), is a statement on national math education produced by a quasi-government organization. Earlier I discussed how the NAS is a Congressional Chartered Nonprofit Organization (CCNO). Such organizations are not tied to federal agencies except for their “honorific” status from being declared by Congress as working in the national interest. Accordingly, NAS receives funding from both federal agencies and private organizations.

The following accounts the conception of the committee that wrote AIU: “The Committee on Mathematics Learning was established by the National Research Council at the end of 1998. It was formed at the request of the Division of Elementary, Secondary, and Informal Education in the National Science Foundation's Directorate for Education and Human Resources and the US Department of Education's Office of Educational Research and Improvement.”[83] Thus this project began inside governmental agencies (National Science Foundation and the Department of Education) and was then handed over to the National Research Council, a subsidiary of the National Academy of Sciences (NAS).

This background information indicates *Adding It Up's* ties to math education for the development of human capital, similar to the National Math Advisory Panel (NMAP). This comes with attention to its conception within the National Science Foundation's

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82 National Research Council, *Adding It Up: Helping Children Learn Mathematics*, eds. Jeremy Kilpatrick, Jane Swafford and Bradford Findell (Washington, DC: National Academy Press, 2001).

83 Ibid., 3.

(NSF) Directorate for Education and Human Resources (EHR). The mission of EHR includes achieving "excellence in U.S. science, technology, engineering and mathematics (STEM) education at all levels and in all settings (both formal and informal) in order to support the development of a diverse and well-prepared workforce of scientists, technicians, engineers, mathematicians and educators..."[84] The education work of NSF supports the development of human capital that corporations need. In chapter 4, I argue that the human capital interest includes using math education to address the workforce needs of many more types of jobs, not just those that are math-intensive.

Adding It Up provides little other background information, such as the manner in which the committee was selected. NAS does have a document indicating its process for selecting committees which states that NAS will "make its best efforts to ensure that (A) no individual appointed to serve on the committee has a conflict of interest that is relevant to the functions to be performed, unless such conflict is promptly and publicly disclosed and the Academy determines that the conflict is unavoidable, (B) the committee membership is fairly balanced as determined by the Academy to be appropriate for the functions to be performed..."[85] In the context of math education, then, NAS determined no conflict of education regarding *Adding It Up's* inclusion of a corporate executive from Exxon. I recognize that such a conflict of interest clause does not include these types of analyses, but I am highlighting how the appointment process for this document actually encouraged particular private interests in its contributions to national math education.

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84 National Science Foundation, "About EHR," accessed July 30, 2011 http://www.nsf.gov/ehr/about.jsp

85 The National Academies, "Policy on Committee Composition and Balance and Conflicts of Interest for Committees Used in the Development of Reports," May 12, 2003, http://sites.nationalacademies.org/NRC/PoliciesandProcedures/index.htm, 2.

For constructing my representative social network surrounding national math education, I could have chosen other documents from among those authored by quasi-governmental organizations. For instance, I earlier referred to another NAS publication *Rising Above the Gathering Storm* whose authoring committee included even more representation from corporations interested in developing human capital. I chose *Adding It Up* over this option and others because of the substantial contribution the document has made to national math education. *Rising Above the Gathering Storm* is credited for little more than indicating the need for improving math education's role in the US economy, whereas *Adding It Up* is referenced by other major documents in the push towards national math education. For example, the *Common Core State Standards* indicates it, along with the National Math Advisory Panel (NMAP), as important resources in the development of new national math standards. I sought to choose math education events that presented substantive arguments on the particulars of math education; these would suggest the ways that academic and private interests operate among the social network.

Figure 2-2 is a sociogram indicating the social network that surrounds *Adding It Up*. As with NMAP's sociogram, the network's individuals are grouped along the bottom half of the oval and the network's organizations are grouped along the top half of the oval. I will elaborate on the distinctions among individuals and groups later in this chapter. One difference from *AIU*'s sociogram and NMAP's sociogram are the fewer number of psychologists and mathematicians, but greater number of math education researchers. This may indicate that NAS, a quasi-government organization, reflects more the interests of math education researchers than does the Federal Advisory Committee.

Also not present in this network are educational business employees, which are quite present in the last event I used, the *Draft of College and Career Readiness* in math.

Figure 2-2: *Adding It Up*'s Social Network

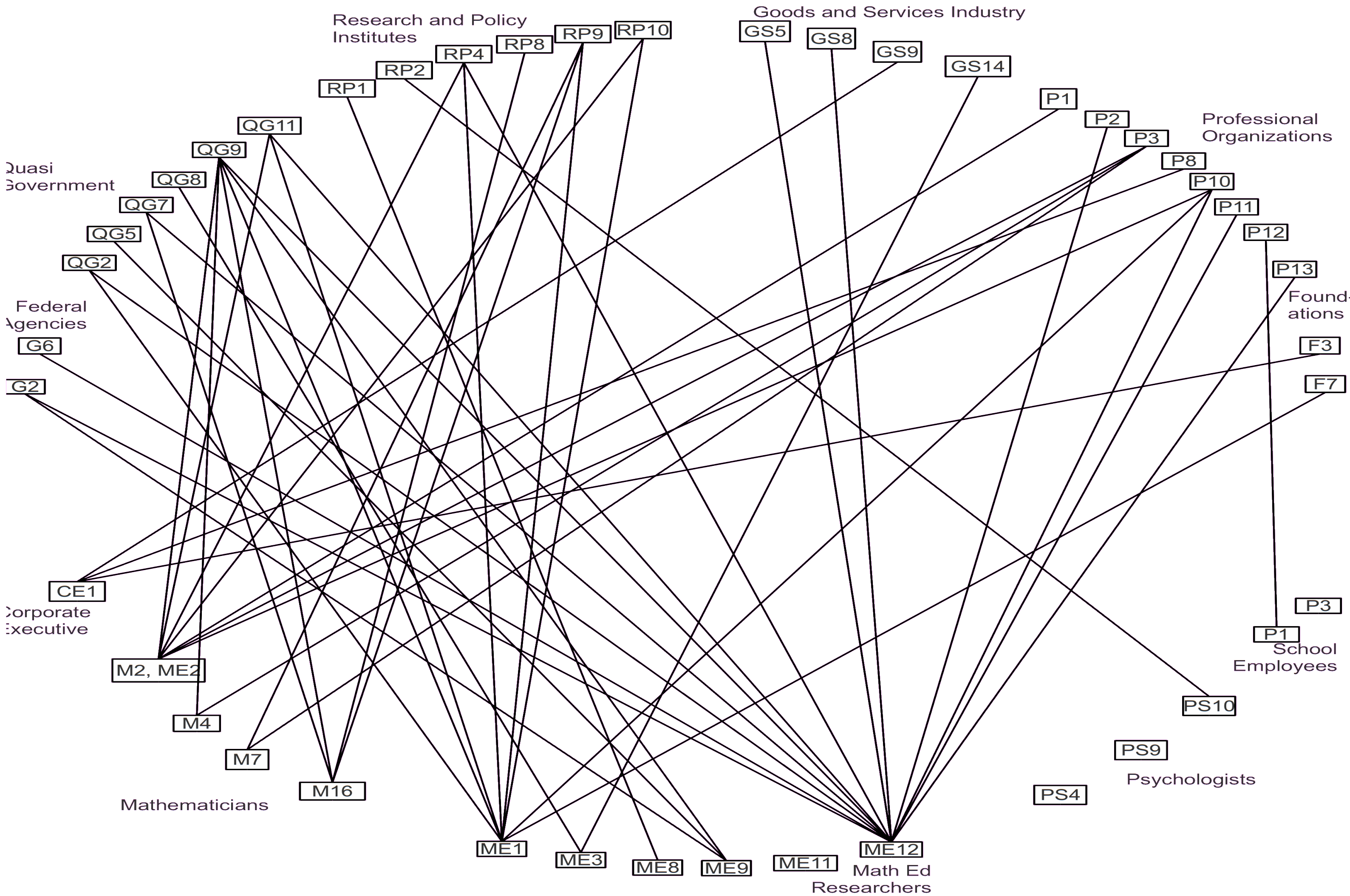

Table 2-2a: *Adding It Up*'s Network Individuals

CE1	Edgar Robinson
M2, ME2	Hyman Bass
M4	Felix Browder
M7	Roger Howe
M16	Hung-Hsi Wu
ME1	Deborah Ball
ME3	Thomas Carpenter
ME8	Karen Fuson
ME9	James Hiebert
ME11	Carolyn Kieran
ME12	Jeremy Kilpatrick
PS4	Jere Brophy
PS9	Richard E. Mayer
PS10	Kevin Miller
P1	Carolyn Day

Table 2-2b: *Adding It Up*'s Network Organizations

G2	Department of Education
G6	National Science Foundation
QG2	Center for Proficiency in Teaching Mathem
QG5	Mid-Atlantic Center for Mathematics Teac
QG7	National Assessment Governing Board
QG8	Nat'l Cent. for Improving Stud. Learn. and
QG9	National Academy of Sciences (and NRC
QG11	RAND
RP1	Achieve, Inc.
RP2	Beckman Institute
RP4	RAND
RP8	Honest Open Logical Debate
RP9	Institute of Math and Education
RP10	Mathematical Sciences Research Institute
GS5	College Board
GS8	Educational Testing Service
GS9	ExxonMobil
GS14	National Center for the Improvement of Ed
P1	American Association for the Advanceme
P2	American Educational Research Associati
P3	American Mathematical Society
P8	Conference Board
P10	International Commission on Math Instruc
P11	Mathematics Association of America
P12	National Council of Supervisors of Mathem
P13	National Council of Teachers of Mathemat
F3	Greenwall Foundation
F7	Spencer Foundation

College and Career Readiness Standards for Mathematics, 2009

The *Common Core State Standards in Mathematics* are national math education standards written by two private organizations, the National Governors Association Center for Best Practices (NGA) and the Council of Chief State School Officers (CCSSO), and with significant influence from another think tank, Achieve, Inc. Despite the fact that board members for NGA and CCSSO are public officials, the two are private nonprofit organizations of different types that influence a consensus among the state governments and for education in the national interest. NGA is a research and policy institute: "the only policy research and development firm that directly serves the nation's governors by developing innovative solutions to today's most pressing public policy challenges."[86] CCSSO is a professional association of all the heads of state departments of education; its mission includes "coordinating consensus [among the chiefs] on federal education matters."[87] Both organizations are funded primarily by a variety of corporations and nonprofit organizations, and thus objective research is compromised.

A clear example demonstrates how funding coincides significantly with the policy initiatives these two organizations make. The NGA requests funding through its "Corporate Fellows" program, presenting it to businesses as follows:

> "As a Corporate Fellow, your contribution supports the National Governors Association Center for Best Practices (NGA Center) and positions you and your colleagues as intellectual resources for providing governors ideas that work. Participation in the program demonstrates your

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86 John Thomasian, *NGA Center for Best Practices Brochure*, accessed December 15, 2011, http://www.nga.org/Files/pdf/CBPBROCHURE.pdf.

87 2011 Council of Chief of State School Officers, "Legislation and Advocacy," accessed December 15, 2011, http://www.ccsso.org/What_We_Do/Legislation_and_Advocacy.html

> company's commitment to improving cooperation and understanding between state government and the business community through development of bipartisan, collaborative solutions to issues affecting our nation."[88]

Similarly, CCSSO seeks "Business Partners" as representatives of the "diverse constituencies" they should work with and from which they should learn (however no other such constituencies are presented). The following providers of educational assessment services are listed on both programs: ACT, Educational Testing Service (ETS), McGraw-Hill and Pearson Education. This representation of education assessment services bears out in NGA/CCSSO push for educational policies requiring these services, such as the No Child Left Behind Act which mandated that each state have educational standards and assessments. As I will discuss in chapter 6, two of these, ETS and Pearson, stand to be awarded megacontracts as a result of NGA/CCSSO's latest effort, the *Common Core State Standards* in math.

The process that created these standards began with the naming of a committee to write the *College and Career Readiness Standards for Mathematics.* This document anchored

> the next phase of the Common Core State Standards Initiative: development of K–12 Mathematics Standards. Those K–12 Standards are in turn expected to guide the development of a next generation of assessments, developed collaboratively by multiple states. The K–12 Mathematics Standards will serve as a guide and tool for aligning instruction, curriculum, assessment, teacher supports, and systems of accountability.[89]

In other words, this event started the process of developing national math standards and

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88 National Governors Association, "NGA Corporate Fellows Program," accessed December 15, 2011, http://www.nga.org/portal/site/nga/menuitem.0bac810bdc41c16ae8ebb856a11010a0/

89 *College and Career Readiness Standards for Mathematics*, 4.

the testing and accountability megacontracts which I discuss in chapter 6. Therefore, I considered its influence greater than that of the standards themselves. I included this as the third event to construct the representative social network surrounding national math education.

There are two lists of authors for the *College and Career Readiness Standards for Mathematics.* The mathematics "Development Work Group" and "Feedback Group" were announced by NGA on July 1, 2009 with the distinctions between the two as follows: "The role of this Feedback Group is to provide information backed by research to inform the standards development process by offering expert input on draft documents. Final decisions regarding the common core standards document will be made by the Standards Development Work Group. The Feedback Group will play an advisory role, not a decision-making role in the process."[90] As to the selection of individuals on these panels, no information is provided but NGA and CCSSO describe the process as inclusive of all stakeholders in education including parents, teachers, and business. No public record of the meetings of the work group or feedback group are made available.

The first sociogram, Figure 2-3, is of the Development Work Group. Notably, the majority of the work group are employees of educational businesses, including ACT and the College Board, which is connected to ETS (see chapter 6). The other significant organization in this sociogram is policy and research institute Achieve, Inc. because four of the listed individuals were employees there. As for the inclusion of academics in this

[90] National Governors Association. *Press Release: Common Core State Standards Development Team and Feedback Group Announced,* July 1, 2009, printed from the National Governors Association website, www.nga.org.

list, of the two mathematicians, one, Jason Zimba, is an educational entrepreneur and the other, William McCallum, consulted for Achieve.

Figure 2-3: *College and Career Readiness Standards for Mathematics'* Social Network, Part 1

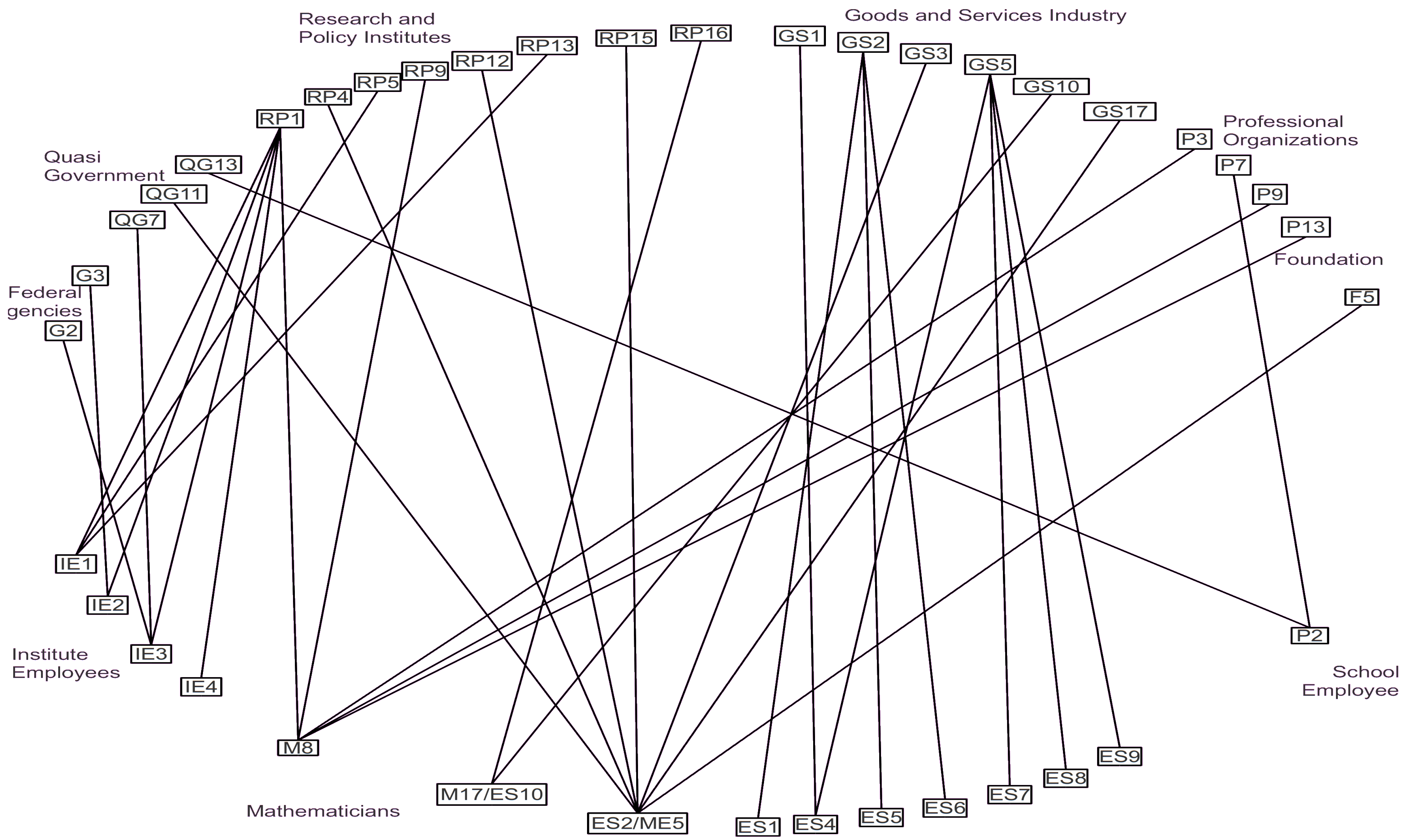

Figure 2-3

Table 2-3a: *CCRSM* Network Individuals

IE1	Kaye Forgione
IE2	John Kraman
IE3	Laura McGiffert Slover
IE4	Douglas Sovde
M8	William McCallum
M17/ES10	Jason Zimba
ES2/ME5	Phil Daro
ES1	Sara Clough
ES4	Marci Ladd
ES5	Sherri Miller
ES6	Ken Mullen
ES7	Robin O'Callaghan
ES8	Andrew Schwartz
ES9	Natasha Vasavada
P2	Susan K. Eddins

Table 2-3b: *CCRSM* Network Organizations

G2	Department of Education
G3	Department of Justice
QG7	National Assessment Governing Board
QG11	RAND
QG13	TERC
RP1	Achieve, Inc.
RP4	RAND
RP5	Council for Basic Education
RP9	Institute of Math and Education
RP12	National Center for Edcuation and the Economy
RP13	National Math and Science Initiative - Uteach
RP15	Strategic Education Research Partnership
RP16	Student Achievement Partners
GS1	Academic Benchmarks
GS2	ACT
GS3	America's Choice
GS5	College Board
GS10	Grow Network, McGraw Hill
GS17	Pearson
P3	American Mathematical Society
P7	Association of State Supervisors of Mathematics
P9	Conference Board Mathematical Sciences
P13	National Council of Teachers of Mathematics
F5	Noyce Foundation

The second sociogram, Figure 2-4, presents the social network of the feedback group. Several more academics are included on this list. Accordingly, there are also several more organizations included in the network. Notably, in comparison to the sociograms for *Adding It Up* and the National Math Advisory Panel (NMAP), the ratio of mathematicians to math education researchers is much greater. I argue in chapter 4 that most mathematicians involved in national math education hold the traditional perspective on math pedagogy. Therefore, the feedback group for the *College and Career Readiness Standards for Mathematics* may support the traditionalist perspective at the expense of the progressivist. This makes sense given the significant presence of the testing industry because, as I argue in chapter 6, educational businesses find providing progressivist math education services too costly.

Figure 2-4: *College and Career Readiness Standards for Maths'* Social Network Part 2

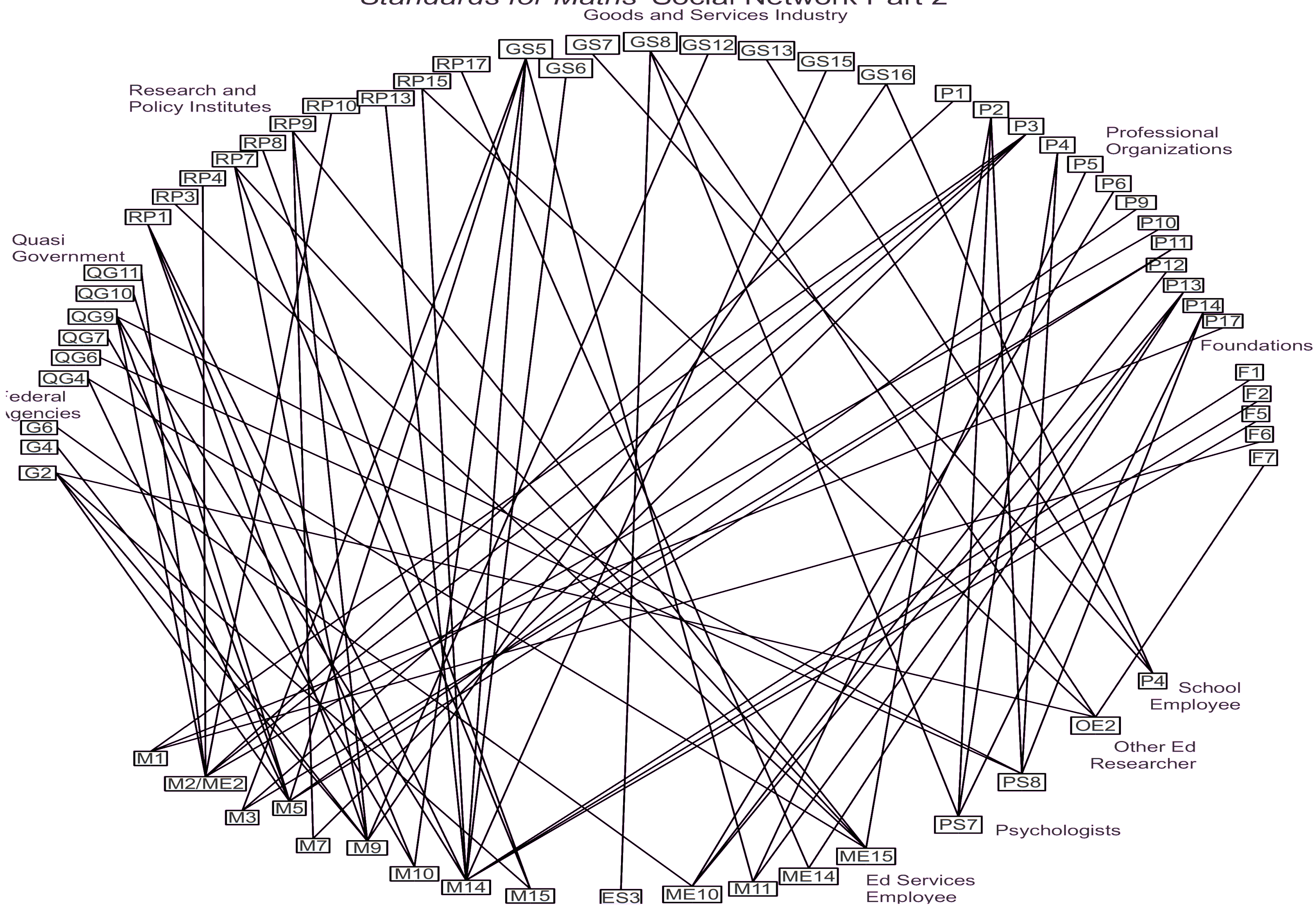

Table 2-4a: *CCRSM* Part 2 Network Individuals

M1	George Andrews
M2/ME2	Hyman Bass
M3	David Bressoud
M5	John Dossey
M7	Roger Howe
M9	James Milgram
M10	Fabio Milner
M14	Uri Treisman
M15	W. Stephen Wilson
ES3	Brian Gong
ME10	Henry Kepner
ME14	Nora Ramirez
ME15	William Schmidt
PS7	Suzanne Lane
PS8	Robert Linn
OE2	Kenji Hakuta
P4	Vern Williams

Table 2-4b: *CCRSM* Part 2 Network Organizations (continued on next page)

G2	Department of Education
G4	National Aeronautics and Space Administration
G6	National Science Foundation
QG4	International Educational Assessment
QG6	Nat'l Center for Research on Evaluation, standards and student testing
QG7	National Assessment Governing Board
QG9	National Academy of Sciences (and NRC and MSEB)
QG10	Organization of Economic Cooperation and Development
QG11	RAND
RP1	Achieve, Inc.
RP3	Brookings Institute
RP4	RAND
RP7	Fordham Institute
RP8	Honest Open Logical Debate
RP9	Institute of Math and Education
RP10	Mathematical Sciences Research Institute
RP13	National Math and Science Initiative - Uteach
RP15	Strategic Education Research Partnership
RP17	TODOS
GS5	College Board
GS6	Consortium for Math and its Applications (COMAP)
GS7	CTY, JHU
GS8	Educational Testing Service

Table 2-4b Continued

GS12	Holt-Reinhart
GS13	MathCounts
GS15	New Teacher Project
GS16	Oxford-Sadlier
P1	American Association for the Advancement of Science
P2	American Educational Research Association
P3	American Mathematical Society
P4	American Psychology Association
P5	American Statistical Association
P6	Association for Mathematics Teacher Educators
P9	Conference Board Mathematical Sciences
P10	International Commission on Math Instruction
P11	Mathematics Association of America
P12	National Council of Supervisors of Mathematics
P13	National Council of Teachers of Mathematics
P14	National Council on Measurement in Education
P17	Society for Industrial and Applied mathematics
F1	Carnegie Foundation for the Advancement of Teaching
F2	Charles Dana Foundation
F5	Noyce Foundation
F6	Simons Foundation
F7	Spencer Foundation

I have presented the individual sociograms for each of the three national math education events that I used to identify a representative social network surrounding national math education. I have commented briefly on each one, especially as they relate to each other, but have saved most commentary on the visual expression of the network for the composite sociogram of all three events, included next. In subsequent chapters, I will use this diagram to indicate the primary interests or themes in national math education. The sociogram's corresponding tables are included on the pages 69-70.

Figure 2-5: National Math Education's Social Network

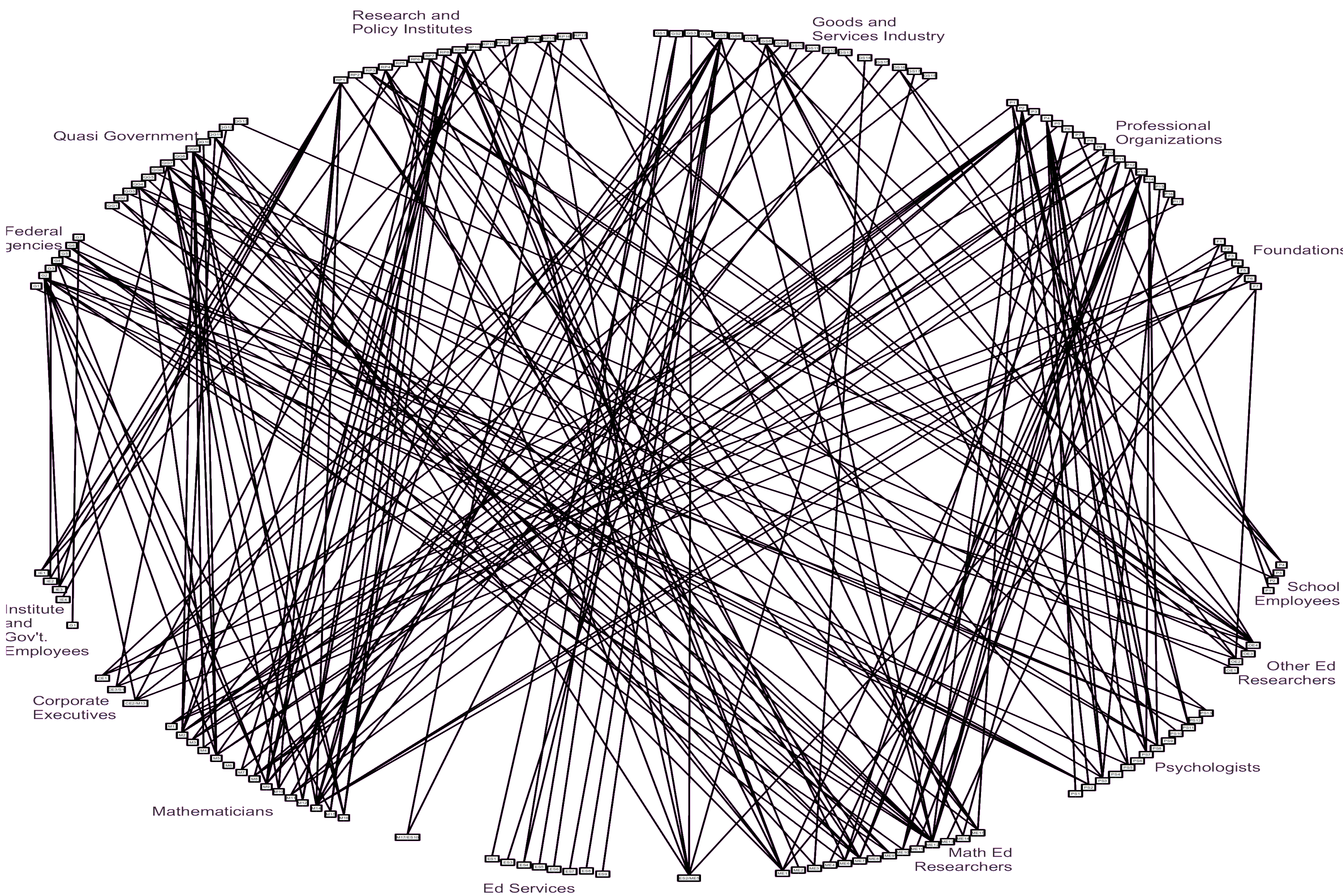

Table 2-5a: National Math Education's Network Individuals

CE1	Robinson
ES1	Clough
ES10/M17	Zimba
ES2/ME5	Daro
ES3	Gong
ES4	Ladd
ES5	Miller
ES6	Mullen
ES7	O'Callaghan
ES8	Schwartz
ES9	Vasavada
G1	Arispe
IE1	Forgione
IE2	Kraman
IE3	Slover
IE4	Sovde
M1	Andrews
M2/ME2	Bass
M3	Bressoud
M4	Browder
M5	Dossey
M6	Fristedt
M7	Howe
M8	McCallum
M9	Milgram
M10	Milner
M11	Peck
M12	Schmid
M13/CE2	Simons
M14	Treisman
M15	Wilson
M16	Wu

ME1	Ball
ME3	Carpenter
ME4	Clements
ME6	Fennell
ME7	Ferrini-Mundy
ME8	Fuson
ME9	Hiebert
ME10	Kepner
ME11	Kieran
ME12	Kilpatrick
ME13	Ma
ME14	Ramirez
ME15	Schmidt
OE1	Gersten
OE2	Hakuta
OE3	Loveless
OE4	Stotsky
P1	Day
P2	Eddins, Susan
P3	Pardo
P4	Williams
PS1	Benbow
PS2	Berch
PS3	Boykin
PS4	Brophy
PS5	Embretson
PS6	Geary
PS7	Lane
PS8	Linn
PS9	Mayer
PS10	Miller, Kevin
PS11	Reyna
PS12	Siegler
PS13	Whitehurst
S1	Faulkner

Table 2-5b: National Math Education's Network Organizations (continued on next page):

F1	Carnegie Foundation for the Advancement of Teaching
F2	Charles Dana Foundation
F3	Greenwall Foundation
F4	Houston Endowment
F5	Noyce Foundation
F6	Simons Foundation
F7	Spencer Foundation
G1	Department of Defense
G2	Department of Education
G3	Department of Justice
G4	National Aeronautics and Space Administration
G5	National Institutes of Health
G6	National Science Foundation
G7	Office of Science and Technology Policy
GS1	Academic Benchmarks
GS2	ACT
GS3	America's Choice
GS4	Carus Publishing
GS5	College Board
GS6	Consortium for Math and its Applications (COMAP)
GS7	CTY, JHU
GS8	Educational Testing Service
GS9	ExxonMobil
GS10	Grow Network, McGraw Hill
GS11	Guaranty Bank
GS12	Holt-Reinhart
GS13	MathCounts
GS14	National Center for the Improvement of Educational Assessment
GS15	New Teacher Project
GS16	Oxford-Sadlier
GS17	Pearson
GS18	Renaissance Technologies
P1	American Association for the Advancement of Science
P2	American Educational Research Association
P3	American Mathematical Society
P4	American Psychology Association
P5	American Statistical Association
P6	Association for Mathematics Teacher Educators
P7	Association of State Supervisors of mathematics
P8	Conference Board
P9	Conference Board Mathematical Sciences
P10	International Commission on Math Instruction
P11	Mathematics Association of America
P12	National Council of Supervisors of Mathematics
P13	National Council of Teachers of Mathematics
P14	National Council on Measurement in Education

Table 2-5b (Continued):

P15	National Education Association
P16	Psychology of Math Education
P17	Society for Industrial and Applied mathematics
QG1	Capstone Research
QG2	Center for Proficiency in Mathematics Teaching
QG3	Instructional Research Group
QG4	International Educational Assessment
QG5	Mid-Atlantic Center for Mathematics Teaching and Learning
QG6	Nat'l Center for Research on Evaluation, standards and student testing
QG7	National Assessment Governing Board
QG8	Nat'l Cent. for Improving Stud. Learn. and Achvmnt in Math & Science
QG9	National Academy of Sciences (and NRC and MSEB)
QG10	Organization of Economic Cooperation and Development
QG11	RAND
QG12	Sandia National Laboratory
QG13	TERC
QG14	US National Commission on Math Instruction
RP1	Achieve, Inc.
RP2	Beckman Institute
RP3	Brookings Institute
RP4	RAND
RP5	Council for Basic Education
RP6	CT Academy for Ed in Math, Sci, Tech
RP7	Fordham Institute
RP8	Honest Open Logical Debate
RP9	Institute of Math and Education
RP10	Mathematical Sciences Research Institute
RP11	Minority Student Achievement Network
RP12	National Center for Edcuation and the Economy
RP13	National Math and Science Initiative - Uteach
RP14	Pioneer Institute
RP15	Strategic Education Research Partnership
RP16	Student Achievement Partners
RP17	TODOS
RP18	US Teacher Ed Study in Math

The representative social network surrounding national math education includes a variety of individuals. Among them are fifteen *math ed researchers*, a term I use to describe persons who have significant background in the field of math education research, generally exhibited by having doctoral degrees in math education research, holding employment within a school of education, other university appointment, or a research institute, and publication of research in math education. There are seventeen *mathematicians*, those who generally have doctoral degrees in mathematics and hold appointments in research oriented settings with contributions to the advancement of applied mathematics, pure mathematics or statistics. In chapter 4 I discuss these two groups' contentions over math pedagogy. There are four *school employees*, including one teacher and the three administrators working in a K-12 school. Although national math education pays much lip service to including the voice of teachers,[91] my network indicates very few teachers as actually included in the process. The thirteen *psychologists* have doctoral degrees in psychological research and hold research appointments contributing to that field. Although one might suspect their contributions to be along the lines of mathematical cognition, many are actually involved with psychometrics, or the science of educational testing services. This associates to the presence of ten *ed business employees*. The four *other ed researchers* hold doctoral degrees in educational research in areas other than mathematics and hold positions in universities or institutes, and the one *scientist* holds a doctoral degree and performed research in a scientific field. The one g*overnment employee* worked within a federal agency and is not an elected politician. Finally, there are several individuals directly representing the corporate interest generally. There are three *corporate executives,* one of whom is also a mathematician and another who is also a scientist. These executives of financial and energy services suggest the development of human capital as the purpose for national math education. In chapter 3, I

[91] As is the case with the *Common Core State Standards for Mathematics* in math. For example, "To write the standards, the NGA Center and CCSSO brought together content experts, teachers, researchers and others," quote from Common Core State Standards Initiative, "Process," accessed August 7, 2011, http://www.corestandards.org/about-the-standards/process.

present findings from my reading of this network to indicate that most agree on this purpose.

Once I determined all of the organizations to which these individuals were linked, I found the categorizations of organizations to be a bit less obvious than doing so for the individuals. I carefully considered various perspectives on organizations; the following describes these categories by reviewing the viewpoints that led me to them. *Federal Agencies* are branches of the federal government and are distinguished from *Quasi Governmental Organizations*, organizations that may appear to function within government but instead contain legal characteristics of both a public and private organization. Help with distinguishing both these *Quasi Government Organizations* from *Government Agencies*, as well as distinguishing organizations within the former category, comes from Kosar's 2008 report to Congress[92] that I mentioned earlier in this chapter. For example, the National Academy of Sciences (and its subsidiary the National Research Council) falls under the *Quasi* category because it was chartered by Congress but remains fairly independent from governmental management. Another example are a handful of research institutes that are fully funded by the National Science Foundation (NSF), such as the Center for Proficiency in Mathematics Teaching. NSF is a federal agency and these small research institutes behave similarly to the Federally Funded Research and Development Centers (FFRDC's), but technically do not qualify because FFRDC's are organizations named as such by the granting institution. Instead, I classified these small research institutes using Kosar's descriptor: "Organizations Independent of, but

92 Kevin Kosar, "The Quasi Government."

Dependent on, Agencies." [93]

The remaining organization categories do not fall under any of Kosar's *Quasi Government* categories; in other words I considered them unaffiliated with governmental agencies and lying entirely within the private domain. I have broken down these organizations into the following four categories of Organizations: *Professional Organizations*, *Research and Policy Institutes*, *Foundations*, and *Goods and Services Industry*. My arrival at said categories began with initial inspection of these organizations as two broad categories: profit and non-profit organizations. Non-profit organizations distinguish themselves from profit organizations by their classification under Internal Revenue Service Code 501(c), thereby declaring their exemption from taxation. However, I aimed to break these organizations down according to primary activity whereas a variety of organizations with quite different aims and activities are non-profit. Addressing this circumstance is The Urban Institute's National Center on Charitable Statistics (NCCS),[94] which has developed a taxonomy aimed to describe the differences in both type of activity and societal issues of concern among the non-profit organizations. To give a sense of their approach, I here include Table 2-6 which reproduces their classification of the various non profits in education:

Table 2-6: Excerpt from Urban Institute's Classification of Educational Non-Profits[95]

B	Education
B01	Alliances & Advocacy

[93] Ibid., p 21
[94] The online resouce is Urban Institute, National Center on Charitable Statistics, http://nccs.urban.org/.
[95] The Urban Institute, "National Taxonomy of Exempt Entities," (May 2005), http://nccs.urban.org/classification/NTEE.cfm.

B02	Management & Technical Assistance
B03	Professional Societies & Associations
B05	Research Institutes & Public Policy Analysis
B11	Single Organization Support
B12	Fund Raising & Fund Distribution
B20	**Elementary & Secondary Schools**
B21	Preschools
B24	Primary & Elementary Schools
B25	Secondary & High Schools
B28	Special Education
B29	Charter Schools
B30	**Vocational and Technical Schools**
B40	**Higher Education**
B41	Two-Year Colleges
B42	Undergraduate Colleges
B43	Universities
B50	**Graduate & Professional Schools**
B60	**Adult Education**
B70	**Libraries**
B80	**Student Services**
B82	Scholarships & Student Financial Aid
B83	Student Sororities & Fraternities
B84	**Alumni Associations**
B90	**Educational Services**
B92	Remedial Reading & Encouragement
B94	Parent & Teacher Groups
B99	**Education NEC**

The NCCS website provides a service of looking up non-profit organizations to see how the Institute classifies them as well as gain access to their publicly recorded tax forms.[96] Many of the private organizations in the network fall under the following codes: “B03, Professional Societies and Organizations;” “B05, Research Institutes and Public Policy Analysis;” “B90, Educational Services;” and “B01: Alliances and Advocacy.” For example, Educational Testing Services (ETS) is coded B90, the National Council of Teachers of Mathematics (NCTM) is coded B03, Achieve, Inc. is coded B05, and, while it does not appear in the NCCS database, the Minority Student Achievement Network is an organization similar to TODOS, Mathematics for All, which NCCS codes as B01. As to be expected, sometimes these codes do not capture differences in activity or topical area, as with the example that both Math for America and NCTM are designated B03, but the former's primary activity is the distribution of money from its public contributions to its selected teachers, whereas NCTM's primary activities include publishing periodicals related to math education, holding annual conferences for individuals to collaborate and develop professionally, and events that articulate issue stances claiming to represent the math education professional community. Whereas NCTM seems appropriately designated under B03, a better fit for Math for America might be “B12, (Education) Fund Raising and Fund Distribution.”

There are also network organizations that pertain primarily to mathematics and not education. According to the Urban Institute, these fall under analogous codes under the “Sciences and Technology” category, such as the American Mathematical Society's designation as “U03: Science and Technology, Professional Societies and Organizations.” Other organizations do not fit in either the mathematics or education headings, such as

96 This database can be accessed at the Urban Institute website, http://nccsdataweb.urban.org/PubApps/search.php.

the Brookings Institution classification as "V22: Economics." Brookings refers to itself as a public policy organization, so it is surprising that NCCS does not designate Brookings as a Research and Public Policy Institute. This again demonstrates the inability of these codes to fully express activities of an organization.

In light of such inadequacies, I have adapted the NCCS taxonomy to develop one appropriate way of organizing the organizations affiliated with NMAP. Whether the area of concern for an organization is mathematics, education, economics, or something else, the organization will generally fall into one of the following categories as relating to its activities: providing goods or services, as a research institute or public policy institute, as a professional community, or as a fund raising and fund distribution body. The latter will include both public charities, such as Math for America and private foundations, such as the Simons Foundation. I recognize that my classification scheme can sometimes obscure the tax designation of organizations, e.g. distinctions between public and private charity organizations; the decision was made to distinguish organizations primarily by their activity.

The preceding discussion on non-profit organizations has led to 4 categories of organizations that are completely independent from government (i.e. not government agencies or quasi-government organizations). For the network's organizations, all for-profit companies (defined as those who must pay taxes on all revenues) provide goods or services. For this reason, I have included them in the same category as the non-profits who provide goods or services. As before, I recognize that this classification obscures a crucial distinction between the for and not for profit organizations providing goods and services. However, placing the two types together serves to highlight a major aspect they hold in common: these companies thrive only when their goods or services are purchased by individuals, groups of individuals, or other organizations. An example may help. Educational Testing Services (ETS) is a non-profit company that provides educational business services much like Pearson, which is a for-profit company. I argue that both are in the network to advance the interest of educational businesses.

Lastly, in some cases I have not been able to fully capture the primary activities of an organization by the category in which I have placed it. For example, I expect some will find my placement of teachers' unions into Professional Organizations as highly problematic. However, I chose to classify them primarily for their activity in fostering a professional community rather than their collective bargaining process. Arguably, each of these activities carry equal priority among these organizations; both the National Education Association and the American Federation of Teachers refer to themselves as Professional Communities. This example serves to indicate the inability of any coding scheme to properly address organization activities. The sociogram uses these categories to help cluster similar organizations together and guide the following narrative on the organizational affiliations to the network's individuals. I intend the organization categories to be illuminating but not definitive.

I have presented the categories of individuals and organizations in the representative social network surrounding national math education that I constructed.

Reading National Math Education's Social Network

My social network samples national math education events from among the state-private hybrids in contemporary governance and, through interlocks, indicates the significant presence of private organizations in each event. However, the aim of this dissertation is not simply to argue that national math education is embedded with private interests; Wedel and others have suggested that most policy and government actions today are. My goal draws further on Wedel's observation of compromise and flexibility in policy social networks: I search for the interests and compromises in the social network of national math education policy. In this section I lay out my approach in searching for these interests. This includes looking more carefully at both the characteristics related to each event and the individuals and organizations presented in the sociograms.

Examining Event Characteristics

In the previous section, I briefly introduced each of the 3 events with their origins and place in the new structures of governance. More detail for each event's context can indicate the interests in national math education that are at play. Searching for such interests in the corporations that funded these events and the politicians or others who had a hand in appointing the individuals can indicate important considerations for the event's social network.

For example, looking at other federal policies connected with the National Math Advisory Panel (the first event in my social network) indicates a strong interest in a math education for the national economy. About a year after the creation of the panel and year before NMAP published their final document, Congress signed into law the America

COMPETES Act,[97] which includes $95 million in FY 08 to help states implement the National Math Panel's recommendations".[98] The Act's full title, America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act, in conjunction with its abbreviation, the America COMPETES Act, puts forth a connection made between math education and a strong national economy. Gutstein, a math education researcher, argues that this Act supports a perspective presented by several national reports whose "consensus position ... is that technological innovation is, and has been historically, the engine for US economic growth and global position. However, while the US has not stood still, other countries are working overtime to catch and surpass the US."[99]

Examining Social Network Actors

The actors in the social network of national math education are the individuals and organizations I included in the sociograms of the previous section. In examining the individuals, data primarily consisted of written statements that are available to the public via a panelist's professional website, statements contained in articles published, or other activities such as recorded or transcribed presentations. I included statements that describe the primary stances each individual has with regard to math education, and most often these represent the panelist's concerns with status quo math education and/or their expressed purposes for math education. Statements made between 2000 and 2010 were the primary target, with a few statements from 1990 and 2000 as well. Many individuals

97 Bill Summary Status for America COMPETES Act.
98 US Department of Education, "National Math Advisory Panel," (August 2007), http://www2.ed.gov/about/bdscomm/list/mathpanel/factsheet.html
99 Eric Gutstein, "The Political Context of NMAP," 416.

in the social network had no publicly available statements or activities to shed light on their views of math education, such as some of the psychologists in the network. For these, I relied on statements and activities regarding general or other education. I also relied on such general education statements for some of the other individuals who have statements specific to math education.

Examining the organizations in the social network involved a similar process. I attempted to attain a general description of the activities and objectives of each organization as they relate to mathematics, math education or education in general. Types of data for this description included organizational mission statements, research reports[100] and other publications, prominent individuals within an organization (such as board members), and activities. To describe each organization's current activities and objectives, I focused primarily on data occurring between 2000 and 2010, additionally some data occurred between 1990 and 2000.

Analysis and Objectivity

With the data from event characteristics and the actors in the social network, my search for the interests in the national math education social network thus ensued. I read through the data, searching for the interests in a national math education that came up often. A great many of the actors had statements that are not difficult to group with other actors' statements or certain characteristics of the events. I began to associate these into

[100] Counting as data are only those research reports that are initiated by the organization, as opposed to research reports that were presented at an event held by the organization. For example, a research report from a corporation like ACT or Fordham Institute is produced by these organizations to serve in their respective interests. However, research reports given at the Mathematical Sciences Research Institute (MSRI) or American Educational Research Association (AERA) are accepted submissions from independent academics.

“interest groups.” Within these statement groups existed a variety of focuses, interests or other variations. These variations resonate with Wedel's notion of actor flexibility in a policy social network.

Once these statement groups were identified and the variations within them delineated, I also searched for the ways that the variations may oppose each other and thus undermine the overlapping interests in the policy network. The interest group presented in chapter 3 is the use of math education to develop human capital; in chapter 4 the opposing pedagogical stances of traditional and progressive; in chapter 5 the content knowledge deficits of math teachers; and in chapter 6 the use of national math education by educational businesses. Finally, taking these statement groups together, I examined how the groups undermine the primary goal of national math education, namely to increase the knowledge and use of mathematics by people living in the US.

I do not intend that my analysis is anything more than my own analysis. In other words, the statement groups I found and then focused on might not be the same as the statement groups found by another who executed the same approach. Here are some aspects that influenced my search and attention. In beginning my search for the themes, I was informed by the historical sketch of national math education in the 20th century that I presented earlier in this chapter as well as Wedel's perspective on contemporary governance. Beginning and throughout the whole process, I was also influenced by my particular experiences as a math enthusiast, a public school math teacher and more generally my own worldview.

I have laid out my method for reading the representative social network surrounding national math education that I constructed as this dissertation's primary unit of analysis. This included reading the statements and activities of the individuals and organizations in the network, with special attention to how they relate to national math education. I found that four interrelated interest groups emerged and each one is the subject of inquiry in the next four chapters. Here I also suggest that my reading purports to be nothing more than my own.

This concludes my chapter reviewing the ideas that informed my particular approach of inquiry into national math education. I adapted social network analysis for its power in describing social phenomenon. Particularly at the center of my approach is Janine Wedel's “new forms of governing,” out of which I identified three national math education events where social networks of individuals and organizations influence this policy domain. These led to the construction of the social network on page 72. I also outlined my approach to reading the network, which led to the interest groups I identify and elaborate upon in the following four chapters. First, I attend to the primary interest, using national math education as a means to develop human capital.

Chapter 3: Math Education for Human Capital

As I presented in the first chapter's historical sketch, an emerging US national math education in the 20th century often represented military and economic interests. These interests remain significant in the present efforts for a national math education. For example, in 2010, 110 corporate CEOs founded the organization "Change the Equation." They pledged "to create widespread literacy in science, technology, engineering and math (STEM) as an investment in our nation that empowers us all."[101] The organization serves as a symbol of the significant attempts by businesses to use education as a means of developing a workforce useful for their needs. This chapter focuses on how such a purpose for education, the investment in human capital, is primarily what is meant by math education "in the national interest."

Human capital theory suggests that particular investment in humans can lead to greater business returns.[102] This perspective views people as a natural resource upon which you can add value. In examining the activities and statements of actors in my representative social network surrounding national math education from chapter 2, I found significant support for developing human capital as a primary purpose for national math education. Some actors in this network are the types of organizations that reap the returns from investment in human capital; others, in the spirit of Janine Wedel's "flexians," do not share this interest but do agree with this purpose for math education for a variety of reasons, such as advancing their particular pedagogical stance regarding

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[101] Change the Equation, "Our Mission and Goals," accessed May 15, 2011, http://www.changetheequation.org/what/our-mission-and-goals/.

[102] Gary Becker, *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*, (Chicago: University of Chicago Press, 1994).

teaching math (see chapter 4).

I begin this chapter with a review of human capital theory, attending to its historical context, primary theorists and its modern conception as related to a global economy. Next, the bulk of this chapter elaborates on my findings regarding network support of using math education to develop human capital. I include a sociogram of the network that indicates actors' aligning with the human capital interest. I also detail the ways that network actors have expressed their commitment to math education for human capital, beginning with those network actors who I argue hold an interest in educating for human capital, similar to the corporations that founded "Change the Equation." The remainder are examples of actors who have adopted these interests, expressing their adoption by either stating math education's role in US economic competitiveness or performing research that compares US math education with that of other nations. Notably, some of these international comparisons of math education have contributed to the triumph of the traditional perspective in national math education.

In this chapter I do not develop an argument for why knowledge of mathematics is important for human capital. For now, I am looking at the presence of the human capital interest in the national math education network. Determining why mathematics is valued, a central question in this dissertation, will become the focus in chapter 4 where I analyze how opposing pedagogical viewpoints align with the human capital interest.

Finally, before I begin, I also draw attention to the fact that I insert commentary regarding human capital theory throughout this chapter. Important points include the fact that a broad range of economists support national investment in the development of human capital, from neoclassical economists like Milton Friedman to those of the Keynesian persuasion, like economist Robert Reich. As well, I consider evidence indicating that human capital theory and according educational policy serves the interest of global elites and their multinational companies, rather than the purported interest of the workers, including both professionals and producers in the economy.

Human Capital Theory

The notion of human capital designates human beings as one form of capital, or those assets that can lead to an increase of assets. Capital has usually been understood to primarily describe money, land, and factory machines, but now often includes "the importance of people - their abilities, their knowledge, and their competences - to economic growth."[103] Because people can be the repositories of intangible qualities that aid in the production of goods and services, investments should be made to improve such capital, much like an industry puts money into its factory machines.

In this section I further elaborate on the history and theoretical underpinnings of education for human capital and the calls for state investment in it. First, I discuss the seminal contribution to human capital theory provided by Gary Becker, part of the Chicago school of economics associated with Milton Friedman. I also indicate how a wide range of economic theorists support the notion of educating for human capital, such as neoclassical economists and liberal economists like Robert Reich. Next, I review that contemporary human capital theory reflects a phenomenon of using nation-state

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[103] Brian Keeley, *Human Capital: How What You Know Shapes Your Life,* (Paris: OECD Publishing, 2007), 29.

educational policy to provide for the needs of a global economy and a priority placed on profits for business, rather than whatever may be gained by the individuals being education. To conclude the section, I connect human capital theory with math education by reviewing some human capital theorists' implication of math education's role in the development of human capital.

Economists as early as Adam Smith presented ideas similar to human capital.[104] However, it was during the rebirth of classical economics in the 1950s and 1960s that human capital theory became a designated field of study. This context, often referred to as neoliberalism or the Chicago school, was an era of economic scholarship that received significant contributions from Friedrich Hayek and Milton Friedman. Central tenets included an “adherence to ... free market principles” and opposition to “state interventionist theories, such as those of John Maynard Keynes.”[105] Free market principles include the assumption that every person behaves rationally in their own economic self interest and that competition among providers of goods and services will lead to the greatest efficiency and quality in production, the greatest satisfying of people's needs and desires, and producing the greatest equality among persons. Part of success in the competition includes wise investment in resources, such as investments in land and the development of skills in people.

Neoliberal economic theory asserts that government's role should be limited, merely a “state that will defend the rights of private property, individual liberties, and

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[104] Scott R. Sweetland, “Human Capital Theory: Foundations of a Field of Inquiry,” *Review of Educational Research* 66, No. 3 (Autumn, 1996), 343.
[105] David Harvey, *A Brief History of Neoliberalism*. (New York: Oxford UP, 2005), 21.

entrepreneurial freedoms."[106] Similarly, as to the government's role in education, Friedman indicates that schools should not be government run, because competing schools will lead to greater efficiency in the educational process, but also that their product should include teaching the skills that corporations can use to make profits.[107] Societal investment in such education, via the state, can lead to increased profits.

This latter point of Friedman's, that government should support the development of human capital, launched several economists into inquiries specifically devoted to human capital. Two Chicago school scholars, Gary Becker and Theodore Schultz, provided the foundation for this work.[108] They sought to provide empirical evidence for the theoretical claim that investment in education results in higher income levels. Schultz "explained that national income had risen significantly during the 1900-1956 period. Furthermore, of the factors contributing to national income growth, the estimated stock of education in the work force had grown at nearly twice the rate of reproducible capital."[109] Schultz highlighted formal schooling as a means for human capital investment and also contributed methods for analysis of investment in human capital. The latter work sought to distinguish expenditures in human capital that result in returns for the investors and those that do not.[110]

Becker's *Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education* quickly claimed its role as the most influential and

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106 Harvey, *A Brief History,* 21.
107 I argue the latter point given Friedman's support of government subsidies for vocational training. See Milton Friedman, "The Role of Government in Education" *Economics and the Public Interest*, ed. Robert A. Solo, (Piscataway, NJ: Rutgers University Press, 1955).
108 Sweetland, "Human Capital Theory," 342.
109 Ibid., 348.
110 Ibid., 348-349.

comprehensive study on human capital investment.[111] In the introduction to the first edition, Becker describes research on human capital as searching for the less tangible qualities that affect economic growth.[112] He seeks to move beyond the "circumstantial evidence" for investing in human capital:

> More highly educated and skilled persons almost always tend to earn more than others. This is true of developed countries as different as the United States and the Soviet Union, of underdeveloped countries as different as India and Cuba, and of the United States one hundred years ago as well as today. Moreover, few if any countries have achieved a sustained period of economic development without having invested substantial amounts in their labor force.[113]

To that end, Becker developed theoretical distinctions to determine exact rates of return on human capital investment. His empirical work in the book primarily involves analyzing the differences in incomes between those who have received formal schooling and those who have not. One implication of this work is that the state should assume the costs of education so that businesses can have more skilled workers upon which to draw.

The idea of government and societal investment in human capital has thrived since the 1960s and now emphasizes efficiency in producing the desired educational outcomes. A 2007 publication of the Organization for Economic Cooperation and Development (OECD) quotes heavily from Schultz and Becker. The primary emphasis in the book is that state and other societal investment in human capital is essential for a nation's economic growth in the global economy. The nations that have the strongest economies are those that provide the most effective education for human capital. The

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[111] M. W. Reder, "Gary Becker's Human Capital: A Review Article " *The Journal of Human Resources* 2, No. 1 (Winter, 1967), 97-104

[112] Gary Becker, *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*, (Chicago: University of Chicago Press, 1994), 11-12

[113] Ibid., 12.

book contains an interview with Becker who answers that, yes, governments should spend money on education in this way. However, “the question is, are we spending it the right way, efficiently, and maybe we can improve the efficiency and end up spending less money and getting more results from that money.”[114] Becker here suggests that education should be streamlined to only produce the outcomes needed by business. This is an important aspect of the human capital theory that I address in chapter 5. The OECD suggests both efficiency in a state's development of human capital and the nation-state's role in developing human capital needed by the global economy.

As I have explained, the origins of human capital theory situate within the neoclassical, free-market economics of Friedman. However, a broad range of economic theorists have taken up the understanding that national investment in the development of human capital will lead to a stronger economy. For example, Robert Reich indicates his like-minded beliefs in a recent article “Bail Out Our Schools.”[115] Reich is known for some economic stances that oppose neoclassical economics, such as tax structures that redistribute wealth by taxing higher income brackets more and lower income brackets less.[116] As for human capital theory, Reich describes his concern over US spending on education as follows:

> Our schools are the engines of our human capital, and if we don’t bail out public education we face a bigger economic Armegeddon years from now. Financial capital moves instantly around the globe to wherever it can earn the best return. Human capital – the skills and insights of our people – is the one resource that’s uniquely American, on which our

114 Keeley, *Human Capital,* 31.
115 Robert Reich, “Bail Out Our Schools,” March 8, 2010, http://robertreich.org/post/435115797
116 This view is expressed in the NY Times interview of Reich: Stephen J. Dubner, "Robert Reich Answers Your Labor Questions,” *The New York Times,* May 1, 2008, http://freakonomics.blogs.nytimes.com/2008/05/01/robert-reich-answers-your-labor-questions/. .

> future living standards uniquely depend.[117]

As with economic theorists of differing viewpoints, Reich indicates human capital development as essential for the American economy. We can also consider a contrasting view not indicated by most economists: human capital development helps global economic elites more than a nation's economy or the wages of the people living in it. I will continue by developing this argument more fully.

Nation-state investment in education for competition in the global economy is a circumstance expressed by the National Center on Education and the Economy (NCEE), one of the research and policy institutes I identified in my representation of the social network surrounding national math education. NCEE's mission is “To analyze the implications of changes in the international economy for American education, formulate an agenda for American education based on that analysis and seek wherever possible to accomplish that agenda through policy change and development of the resources educators would need to carry it out.” NCEE publications including “Tough Choice or Tough Times” offer further clarification on what these changes are:

> When the report of the first Commission on the Skills of the American Workforce, America’s Choice: high skills or low wages!, was released in 1990, the globalization of the world’s economy was just getting underway. That Commission understood the threat in the straightforward terms captured in the report’s subtitle. A worldwide market was developing in low-skill labor, it said, and the work requiring low-skills would go to those countries where the price of low-skill labor was the lowest. If the United States wanted to continue to compete in that market, it could look forward to a continued decline in wages and very long working hours. Alternatively, it could abandon low-skill work and concentrate on competing in the worldwide market for high-value-added products and services. To do that, it would have to adopt internationally

[117] Reich, “Bail Out Our Schools.”

> benchmarked standards for educating its students and its workers, because only countries with highly skilled workforces could successfully compete in that market. [118]

The quote asserts that nations are competing with each other in their production of the best human capital, specifically those intangible qualities usable for the professional sector, as opposed to the labor involved in producing goods. The nation that wins the competition is the one that invests "in infrastructure, education, and research and development to allow their citizens to have the opportunity to earn world-class standards of living."[119] Therefore, governments should provide an appropriate education for their citizens to have the best chance at gaining employment by corporations who now look across the globe for their professionals. Ironically for the US, however, the global competition of workers lowers the earning potential of US workers, clearly in the case of production workers and potentially in the case of some professional jobs. Support for these claims comes from an article published by the Economic Policy Institute, whose board includes Robert Reich.

NCEE's quotation indicates that the global economy increases the wages of professionals and not producers in the economy. First, most American workers do not benefit from global competition because they are not professionals:

> Production workers constitute roughly 75% of the entire U.S. workforce, and workers without a four-year college degree constitute roughly 70% of this workforce. Hence, while gross *gains* may exceed gross *losses* in the U.S. as global integration proceeds, it is not necessarily the case that *winners* outnumber *losers*. Global integration, in short, has the potential

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[118] National Center on Education and the Economy, *Tough Choices Or Tough Times Executive Summary*, 2007, http://www.ncee.org/publications/tough-choices-or-tough-times-consortium-publications/,

[119] Lester C. Thurow, "Globalization: The Product of a Knowledge-Based Economy" A*nnals of the American Academy of Political and Social Science* 570, (July, 2000), 19.

to inflict *permanent* harm to *most* American workers...[120]

For this reason, income inequality between professional and production workers has grown significantly since 1979.[121] In other words, globalization hurts the majority of workers in the US. Accordingly, NCEE and those advancing the development of human capital desire most future US citizens to become professionals. However, globalization is also predicted to hurt the wages of some of these professionals as well. From the same Economic and Policy Institute white paper,

> a number of economic researchers and observers have made forecasts as to the number of jobs that could be potentially "up for grabs" in the future, as technology, policy, and the introduction of billions of workers from China, India, and the former Eastern Bloc countries into the capitalist global economy make more jobs internationally contestable, particularly through service-sector offshoring.[122]

The "service-sector offshoring" includes several jobs more aligned with professionals than producers in the economy, such as computer programmers needed by the information and communications technology sector.

Therefore, investment in math education does not seem to serve the nation's economic health via increasing wages, but instead a global economic health via global economic growth (with disregard for who receives the benefit of this growth). One winner in this globalization might be the information and communications technology companies which are able to offshore their professional jobs. The following quote indicates the variety of such ICT companies' offshoring efforts:

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120 Josh Bivens, "Globalization and American Wages: Today and Tomorrow," October 10, 2007, EPI Briefing Paper #196, http://www.epi.org/publications/entry/bp196/.
121 Ibid.
122 Ibid.

> In July 2003, for instance, IBM acknowledged that it was speeding up its schedule to shift 3 million service jobs to China and India. Microsoft Senior Vice President Brian Valentine admitted in a July 2002 presentation that work could be had in India at "two heads for the price of one." AT&T Wireless and Boeing are among other large-scale operations known to be shifting IT labor pools from Washington State to India and other low-cost countries. Even state agencies, including the departments of corrections and social and health services, are outsourcing to offshore computer programmers.[123]

Therefore, globalization also reduces the earning potential of professionals, at least in the case of those in the ICT sector. I argue that globalization reduces wages for US workers who are producers and professionals in the economy. The reduction of labor costs benefits these multinational corporations that draw from across the globe for their labor. Therefore, the US development of human capital, with its importance for competing in the global economy, serves the interest of the bottom line of for-profit organizations. This indicates why such corporations, like Apple, Gates Foundation, Boeing, Union Carbide, Verizon, Walmart, Hewlett Foundation and Xerox, provide the funding for NCEE's activities.[124] In a capitalist society, corporations have the right to seek profits, just as individuals have the right to pursue education for employment or other personal goals. In this case, corporations are seeking profits by utilizing the public education system for increasing their bottom-line.

Moving to math's role in educating for human capital, I begin by revisiting contributions from the aforementioned prominent figure in the development of human capital theory, Gary Becker. A recent comment from him asserts that math education is

[123] Silja J.A. Talvi, "Tech Workers Combat Offshoring," January 26, 2004, http://www.inthesetimes.com/article/687/.

[124] National Center on Education and the Economy, "About NCEE," accessed December 1, 2010, http://www.ncee.org/about-ncee/funders/.

somehow important in the development of human capital. From an addition to his 1993 re-print of *Human Capital*: Concerns about investment in human capital "are stimulated by tough economic competition from a renewed Europe, Japan, Korea, and other Asian countries, by sluggish rates of productivity in the United States during the past fifteen years, by a large drop in SAT scores, and by the dismal performance of American high school students on international tests in mathematics."[125] The results of student performance on math tests is often attended to by economists, indicating their connecting of math education with economic performance. In this way, economists view math education as a means to develop human capital. I attend to these particulars in chapter 4, where I discuss how the opposing pedagogical viewpoints in the math wars, namely traditional and progressive math pedagogy, both indicate ways that math education can develop human capital.

There has been more attention to these international math assessments, with some attempts at determining to what extent performance on these tests correlates with economic growth. Particularly influential among these attempts is the work of Eric A. Hanushek and Ludger Woessman. Their analysis indicates that a nation's investment in cognitive skill development (as measured by the outcomes on international math tests) contributes more to a nation's economic growth than its support of free trade and property rights or regulations on the product and labor markets.[126] They use a nation's GDP per capita to indicate economic well-being as opposed to other indications of a society's

125 Becker, *Human Capital,* 17.

126 Eric A. Hanushek and Ludger Woessman, "How much do Educational Outcomes Matter in OECD Countries?" CESIFO Working Paper No. 3238 Category 5: Economics of Education, November 2010, http://www.cepr.org/meets/wkcn/9/979/papers/hanushek_woessmann.pdf

economic health, such as real wage earnings or measures of income distribution. This marks a significant difference from the earlier work of Becker, who measured the return on investments in human capital by the wage earnings of those that received education.

Hanushek and Woessman suggest that human capital theory, presently or perhaps always, is concerned primarily with the rate of return for businesses, not individuals. Using GDP per capita as a measure indicates only how successful a nation's economic output is, with no consideration regarding who receives this benefit. Quite the contrary, given the stratification of wealth in the US from the 1980's through today,[127] measuring GDP per capita clearly signifies an emphasis on corporate profits. Human capital theory, at least in its present form, considers state investment in human capital as an important contributor to corporate profit. This is consistent with my previous considerations of globalization's effects on US wages, including the workers regarded as both professionals and producers.

My review of human capital theory provides a framework for identifying those in the network who align with this theory. I have highlighted how human capital theory emerged from the era of neoclassical economics and thereby emphasizes the contradictory theme of a free market, i.e. non-government run, approach to education coupled with a state that forces educational outcomes to meet the needs of business. However, economic theorists who do not share the neoliberal view, such as Robert Reich, also embrace human capital theory. In all cases, the theory investigates how such state investment in education can lead to economic growth and then promotes this investment.

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[127] For documentation, see, for example, Harvey, *A Brief History*, 16.

Today, a nation's investment in such human capital is argued to impact that nation's economic growth. As indicated by the work of Hanushek and Woessman, this perspective clearly prioritizes the interests of such growth over the interests of those that receive the education. Furthermore, US competition in the global economy reduces the wages of both production workers, the majority of labor in the US, and professionals. Lastly, human capital theorists pay attention to math education, indicating their belief in its role in the development of human capital. Using this review of human capital, I now present the various network actors who desire a state that educates for human capital, who represent those that do, and finally those who adopt this interest to advance their own.

Human Capital in National Math Education's Social Network

Now that I have elaborated on what it means to educate for human capital, I focus on the connection between it and national math education. Upon initial inspection of the writings and activities of my network's actors, I found that several indicated commitment to a math education that serves the needs of human capital. The results of my inquiry are expressed in the sociogram below, Figure 3-1, a reproduction of chapter 2's sociogram on page 72. This time, however, the sociogram also indicates the network actors that align with human capital. Those that are gray are those I found to indicate such commitments because they are either corporations that will benefit from a national math education that develops human capital, or because they are other individuals or organizations who state this as the purpose for math education. For example, one organization that holds the human capital interest is “GS9,” ExxonMobil. This organization requires human capital to increase profit margins. There are also those network actors that are not the corporations themselves that will benefit from human capital development, but instead they are organizations that represent these corporations. An example from this category is the research and policy institute "RP1," Achieve, Inc., which receives funding from several corporations and has corporate executives on its board. Third are those academics that express the human capital interest; an example is "ME6," Francis (Skip) Fennell. He is a math education researcher who is not a board executive of an organization that uses human capital, but did adopt such an interest because he stated that math education will help the US compete in a global economy. Later I argue more clearly how these and other actions represent an adoption of the human capital interest. Of the network's 147 actors, 86 are gray. For greater clarity, I have also repeated the tables of network actors, this time indicating those actors who express the human capital interest.

Figure 3-1: Human Capital in National Math Education's Social Network

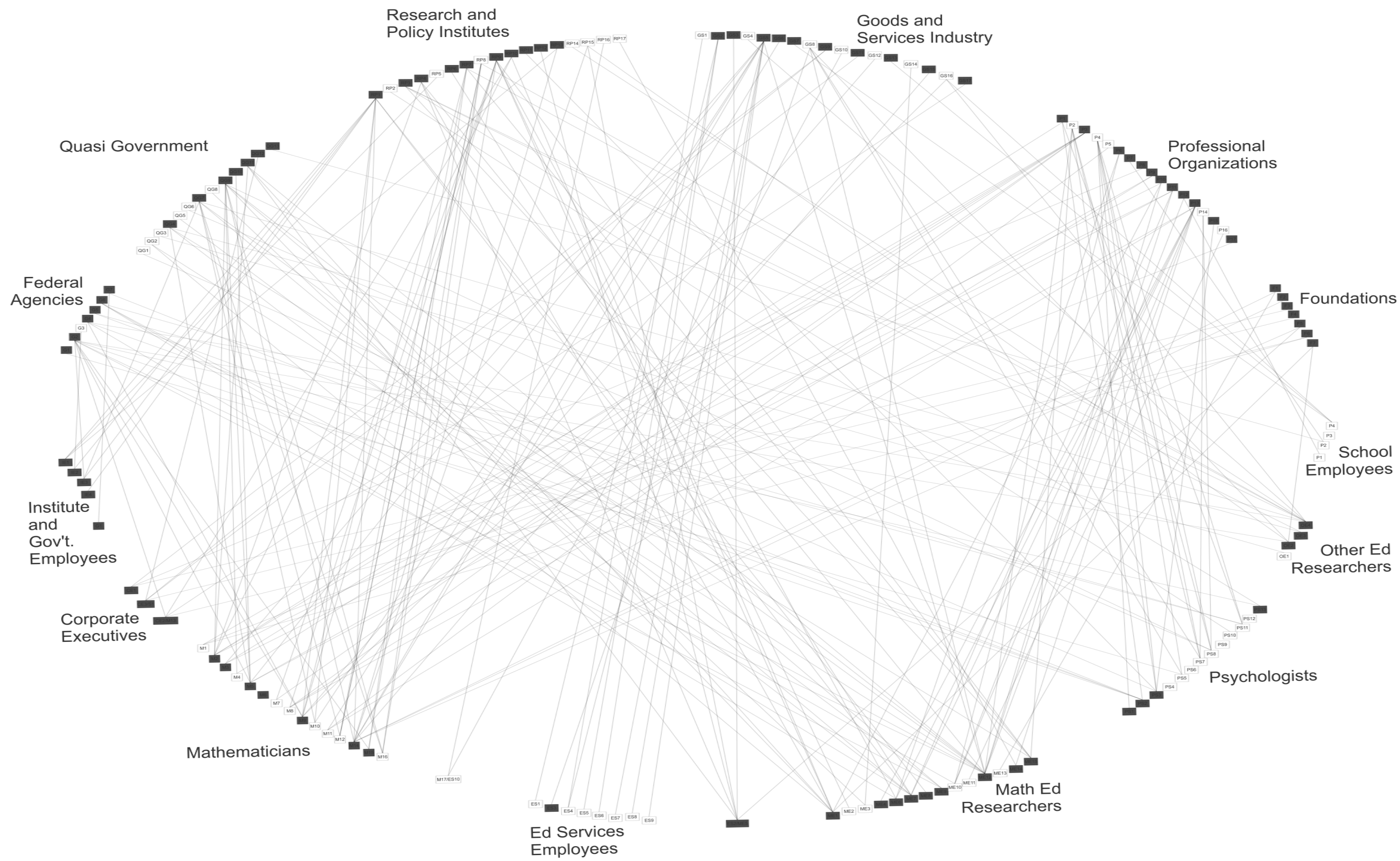

Table 3-1a: Network Individuals Expressing Human Capital

CE1	Robinson
ES1	Clough
ES10/M17	Zimba
ES2/ME5	Daro
ES3	Gong
ES4	Ladd
ES5	Miller
ES6	Mullen
ES7	O'Callaghan
ES8	Schwartz
ES9	Vasavada
G1	Arispe
IE1	Forgione
IE2	Kraman
IE3	Slover
IE4	Sovde
M1	Andrews
M2/ME2	Bass
M3	Bressoud
M4	Browder
M5	Dossey
M6	Fristedt
M7	Howe
M8	McCallum
M9	Milgram
M10	Milner
M11	Peck
M12	Schmid
M13/CE2	Simons
M14	Treisman
M15	Wilson
M16	Wu

ME1	Ball
ME3	Carpenter
ME4	Clements
ME6	Fennell
ME7	Ferrini-Mundy
ME8	Fuson
ME9	Hiebert
ME10	Kepner
ME11	Kieran
ME12	Kilpatrick
ME13	Ma
ME14	Ramirez
ME15	Schmidt
OE1	Gersten
OE2	Hakuta
OE3	Loveless
OE4	Stotsky
P1	Day
P2	Eddins, Susan
P3	Pardo
P4	Williams
PS1	Benbow
PS2	Berch
PS3	Boykin
PS4	Brophy
PS5	Embretson
PS6	Geary
PS7	Lane
PS8	Linn
PS9	Mayer
PS10	Miller, Kevin
PS11	Reyna
PS12	Siegler
PS13	Whitehurst
S1	Faulkner

Table 3-1b: Network Organizations Expressing Human Capital (continued on next page)

F1	Carnegie Foundation for the Advancement of Teaching
F2	Charles Dana Foundation
F3	Greenwall Foundation
F4	Houston Endowment
F5	Noyce Foundation
F6	Simons Foundation
F7	Spencer Foundation
G1	Department of Defense
G2	Department of Education
G3	Department of Justice
G4	National Aeronautics and Space Administration
G5	National Institutes of Health
G6	National Science Foundation
G7	Office of Science and Technology Policy
GS1	Academic Benchmarks
GS2	ACT
GS3	America's Choice
GS4	Carus Publishing
GS5	College Board
GS6	Consortium for Math and its Applications (COMAP)
GS7	CTY, JHU
GS8	Educational Testing Service
GS9	ExxonMobil
GS10	Grow Network, McGraw Hill
GS11	Guaranty Bank
GS12	Holt-Reinhart
GS13	MathCounts
GS14	National Center for the Improvement of Educational Assessment
GS15	New Teacher Project
GS16	Oxford-Sadlier
GS17	Pearson
GS18	Renaissance Technologies
P1	American Association for the Advancement of Science
P2	American Educational Research Association
P3	American Mathematical Society
P4	American Psychology Association
P5	American Statistical Association
P6	Association for Mathematics Teacher Educators
P7	Association of State Supervisors of mathematics
P8	Conference Board
P9	Conference Board Mathematical Sciences
P10	International Commission on Math Instruction
P11	Mathematics Association of America
P12	National Council of Supervisors of Mathematics
P13	National Council of Teachers of Mathematics
P14	National Council on Measurement in Education

P15	National Education Association
P16	Psychology of Math Education
P17	Society for Industrial and Applied mathematics
QG1	Capstone Research
QG2	Center for Proficiency in Mathematics Teaching
QG3	Instructional Research Group
QG4	International Educational Assessment
QG5	Mid-Atlantic Center for Mathematics Teaching and Learning
QG6	Nat'l Center for Research on Evaluation, standards and student testi
QG7	National Assessment Governing Board
QG8	Nat'l Cent. for Improving Stud. Learn. and Achvmnt in Math & Scien
QG9	National Academy of Sciences (and NRC and MSEB)
QG10	Organization of Economic Cooperation and Development
QG11	RAND
QG12	Sandia National Laboratory
QG13	TERC
QG14	US National Commission on Math Instruction
RP1	Achieve, Inc.
RP2	Beckman Institute
RP3	Brookings Institute
RP4	RAND
RP5	Council for Basic Education
RP6	CT Academy for Ed in Math, Sci, Tech
RP7	Fordham Institute
RP8	Honest Open Logical Debate
RP9	Institute of Math and Education
RP10	Mathematical Sciences Research Institute
RP11	Minority Student Achievement Network
RP12	National Center for Edcuation and the Economy
RP13	National Math and Science Initiative - Uteach
RP14	Pioneer Institute
RP15	Strategic Education Research Partnership
RP16	Student Achievement Partners
RP17	TODOS
RP18	US Teacher Ed Study in Math

The remaining sections of this chapter elaborate on these network actors who hold, represent or adopt the human capital interest. I have grouped these various actors into the following sections. First, I review examples of businesses in the network that require education to develop human capital. Next are examples of the types of organizations that represent the interest via corporate influence. The remaining sections discuss ways that other actors adopt the interest, first by highlighting actors who suggest math education's importance in US economic competition in the global economy. Other network actors express this connection by their research on international comparative math tests, which are argued to represent the concern over developing human capital. Lastly, I present evidence indicating that educational business, an auxiliary interest in national math education and the subject of chapter 6, adopts the human capital interest.

Network Actors Who Desire the Development of Human Capital

Here I present the network actors for whom investment in human capital is useful. That is, several of the actors in my representation of the network surrounding national math education require a workforce. Therefore, I argue they exist in the network because they want the state to invest in developing in humans particular intangible qualities. This opposes other explanations for their inclusion in the network, such as the claim of private philanthropy for the good of society. Rather, in light of the development of human capital theory, I argue these corporations stand to gain by involving themselves in educational policy.

Broadly speaking, these network actors are businesses competing in a global economy. They include businesses in financial services, military services, information and communication technology, and energy. All of these sectors point to advancements in technology as a critical contributor to success, or profit increases. The inclusion of military service corporations marks a significant change from my historical sketch, especially the middle decades of the 20th century. I found no military officials in my social network as were discussed in chapter 1. However, military interests remain present in the contemporary talk about national math education and are situated within the interests of businesses who provide military services.

Exxon, Guaranty Bank, the Noyce Foundation, Renaissance Technologies, RAND, and Sandia National Laboratory represent the types of actors surrounding a national math education who see math education as a means to develop the human capital they require. I will now proceed through the types of corporations by offering a few examples of how an employee's knowledge and use of mathematics may be useful for these types of corporations. However, I devote closer attention to the corporate motives behind math education in chapter 4 when I discuss the opposing stances in math education's pedagogy wars. There, motivations include math education's connections to the contemporary knowledge economy, efficient identification of exceptional human capital, and a moral education.

The presence of Renaissance Technologies and Guaranty Bank signifies how math education can provide the human capital required by the financial services industry. For example, Renaissance Technologies, James Simons' investment management company, uses creative thinkers with advanced mathematical expertise for the design of innovative and complex hedge funds.[128] Such work leads to significant profits for the company, as indicated by the success of Renaissance Technologies' Medallion Fund.[129]

On the other hand, the Noyce Foundation represents math education for the human capital needed for information and communications technology. The Noyce Foundation was founded by the family of Robert Noyce, "co-founder of Intel and inventor of the integrated circuit which fueled the personal computer revolution and gave Silicon Valley its name."[130] The Foundation funds projects that improve the teaching of science and math, which reflects Noyce's "concern about the shrinking pipeline of students interested and committed to science-related careers." Information and communication technologies businesses provide both consumer technologies and services to other businesses, including those working in public education.

Similarly, Exxon requires the development of technology for greater profits in their production of energy. "Technology is more important today than ever, since a significant portion of the world's oil and gas resources is located in challenging environments such as deepwater, heavy oil/oil sands, tight gas and Arctic regions, which require innovative approaches to energy production."[131] This begins to indicate the reasons for Exxon's philanthropic endeavors in national math education, including their prominent role in "Change the Equation," the organization I referred to when introducing

128 Scott Patterson, *The Quants: How a New Breed of Math Whizzes Conquered Wall Street and Nearly Destroyed It* (New York: Crown Business, 2008), 108-117.

129 The following article indicates how Simons' successful hedge fund is only available to Renaissance Tech employees: Susan Pulliam and Jenny, "Simons Questioned by Investors: Disparity is Seen in Running of Two Renaissance Funds," May 15, 2009, *The Wall Street Journal.*

130 Noyce Foundation, "About Us," accessed June 1, 2011, http://www.noycefdn.org/aboutus.php.

131 ExxonMobil, "Producing Energy," accessed May 15, 2011, http://www.exxonmobil.com/Corporate/energy_production.aspx.

this chapter. Given the US military presence in the Middle East, Exxon's energy services also bring up the notion that their human capital investment might dovetail with the military services sector.

More to this point, the human capital required by the military services sector is better expressed by the network presence of RAND and Sandia National Laboratories. Both are government supported institutions that provide research and development in the technologies needed for the US military. RAND "conducts a broad array of national security research for the U.S. Department of Defense and allied ministries of defense."[132] Currently, Sandia meets "national needs" including nuclear weapons, defense systems and homeland security and defense.[133] The work of Sandia is contracted out to Lockheed Martin. To be fair, both RAND and Sandia do perform research in other areas, but their interest in human capital for providing military services is undeniable as it is a major component of the services they provide.

While the corporate motives for investing in math education remain nebulous, I have thus far indicated the types of corporations that desire such investment. These include businesses that work in the financial, information and communications technology, military and energy sectors. The next section presents the corporate shadows within the network, that is, those network actors that have significant influence from these types of businesses but are not these businesses themselves. This variety of organizations indicate a few other industrial sectors at play in national math education,

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[132] RAND, "National Security," accessed May 15, 2011http://www.rand.org/topics/national-security.html
[133] Sandia National Laboratory, "About Sandia," accessed May 15, 2011, http://www.sandia.gov/about/index.html. accessed may 15, 2011

including pharmaceuticals.

Network Actors Representing the Corporate Interest

The previous section detailed those actors in the network that actually hold the human capital interest and here I will present how the same types of businesses hide within other actors in the network. These actors do not directly benefit from investment in human capital, but instead represent those that do. Within my social network surrounding national math education, there are organizations who have corporate board members or who are funded by businesses with the human capital interest. I will provide examples from among the network actors that fit this category, having chosen these particular examples to indicate the breadth of type of organization (based on activity) that represent the human capital interest. These are research and policy institutes National Center on Education and the Economy, Achieve, Inc., Brookings Institution, Center for Ed Reform, Conference Board, Minority Student Achievement Network, Fordham Institute, New Teacher Project, TERC and the National Math and Science Initiative; goods and services organizations America's Choice; professional organizations American Association for the Advancement of Science (AAAS), American Statistical Association, Society for Industrial and Applied Mathematics, and Conference Board of the Mathematical Sciences, and quasi-governmental organization the National Academy of Sciences. In addition I discuss two individuals in the network that represent the human capital interests, these are Edgar Robinson and Irma Arispe.

Taking together these people and organizations, I am highlighting the network actors who represent corporations with a human capital interest. Upon examination, the shadows of business in national math education include information and communications technology, military services, financial services, pharmaceuticals and energy. For example, the funders of the National Center on Education and the Economy include several representatives from information and communications technology, such as Bill and Melinda Gates, Apple Computer, and Xerox. Also listed is Boeing, which indicates the needs of advancements for military technology.

I begin with these types of actors who represent the corporate interest and state investment in human capital quite strongly, such as the National Center on Education and the Economy (NCEE) and Conference Board. A quote I earlier included from NCEE indicates how their mission describes the human capital interest exactly. Furthermore, over the years, NCEE has received funding from the following corporations or affiliates with the human capital interest: Apple, Gates Foundation, Boeing, Union Carbide, Verizon, Walmart, Hewlett Foundation and Xerox.[134]

On the other hand, the Conference Board is a member organization of corporate executives, with board members from financial institutions like Deutsche Bank and Citigroup.[135] The group "is an objective, independent source of economic and business knowledge with one agenda: to help our member companies understand and deal with the most critical issues of our time."[136] One specific knowledge provided is human capital,

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134 National Center on Education and the Economy, "About NCEE" accessed December 1, 2010, http://www.ncee.org/about-ncee/funders/

135 Conference Board, "Trustees," accessed July 24, 2011, http://www.conference-board.org/about/index.cfm?id=1979.

136 Conference Board, "About Us" accessed July 24, 2011, http://www.conference-board.org/about/index.cfm?id=1980.

including "Identifying, implementing, and evaluating the best global people strategies to achieve financial and operational success."[137] Therefore, NCEE and Conference Board are two organizations that have corporate presence and overtly state their interest to develop human capital.

Achieve, Inc., the network research and policy institute that aided in developing the *Common Core State Standards* in math, also represents corporations desiring the development of human capital because this organization is funded by such corporations and has corporate executives on its board. Their funding over the years includes financial institutions such as Washington Mutual, Prudential, and Chase; information and communications technology corporations such as Microsoft, Hewlett Packard, Intel, and IBM; other engineering firms, including those that address the needs of the military like Boeing and Battelle, and others like Xerox and Kodak; and finally several insurance companies, such as Nationwide and State Farm. As with Conference Board and NCEE, Achieve accordingly indicates a commitment to the human capital interest. Later in this chapter I describe their expressed commitments as connected to the educational businesses' concern over an education for "College and Career Readiness."

Another network research and policy institute with the presence of the human capital interest is The Center for Education Reform (CER). The Center focuses its efforts on "advocating for school choice, advancing the charter school movement, and challenging the education establishment."[138] Among CER's board members are venture

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137 Conference Board, "Human Capital," accessed July 24, 2011, http://www.conference-board.org/topics/topics.cfm?topicid=40

138 Center for Education Reform, "CER Mission," accessed July 24, 2011, http://www.edreform.com/CER_Mission/.

capitalists, such as Robert Johnston in pharmaceuticals and Angus Davis,[139] whose company TellMe Networks was purchased by Microsoft.[140] Thus, the human capital interest lurks behind CER. Also, the board's entrepreneurs indicates the connection between venture capital interests and charter schools. In other words, educational entrepreneurs require charter school policy in order to create their educational management companies, such as KIPP. The New Schools Venture Fund[141] is a good resource to find more information on venture capital in education. However, these types of educational businesses were not a significant theme in my network surrounding math education. As I will discuss in chapter 6, among the variety of educational businesses, the testing industry holds the greatest power in national math education.

The Fordham Institute has board members and funding from the corporate world. These include Fordham's Bruno Manno of the Walton Family Foundation,[142] connected to Walmart Corporation and funding from Hewlett and Gates. Therefore, Fordham's shadow includes the retail and information and communications technology sectors. Likewise, the Brookings Institution has board members from banks (Goldman Sachs) and management firms (McKinsey & Company).[143] Accordingly, Brooking's "Brown Center on Educational Policy" aims its work to affect "the productivity and living standards of its workers, and its 'competitiveness' amid global economic pressures."[144]

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[139] Center for Education Reform, "About CER," accessed July 24, 2011, http://edreform.com/about_cer/?Board_of_Directors.

[140] Microsoft, "Microsoft to Acquire Tell Me Networks," March 14, 2007, http://www.microsoft.com/presspass/press/2007/mar07/03-14powerofspeechpr.mspx

[141] See the New Schools Venture Fund website for more information: http://www.newschools.org/ventures.

[142] Fordham Institute, "Board of Trustees," accessed April 26, 2011, www.edexcellence.net/about-us/board-of-trustees.

[143] Brookings Institution, "Trustees," accessed March 8, 2011, http://www.brookings.edu/about/Trustees.aspx.

[144] Brookings Institution, "About Us," July 24, 2011, http://www.brookings.edu/brown/About-Us.aspx.

The Minority Student Achievement Network (MSAN) connects school leaders from across the country who attempt to close the test score gaps between “minority” and white students. One of MSAN's projects, in partnership with Strategic Education Research Partnership Institute (SERP), was funded by financial institution Goldman Sachs and specifically addressed the learning of Algebra. “Nationwide, only about one-half of all students and about one-third of all minority students complete Algebra I, which is widely considered to be a crucial gatekeeper course that leads to success in the high school mathematics required for college study.”[145] Here, MSAN and Goldman Sachs pay reference to the commonly asserted connection between one's success in Algebra and later academic and job opportunities. In chapter 4, I consider more carefully this “gatekeeping” practice of math education, and its means by which students can be sorted into the professionals and producers of the economy.

Another network research and policy institute, The New Teacher Project (TNTP), has several corporate executives on their board of directors, such as a partner from Bain and Company which, in part, consults for industrial clients in “performance improvement.”[146] In chapter 5, I argue how TNTP increases the efficiency of educating for human capital by advocating for making it easier to fire teachers who do not teach in the ways that develop human capital.

TERC, originally known as the Technical Education Research Centers, receives funding from, among other sources, Microsoft, IBM and Hewlett Packard. Again these

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145 SERP Institute, “Addressing the Algebra Skills and School Engagement of Minorities,” accessed August 7, 2011, http://msan.wceruw.org/SERP_Algebra_Skills.pdf.

146 Bain and Company, “Performance Improvement,” accessed June 24, 2011, http://www.bain.com/consulting-services/performance-improvement/index.aspx.

indicate the Information and Communications Technology interest in math education. TERC was founded amidst concern over the Soviet launch of Sputnik, thus indicating TERC's historical connection to national math education for the military. Today, the activity of TERC comprises developing curricular materials and professional development for teachers. Another network organization, America's Choice, provides similar activity. This for profit company first began as a subsidiary of the National Center on Education and the Economy (NCEE) and has just recently been acquired by Pearson, a large educational corporation. Therefore, both TERC and America's Choice represent the human capital interest. Like TERC, America's Choice provides curricular materials and professional development for teachers. In chapter 5, I present in more detail these efforts of the human capital interest, specifically how they use the professional development of teachers to re-educate them for the type of math education that develops human capital.

The human capital interest also lurks behind a number of professional organizations in the network. The American Statistical Association's (ASA) board members include a vice president from pharmaceutical giant Pfizer, Inc.[147] The connection between statistics and pharmaceuticals is clear with their reliance on experimental studies and statistical analysis for the advancement of drugs. The officers and trustees of the Society for Industrial and Applied Mathematics (SIAM) include leaders from Boeing and Hewlett Packard.[148] Lastly, the Conference Board of Mathematical Sciences (CBMS) is the umbrella professional organization that includes

147 Americant Statistical Association, "Leadership," accessed April 26, 2011, http://www.amstat.org/about/leadership.cfm.

148 Society for Industrial and Applied Mathematics, "Board," accessed April 29, 2011, http://www.siam.org/about/board.php.

most professional societies related to mathematics, such as SIAM, ASA, the Mathematical Association of America (MAA), the American Mathematical Society (AMS) and the National Council of Teachers of Mathematics (NCTM). The following quote indicates CBMS' historical context as related to the US military:

> Formally incorporated in the nation's capital in 1960, CBMS traces its roots back to a War Policy Committee formed in 1942 by the American Mathematical Society and the Mathematical Association of America and its post-war successor, the Policy Committee for Mathematics which included six mathematics organizations. This committee became the Conference Organization of the Mathematical Sciences in 1958, and finally incorporated as CBMS in 1960 with seven member societies, growing over the years to include its present seventeen members.[149]

Today, the activity of CBMS is often supported by ExxonMobil. For example, ExxonMobil funded two of their recent national conferences, one on the Mathematical Education of Teachers and another that discussed the National Math Advisory Panel (NMAP) report. In chapter 5 I suggest that these and other activities by Exxon indicate their interest in re-educating math teachers to develop human capital efficiently.

The National Academy of Sciences (NAS) is a quasi-governmental organization that endures significant influence from corporations with the human capital interest. For example, NAS published the widely disseminated document on national math education *Rising Above the Gathering Storm.* Included on the authoring committee were executives from Lockheed Martin, Intel, Exxon Mobil, and DuPont. NAS also houses the National Research Council's Mathematical Sciences Education Board (MSEB). MSEB is responsible for authoring several influential documents on national math education, such

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[149] Conference Board of Mathematical Sciences, “About CBMS,” accessed December 8, 2010, http://www.cbmsweb.org/Members/about_cbms.htm.

as their 1997 publication *Toward Excellence in K-8 Mathematics Education*.[150] Over the years, members of MSEB have included executives from corporations with the human capital interest. These include representatives for AT&T, IBM, Boeing, and Oak Ridge National Laboratory, a Federally Funded Research and Development Center (FFRDC) that addresses the needs of US military operations.

As for examples of network individuals who represent the corporate interest, Edgar Robinson was a coauthor of *Adding It Up*, a publication of NAS and one of the three national math education events I used to identify the network I am analyzing in this dissertation. Robinson was vice president and treasurer of Exxon until 1998. Another individual in the network, Irma Arispe, was a member of the National Mathematics Advisory Panel (NMAP) who worked in the federal government's Office of Science Technology and Policy (OSTP). This auxiliary government agency "works with the private sector through the President's Council of Advisors on Science and Technology (PCAST) to ensure federal investments in science and technology contribute to economic prosperity, environmental quality and national security. "[151] The 2006 PCAST included executives from Lockheed Martin and Dell Computer.

Thus far I have presented examples of network actors who desire investment in human capital or represent those that do. Looking at both the explicit and lurking commitments to human capital in this and the previous sections reveals that the following industrial sectors require human capital: information and communications technology,

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[150] Mathematical Sciences Education Board, *Toward Excellence in K-8 Mathematics Education,* (Washington, DC: National Academy of Sciences, 1997).

[151] Quote taken from Arispe's biography for the National Math Advisory Panel, available at: http://www2.ed.gov/about/bdscomm/list/mathpanel/

energy, financial services, military, and pharmaceuticals. Upon considering the number of times these sectors present themselves in the network, information and communications technology appears more frequently than others. This will prove relevant when I discuss the educational business' shift to online assessment and instruction in chapter 6. Moving on, several network actors who lack the economic incentive to develop human capital also articulate that this is a purpose for math education. I first highlight those that state the need for math education for US competition in the global economy.

The US Competes in a Global Economy

In this section, I present the first set of network actors who adopt educating for human capital as a primary purpose for national math education. In particular, the actors here included from my representation of the social network surrounding math education all make the claim that math education, or knowledge and use of mathematics, will help the US compete in the global economy. These, and other similar expressions, reflect a belief that the US economy will remain strong if its citizens are the best trained for today's workforce needs. As I indicated earlier, while the US GDP may continue to climb, training for a competent workforce is in the interest of corporate profit rather than individual economic success. In fact, US participation in the global economy reduces the earning potential of its citizens. In other words, these actors who adopt the human capital interest are expressing alliance with the interest of the corporations who gain from human capital development rather than the citizens.

I begin by providing an example statement from each network actor I found to have expressed these explicit statements connecting math education with US economic viability. These statements come from network actors who do not desire investment in human capital for corporate profits or from those that represent such interest. Because these actors adopt the interest, I am simultaneously using and affirming Janine Wedel's notion of "flexians," where actors in a policy social network adopt others' interests to advance their own. Some of the interests that are advanced include one's pedagogical stance towards math education, my subject of inquiry in chapter 4, or the interest in making profit by providing educational services, which I attend to in chapter 6.

Explicit statements connecting math education and the US economy come from both individuals and organizations in the network. Examples of these individuals include mathematicians Hyman Bass, David Bressoud and John Dossey; math education researcher Francis (Skip) Fennell; and psychologists Grover "Russ" Whitehurst, Camilla Benbow and Dan Berch. The organizations include professional organizations, such as American Mathematical Society (AMS), Mathematical Association of America (MAA) and the National Council of Teachers of Mathematics (NCTM); government agencies National Aeronautics and Space Administration (NASA) and the Department of Education (DOE); and goods and services organization MathCounts. Several others also make such statements, yet I have reserved some of these examples for the following chapter when I discuss how the opposing pedagogical stances of traditional and progressive both justify their stance by the connections to human capital.

Mathematician David Bressoud gave public testimony in support of increasing funding for the National Science Foundation's (NSF) programs in Science Technology

Engineering and Mathematics (STEM) Education. From this speech:

> Much of America's competitive advantage in the world today is the result of its leadership in science and technology... Emerging powerhouses such as China and India are investing heavily in their universities and scientific institutes. As they also realize, promoting scientific and technological innovation requires more than funding laboratories and institutes. It requires educating the next generation of scientists and engineers who will populate those centers of excellence .[152]

The competitive advantage pays reference to the global economy and the US concern of the strengthening of the Chinese and Indian economies.

In 1995, Hyman Bass, well respected researcher in math and math education, gave an introductory address to a National Research Council workshop with the title "Mathematical Preparation of the Technical Work Force."[153] As expressed by the title, the workshop centered on the theme of human capital and was partially financed by the Sloan Foundation, whose areas of interest include science education to support the scientific enterprise and more generally US economic performance.[154] This workshop indicates the commitment to math education that develops human capital, an interest of corporations who have the right to seek profits in capitalist society. In his introductory remarks to the conference, Bass' stated the reason for the National Research Council's attention to K-12 education as follows: "Its interest in the issue stems from the fact that improvement of mathematics and science education is a national problem of great urgency, one whose solution has a great bearing on the well-being of our scientific enterprise and

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152 David M. Bressoud, "Statement of Dr. David Bressoud, Past-President of the Mathematical Association of America and Dewitt Wallace Professor of Mathematics, Macalester College," accessed July 20, 2011, http://appropriations.house.gov/_files/MathematicalAssociationofAmerica.pdf.

153 National Academy of Sciences, *Mathematical Preparation of the Technical Work Force: Report of a Workshop,* (Washington, DC: National Academy Press, 1995).

154 Alred P. Sloan Foundation, "Major Program Areas," 2008, http://www.sloan.org/program/1.

technologically based economy...”[155] Mathematician and former President of the National Council of Teachers of Mathematics (NCTM) John Dossey also demonstrates an alliance to math education for human capital. In 1988, he states that “the skills and expertise of a country's workforce are the foundation of its economic success. Lately, in our country, this foundation appears too fragile to withstand the challenges of the 21st century.”

Francis (Skip) Fennell, former president of the National Council of Teachers of Mathematics (NCTM), has expressed math education for human capital in three presentations[156] he gave in 2007 and 2008. All of these contain “competitiveness” in the title and their contents further elaborate how a math education can create an educated workforce for the US to remain competitive within the new global economy. In the presentation at Maryland's “Mathematics for All” conference[157], Fennell quotes from *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Future*[158] and the America COMPETES Act (see my discussion of this Act in chapter 2).

Psychologist and former Assistant Secretary of Education Grover “Russ” Whitehurst has authored several articles at Brookings Institution that connect math education with human capital. In one, Whitehurst calls for more refined studies of the

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155 Hyman Bass, “Introductory Remarks,” National Academy of Sciences, *Mathematical Preparation of the Technical Work Force: Report of a Workshop,* (Washington, DC: National Academy Press, 1995), 9.

156 Francis (Skip) Fennell, “Challenges - Competitiveness; Math for All Students Everyday," May 22, 2007, http://ffennell.com/presentations/MDQuadCountyChallengesCompetiveness.pdf; “Competitiveness, Coherence, Communication, and Choices: What should we do?,” Oct. 15, 2007, http://ffennell.com/presentations/Bucknell4CsOct152007.pdf; and “Competitiveness, Coherence & Communication Challenges for Mathematics Teaching and Learning,” Oct. 30, 2008, http://ffennell.com/NCTM/NCTMRegionalSCOct302008.pdf

157 Francis (Skip) Fennell, “Challenges - Competitiveness; Math for All Students Everyday," May 22, 2007, http://ffennell.com/presentations/MDQuadCountyChallengesCompetiveness.pdf.

158 National Academy of Sciences. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future Committee on Prospering in the Global Economy of the 21st Century:An Agenda for American Science and Technology,* (Washington, DC: National Academy Press, 2007) PDF available at http://www.nap.edu/catalog/11463.html.

relationship between education and economic growth. While “the relationship between years of schooling and economic output at the national level is complex,” a better measure comes from “scores on tests of cognitive skills in literacy and mathematics [which] are stronger predictors of economic output than years of schooling.”[159] Camilla Benbow, another psychologist, explicitly links math education to economic competitiveness. In “Education and US Competitiveness” she states that “We must ... attend to the needs of today's K-12 students and not neglect those who demonstrate potential talent in the science, technology, engineering, and mathematics (STEM) fields. We need both a well-prepared workforce and the future innovators whose ideas could transform the economy. This does not just happen by chance.”[160]

Psychologist Dan Berch explicitly links math education to human capital in a report on research in Science, Technology, Engineering and Math (STEM) education that he coauthored as a government employee.[161] This report calls for scientific research on the best methods in education, where scientific research is taken to mean controlled experiments comparing varying methods and student achievement primarily defined by results on tests. Their motivation is expressed in the following quote from the report: “The results described here make it rather obvious that we are in urgent need of developing evidence-based methods for how best to help the American public become

[159] Grover “Russ” Whitehurst, “Higher Education and the Economy,” August 9, 2010, http://www.brookings.edu/opinions/2010/0809_obama_college_whitehurst.aspx.

[160] Camila P. Benbow, “Education and US Competitiveness,” *Issues in Science and Technology* 23, 4 (Summer 2007).

[161] The National Science and Technology Council Committee on Science, Subcommittee on Education and Workforce, “Review and Appraisal of the Federal Investment in STEM Education Research,” October 6, 2006, http://www.whitehouse.gov/files/documents/ostp/NSTC %20Reports/STEMEducationResearchOctober06.pdf

more cognizant of the growing importance of STEM education for the future economic prosperity of this country."[162]

Moving to the network's organizations that tie math education to the US economy, I begin with the two professional organizations with such statements. The American Mathematical Society (AMS) states that

> During the annual federal appropriations process, [we] work hard to ensure adequate budget growth in those federal agencies that support science research and education. Significant, sustainable federal support of scientific development and technological innovation is critical to ensuring US competitiveness in today's global marketplace.[163]

Similarly, in fiscal year 2011, the Mathematical Association of America (MAA) encouraged the federal government to spend money on the undergraduate education of students in the Science, Technology, Mathematics and Engineering (STEM) fields. They argued that "to ensure the social, economic health and security of our nation, the capacity of America's colleges and universities must be increased to train the next generation of STEM professionals."[164] The MAA considers math education important because it leads to the professionals that will encourage progress in technology, as well as profits for the corporations working in these fields.

Three government agencies in the network surrounding math education make explicit connections between math education and the US economy or military. The Department of Education (DOE) states its mission to "promote student achievement and

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162 Ibid., 50.

163 American Mathematical Society, "Federal Budget for Math and Science," accessed July 1, 2011, http://www.ams.org/policy/government/federal-budget/federal-budget.

164 Mathematical Association of America, "FY 2011 Commerce, Justice, Science Appropriations Bill Support for Recruitment and Retention in Undergraduate STEM Education National Science Foundation," accessed July 1, 2011, www.maa.org/sciencepolicy/2011_AC_Reauthorization.pdf

preparation for global competitiveness."[165] Subsidiaries of the DOE including its research branch, Office of Educational Research (OERI) before 2002 and Institute of Education Sciences (IES) after 2002, also claim to execute research in the name of the US economy and national security. Similarly, the National Aeronautics and Space Administration (NASA) prepares educational programs because "Access to high-quality education is also recognized as a key to the door of economic opportunity for all Americans in an era when global competition challenges our workers to operate at world-leading standards of productivity. "[166] The National Science Foundation (NSF) presents the human capital needs of both the military and the economy in the expressed mission of its Directorate for Education and Human Resources (EHR) division. There they state that the purpose of their work to "achieve excellence in STEM education" is "to enhance the ... prosperity, ... and security of the nation."[167]

The last organization in the network surrounding national math education that connects math education to the US economy is MathCounts, a goods and services corporation that provides supplemental math education resources for gifted students, most often in the form of math competitions. In 2007, their chairman stated their associations with business and the connection between math education and the economy:

> As we continue a tradition started by our founding sponsors and corporate partners of ensuring that middle school students develop strong skills and

[165] US Department of Education, "What We Do," accessed July 1, 2011, http://www2.ed.gov/about/what-we-do.html.
[166] National Aeronautics and Space Administration, "An Opportunity To Educate: International Space Station National Laboratory," (2008), http://www.nasa.gov/pdf/257371main_issopp_omb_rev2.pdf.
[167] National Science Foundation, "About Education and Human Resources," accessed July 1, 2011, www.nsf.gov/ehr/about.jsp

> enthusiasm for mathematics, we are encouraged by a shift in attitude towards math and its recognition as an essential component of our nation's future global standing.[168]

The next group of network actors are placed together because they articulate a connection between math education and the preparation of a talented workforce. Because these types of statements prioritize the use of such education by employers, they clearly reflect the notion of human capital. To begin, I present a handful of network actors that simply make statements about a talented workforce, or use the phrase human capital, with little indication of how this workforce can be developed by math education. They are three research and policy institutes: the Institute of Mathematics and Education (IME), the Mathematical Sciences Research Institute (MSRI), and Student Achievement Partners.

The vision of the Institute of Mathematics and Education (IME), a research institute of mathematicians and math education researchers, includes the preparation of future scientists, engineers, and workers.[169] Similarly, the Mathematical Sciences and Research Institute (MSRI), " is dedicated to the advancement and communication of fundamental knowledge in mathematics and the mathematical sciences [and] to the development of human capital for the growth and use of such knowledge."[170] The founder of Student Achievement Partners, "an organization which assembles leading thinkers and researchers to design actions to substantially improve student achievement," was a participant in a panel titled "Performance, Not Paper: A New Approach to Human Capital

168 MathCounts, "MathCounts 2007 Annual Report," (2007), https://mathcounts.org/Page.aspx?pid=1856.

169 Institute of Mathematics and Education, accessed March 3, 2011, http://ime.math.arizona.edu/index.html.

170 Mathematical Sciences Research Institute, "About MSRI," accessed December 13, 2010, available at http://www.msri.org/web/msri/static-pages/-/node/234.

."[171]

In this section I have presented the actors from the social network surrounding national math education that adopt the notion of educating for human capital because they articulate a connection between math education and the US economy or the US workforce. The significance of these statements is that each actor aligns with the development of human capital for business rather than the interests of people living in the US because globalization leads to reduced wages for all job types. Next, I focus on the actors who compare the performance in mathematics of US students against that of students in other countries. They too operate under the incorrect assumption that a strong math education for US students will result in greater US economic growth.

US Students Compete in a Global Mathematics

Besides the statements of math education's role in US economic competitiveness are network actors' statements and activities that compare US math education performance to that of other countries. These practices are argued by one network actor, psychologist Robert Linn, as committed within the context of a math education for human capital, specifically one that allows the US to compete in the global economy. In this section I detail the network actors who are involved in comparing US math education with other countries.

Psychologist Robert Linn writes that

International comparisons have played a prominent role, sometimes

[171] The conference "The Ten Best Ideas in K-12 Education Reform" was hosted by The Philanthropy Roundtable. Details of the conference can be found at: http://www.philanthropyroundtable.org/.

> explicitly and sometimes implicitly, in the debate about standards...Even when not mentioned, the international emphasis is evident from the context that stress economic competition and assumes that there is a close link between a nation's educational achievement and its economic competitiveness.[172]

As I have indicated in this chapter, such economic competition between nations serves the interests of global economic health by reducing overall wages. The US motivation to invest in math education serves the interests of global human capital, rather than purely the US economy and not the interests of people living in the US. Therefore, such attention to international assessments should be associated with providing the human capital needed by the global economy.

Many network actors concern themselves with US student performance on two international assessments: the International Association for the Assessment of Educational Achievement's (IEA) Trends In Math and Science Study (TIMSS) and the Organization for Economic Cooperation and Development's (OECD) Programme International Student Assessment (PISA). Both IEA and OECD are actors in my representation of the social network surrounding national math education. Additionally, some network actors analyze other aspects of US math education, such as the mathematical knowledge of teachers, against that in other countries.

By Linn's argument, the fact that International Association for the Assessment of Educational Achievement (IEA) and Organization for Economic Cooperation and Development (OECD) produce these international assessments is enough to say the two organizations support human capital. However, examining the two organizations in this

[172] Robert Linn and Eva L. Baker, "What Do International Assessments Imply for World-Class Standards?" *Educational Evaluation and Policy Analysis* 17, No. 4 (Winter, 1995), 405-418.

context also helps to elaborate on why such international comparison represents the theme of math education for human capital. Both organizations serve the interests of the contemporary economy, the OECD more explicit of the two in this regard. The OECD's mission includes promoting “policies that will improve the economic and social well-being of people around the world.” While the OECD claims to “make life harder for ... crooked businessmen,” it indicates a “shared commitment to market economies.”[173]

On the other hand, IEA connections to the economy are implicit. IEA's situation in an emerging global economy is most clearly seen by the World Bank's and United Nations Development Programme's funding of TIMSS 2007.[174] The World Bank’s actions to “provide low-interest loans, interest-free credits and grants to developing countries for a wide array of purposes that include investments in education, health, public administration, infrastructure, financial and private sector development, agriculture, and environmental and natural resource management”[175] indicates a commitment to market economies, like OECD.

Furthermore, TIMSS has a long history which mirrors the emergence of the global economy. The test began with IEA's pilot study in 1959 that compared math achievement among students in the following twelve countries: Belgium, England, Finland, France, Germany (FRG), Israel, Poland, Scotland, Sweden, Switzerland, United States, and Yugoslavia. Since then, the number of participating countries has grown steadily; the latest Trends in International Mathematics and Science Study (2007) included the 60

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173 Organization for Economic Cooperation and Development, “About OECD,” accessed May 14, 2011, http://www.oecd.org/pages/0,3417,en_36734052_36734103_1_1_1_1_1,00.html

174 International Association for the Assessment of Educational Achievement, “Trends in International Mathematics and Science Study 2007,” accessed December 6, 2008, http://www.iea.nl.

175 World Bank, “About Us,” accessed December 6, 2008, http://web.worldbank.org.

countries listed in Table 3-2[176]:

Table 3-2: List of Country Participation in TIMSS 2007

Algeria	England	Latvia	Saudi Arabia
Armenia	Georgia	Lebanon	Scotland
Australia	Germany	Lithuania	Serbia
Austria	Ghana	Malaysia	Singapore
Bosnia and Herzegovina	Hong Kong SAR	Malta	Slovak Republic
Botswana	Hungary	Mongolia	Slovenia
Bulgaria	Indonesia	Morocco	Spain
Canada	Iran	The Netherlands	Syria
Chinese Taipei	Israel	New Zealand	Sweden
Colombia	Italy	Norway	Thailand
Cyprus	Japan	Oman	Tunisia
Czech Republic	Jordan	Palestinian Nat'l Authority	Turkey
Denmark	Kazakhstan	Qatar	Ukraine
Dubai	Korea	Romania	United States
Egypt	Kuwait	Russian Federation	Yemen
El Salvador			

Clearly the IEA has expanded its influence and indicates a commitment among several countries to offering a similar math education to their youth. This commitment came to be as a result of the expanding global knowledge economy and each nation's quest to prepare its citizens to compete within it as described earlier.

Now that I have indicated the manner in which such international comparisons are linked to human capital, I move on to presenting those network actors who participate in such comparisons of US math education to that of other countries. Besides the IEA,

[176]"Trends in international mathematics and science study 2007," 2008.

OECD and Robert Linn as outlined above, they are math education researchers Joan Ferrini-Mundy, Karen Fuson, James Hiebert, Jeremy Kilpatrick, William Schmidt, Francis (Skip) Fennell; mathematicians Roger Howe, James Milgram and Hung-Hsi Wu; psychologist Richard Mayer; other education researcher Tom Loveless; and research and policy institutes the Brookings Institution and the Fordham Institute.

To begin are the network actors who played an inside or auxiliary role in the IEA's Trends in International Math and Science Study. First off, math education researchers have aided in the development of the assessment: Joan Ferrini-Mundy and Jeremy Kilpatrick were on the expert panels in mathematics for TIMSS 2003. Then there are those network actors who use the results of TIMSS to state implications for US math education policy. This again includes Kilpatrick's emphasis on US student performance in Algebra[177] as well as James Hiebert's studies comparing the teaching practices in math education across various nations as evidenced from the 1999 TIMSS video studies.[178]

William Schmidt presented similar work that seems to have gained significant ground in math education policy. His work compares the national math curricula of countries with high achievement on TIMSS. He also admits this work responds to calls from "the business community" and "economists," among others, to improve math education.[179] Of all the international comparison projects, Schmidt's work is very

177 see The Brookings Institution Brown Center on Education Policy, "Lessons Learned: What International Assessments Tell Us About Math Achievement," January 23, 2008, http://www.brookings.edu/events/2008/0123_math.aspx.

178 J. Hiebert, R. Gallimore, H. Garnier, K. B. Givven, H. Hollingsworth, J. Jacobs, A.M.-Y. Chui, D. Wearner, M. Smith, A. Manaster, E. Tseng, W. Etterbeek, C. Manaster, P. Gonzalez and J. W. Stigler, *Teaching Mathematics in Seven Countries: Results from the TIMSS 1999 Video Study.* Washington, D.C.: U.S. Department of Education, National Center for Education Statistics.

179 William H. Schmidt, Hsing Chi Wang and Curtis C. Mcknight, "Curriculum Coherence: An Examination of US Mathematics and Science Content Standards From an International Perspective," *Journal of Curriculum Studies* 37, No. 5 (2005), 525.

influential on the advancement of particulars in a national math education. I will return to this in a later section in this chapter, "Internationally Benchmarked Education Equals Authoritarian Education."

Schmidt's research was republished by the Fordham Institution in the 2009 report *International Lessons About National Standards.*[180] In the document's foreword Institution leader Checker Finn writes that "Widespread concern about America's economic competitiveness in the 21st century is rekindling interest in how other countries -- especially those that seem to be gaining on us -- accomplish what they do by way of nurturing and strengthening their human capital. "[181] This Fordham publication not only commits the research and policy institute to such international comparative work in math education, it also again articulates how such research is motivated by human capital.

Other network actors have presented research on international comparisons of math education in addition to the work from the IEA. Karen Fuson's work in studying the achievement of Latino first graders is motivated by "the considerably lower level of primary school mathematics learning by children in the United States compared with that of children in China, Japan, and Korea."[182] In other work, Fuson suggests the need for a national curriculum for elementary school mathematics to raise the mathematical achievement of US students to that of "the Soviet Union and the Far East."[183] Similarly,

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180 William H. Schmidt, Richard Houang and Sharif Shakrani, *International Lessons About National Standards,* August 2009, http://www.edexcellence.net/publications-issues/publications/international-lessons-about.html.

181 Ibid, 5.

182 Karen Fuson, Steven T. Smith and Ana Maria Lo Cicero, "Supporting Latino First Graders' Ten-Structured Thinking in Urban Classrooms," *Journal for Research in Mathematics Education* 28, No 6 (1997), 738.

183 Karen C. Fuson, James W. Stigler, Karen Bartsch, "Grade Placement of Addition and Subtraction Topics in Japan, Mainland China, the Soviet Union, Taiwan, and the United States," *Journal for Research in Mathematics Education* 19, No. 5 (Nov., 1988), 449.

psychologist Richard Mayer compared how math textbooks in Japan and the US differ with respect to their treatment of problem-solving.[184]

The last international comparative project in math education that I highlight brings together many network actors. It highlights the differences in the math knowledge of teachers from among various countries. Math education researcher Liping Ma provided significant groundwork in this type of research, and the US Teacher Education Study in Mathematics (US-TEDS M) continues this work. On the advisory board of US-TEDS M are mathematicians Roger Howe, James Milgram and Hung-Hsi Wu; math education researchers Francis (Skip) Fennell, Jeremy Kilpatrick and William Schmidt; and other education researcher Tom Loveless. It is also supported by the IEA as well as funded by Boeing, GE, and Bill and Melinda Gates, thereby demonstrating further alliance with the human capital interest as I described earlier. Their work focuses on researching the variations in preparation of math teachers among nations.

This focus includes attention to comparing the math knowledge of such teachers, work that began with Ma's seminal *Knowing and Teaching Elementary School Mathematics*. In this book, she argues that elementary school teachers in China can explain the mathematics underlying division of fractions better than those in the US.[185] The US-TEDS M continues to measure such content knowledge, recently concluding that "U.S. future elementary teachers' mathematics knowledge isn't distinctively high or low

184 Richard E. Mayer, Valerie Sims, Hidetsugu Tajika, "A Comparison of How Textbooks Teach Mathematical Problem Solving in Japan and the United States," *American Educational Research Journal* 32, No. 2 (Summer, 1995), 443-460.

185 Roger Howe, "Knowing and Teaching Elementary Mathematics Reviewed by Roger Howe," *Notices of the AMS*, September 1999, 881-887.

but certainly isn’t at the level we as a nation would like.”[186] In other words, Ma's initial hypothesis may still be true, but international comparisons do not support the claim that US math teachers know significantly less math than their counterparts in other countries. I will examine in more detail these findings in chapter 5, where I connect the development of human capital with the myth that US math teachers do not know math.

This section has outlined the variety of network actors who adopt educating for human capital because they compare US math education with that of other countries, a practice argued as an outgrowth over concern that the US was not competing well in the global economy. The magnitude of interest and work in this area indicates the extent to which there is a perception that math education contributes to economic growth. In the section following, I examine the particularly influential research that compares US math education to that of other countries.

Internationally Benchmarked Education Equals Authoritarian Education

Earlier I introduced the work of network math education researcher William Schmidt, which is another example of comparing US math education with that of other countries. I am devoting this section to Schmidt's work for its influence on the particulars of national math education and for its striking implications with regard to the human capital interest. As with all international comparative work in math education, I assume this to be motivated by the implied connections between math education and the US economy. Schmidt contributed a notion of “coherent” math curriculum, which resonates

[186] 2010 Teacher Education Study in Mathematics (TEDS-M), “Frequently Asked Questions,” accessed July 15, 2011, http://www.educ.msu.edu/content/sites/usteds/documents/USTEDS-FAQ.pdf.

with the traditional perspective on math education I will outline in the next chapter.

Schmidt's work[187] compares the US math curriculum to that of the countries who performed well on the Trends in International Math and Science Study (TIMSS). Specifically, the countries he chose were Singapore, South Korea, Hong Kong, Belgium, and the Czech Republic, most of which had a national math curriculum in place. For the US' standards, he used the National Council of Mathematics' (NCTM) *Curriculum and Evaluation Standards for Mathematics* from 1989.

Schmidt compared these curricula on the basis of whether they satisfied his notion of coherence, quoted below:

> We define content standards, in the aggregate, to be coherent if they are articulated over time as a sequence of topics and performances consistent with the logical and, if appropriate, hierarchical nature of the disciplinary content from which the subject-matter derives. This is not to suggest the existence of a single coherent sequence, only that such a sequence reflect the inherent structure of the discipline. This implies that, for a set of content standards 'to be coherent', they must evolve from particulars (e.g. simple mathematics facts and routine computational procedures associated with whole numbers and fractions) to deeper structures. [188]

Coherent curricula, then, are rigidly defined for the students and teachers. Notably, Schmidt also hints at a traditional math education emphasizing math facts and procedures.

Schmidt and his colleagues determined the US curriculum to not be coherent, yet the countries who performed well on TIMSS had an "aggregate curriculum" that was coherent. This comes as no surprise when considering that three of the six countries are authoritarian capitalist countries. Authoritarian capitalism is a political structure which

187 William Schmidt et al., "Curriculum Coherence."

188 Ibid., 528.

promotes free enterprise for its individuals but does not allow citizens several rights, including free speech or protesting one's working conditions. Singapore is a good example of this type of societal structure, but South Korea and now China also fit the model. In this political and economic climate, we would expect an educational system that imposes rigid structures, such as coherent curriculum, on its teachers and students. Education will also primarily serve the needs of the economy through development of human capital.

Therefore, Schmidt's work implies that US math education should liken itself to the math education existing in authoritarian capitalist countries. This seems to support the human capital interest, and perhaps in ways more related to the traditional perspective's contributions to developing human capital than the progressivists (see the next chapter). Schmidt's development of a "coherent national curriculum" has also justified the needs of a testing industry frustrated by 50 different state curricula. In other words, Schmidt used international comparisons to justify what the testing industry needs to increase its productivity. I will discuss this quest for efficiency, and its connection to traditional math education, in greater detail in the chapter on the educational services sector, chapter 6.

Out of William Schmidt's work that compared US math education to that of authoritarian capitalist countries emerged the idea of a coherent national curriculum. This influence is seen throughout the new national math standards, the *Common Core State Standards for Mathematics*, such as with their quoting of Schmidt's definition of "coherence" on pages 3 to 4.[189] Thus, Schmidt's work has contributed to the triumph of

[189] Common Core State Standards Initiative, *Common Core State Standards for Mathematics*, 3-4.

the traditional perspective, a notion I suggested in the introductory chapter. I have suggested how this interest connects to human capital, and I will again revisit this connection in chapter 4, where I suggest how such a traditional curriculum develops human capital. I have also indicated how Schmidt's work resonates with the educational business interest. Next, I turn to how this industry articulates their agreement that math education should develop human capital.

The Testing Industry's College and Career Readiness

In this chapter I have identified the development of human capital as the primary interest expressed in my representative social network surrounding national math education. However, an auxiliary interest also exists in the network, namely that of the educational businesses who stand to gain by providing this development in people. I review in detail these educational businesses in chapter 6, concluding the testing industry as the primary type of educational business in the network. For now, I highlight how this industry has aligned their efforts with the human capital thrust in math education. This occurs mostly through their efforts to define what it means to be ready for “college and career,” a notion I will explain alongside my presentation of the network actors that articulate it. These are goods and services organizations ACT, the Educational Testing Service (ETS), and College Board; professional organization American Educational Research Association (AERA); research and policy institute Achieve, Inc., and two employees of Achieve, John Kraman and Kaye Forgione.

The network actors that I will examine in this section articulate their commitments to human capital via a notion of "college and career readiness." These actors, in one way or another related to the testing business, provide services that they claim will determine which students have fully developed human capital, either for use as a producer or a professional in the economy. Career readiness, taken to mean those students who do not pursue college after high school, refers to the qualities needed by industries for people to produce things, rather than professionals in the economy. College readiness resonates with the push for the higher education as needed for professional careers like computer programming for information and communications technology.

One network educational business, ACT, can be credited with providing the definitive research indicating that, as the organization posits, the type of education required to develop human capital for both professionals and producers is one and the same. In their research report, I first draw attention to how they articulate the testing industry's commitments to develop human capital:

> The primary mission of our public education system is to give every student the opportunity to live a meaningful and productive life, which includes earning a wage sufficient to support a small family. All students need to develop the knowledge and skills that will give them real options after high school. No student's choices should be limited by a system that can sometimes appear to have different goals for different groups. Educating some students to a lesser standard than others narrows their options to jobs that, in today's economy, no longer pay well enough to support a family of four. Widening access to the American dream through public education has always been one of the foundations of our society, and it is more critical than ever to our ability to remain competitive in today's global economy. [190]

Notably, this quote pays reference to US economic competitiveness and a euphemized

[190] ACT, Inc., "Ready for College and Ready for Work: Same or Different?" 2006, http://www.act.org/research/policymakers/reports/workready.html, 2.

definition of human capital ("...the knowledge and skills that will give them real options...."). The passage also contains references to the knowledge economy and equity, two aspects of progressive math education that I argue in chapter 4 are advanced in national math education for their relevance to human capital.

The point of the ACT report is to suggest that the needs of human capital are the same whether someone pursues higher education or not. "Whether planning to enter college or workforce training programs after graduation, high school students need to be educated to a comparable level of readiness in reading and mathematics."[191] The research uses the similarities between ACT tests that assess "workforce readiness training" and the ACT, an aptitude test used for admission to colleges, to prove that the needs for both college and career are the same. In chapter 6, I examine their specific conclusions to indicate that "college and career readiness," the notion that preparing students for college or the workforce are one and the same, rests on shaky grounds. There I also provide the reasons why the testing industry promotes such false research: the testing industry's need for standardization will increase the efficiency because they provide the service of testing all students. In other words, ACT and other testing companies will require less real capital to test all students if all students are educated the same way.

My reading of the network reveals associations between the testing industry and academics, allowing me to conclude that other testing companies and such professional organizations as American Educational Research Association (AERA) similarly endorse the notion of "college and career readiness." A conference titled "Building Better

[191] Ibid., 1.

Students: Preparation for Life After High School" was hosted by AERA and two other testing companies in the network, Educational Testing Services (ETS) and the College Board. Additionally, presentations were given by representatives from ACT, Inc.[192] The conference brought "together 21 acclaimed scholars who have conducted research from a variety of perspectives to improve our understanding of college and workforce readiness."[193] This evidence indicates the network actors commitments to a standard curriculum that will develop human capital for either producers or professionals in the economy.

Another proponent of "college and career readiness" is Achieve, Inc., a research and policy institute in the network that has aided in the production of the *Common Core State Standards* in mathematics. For example, Achieve facilitates the Partnership for the Assessment of Readiness for College and Careers (PARCC), thereby providing the 25 states who in 2010 won Race to the Top federal money with "an assessment system that measures and documents students' college and career readiness by the end of high school."[194] Later in the chapter on educational business, I devote attention to how PARCC and other networks of states leads to testing megacontracts for educational corporations such as Pearson. For now, I indicate how the research and policy institute Achieve, Inc., and these educational businesses that stand to gain from their efforts, all do so within the spirit of developing human capital.

Furthering this point, two Achieve employees, John Kraman and Kaye Forgione,

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192 Educational Testing Service, "Building Better Students Conference Overview," accessed July 1, 2011, http://www.ets.org/c/15481/index.html.
193 Ibid.
194 Achieve, Inc., "About Achieve," accessed May 1, 2011, http://www.achieve.org/about-achieve.

also demonstrate Achieve's college and career readiness initiative. Forgione gave a 2008 presentation called “Fractions, Algebra, Truckers and Techies : Making High School Math Work for Every Student; ”[195] Kraman authored a paper attending to specific ways “to align high school academic standards, course requirements, and assessments with the real world expectations of college and the workplace. ”[196] Kraman's paper speaks to the concerns that heavy focus on math might impact other content areas. This point makes interesting the fact that Kraman came up in my social network surrounding math education. However, I mainly provide these as examples of network individuals, specifically research and policy institute employees, who indicate alliance with the testing industry's “college and career readiness.”

Another noteworthy consideration comes with the juxtaposition of “college and career readiness” and other human capital commitments as expressed earlier in this chapter. I remind the reader of the National Center on Education and Economy's (NCEE) concern that the US must develop human capital so that most students will become professionals. With “college and career readiness,” the testing industry folds the education of both professionals and producers into one. I have already suggested that this serves the interest of educational business by standardizing education for all and thereby increasing their efficiency. However, this could also be related to efforts made by NCEE and similar organizations seeking to develop the human capital for professionals. In other

195 Kaye Forgione, “Fractions, Algebra, Truckers and Techies: Making High School Math Work for Every Student,” accessed July 1, 2011, http://www.utdanacenter.org/umln/downloads/dc08/forgione_seeley.pdf.

196 John Kraman, Mathew Gandal and Michael Cohen. “Is a Default Curriculum in High School a Good Strategy for Promoting the Humanties?” accessed July 1, 2011, http://www.edexcellencemedia.net/publications/2007/200707_beyondthebasics/Beyond_The_Basics_Gandal.pdf.

words, the testing industry's similar education for professionals and producers in the economy could instead capture primarily the education geared towards professionals and forsake the development of human capital for production. As I argued earlier, these efforts fail to recognize both the amount of people in the US that remain producers in the economy as well as the contribution such actions make to the lowering of wages for both US professionals and producers.

At the very least, the testing industry adopts the human capital interest because it stands to provide services related to the development of human capital. I have provided the evidence of such adoption via this industry's current concern with "college and career readiness," and identified other actors in the network that express a similar notion. Possibly, the testing industry alignment satisfies the particulars of human capital development for professionals. However, in chapter 6 I provide evidence that the services that the testing industry provides conflicts with the types of knowledge needed by professionals and provided by progressive math education's focus on independent thinking and problem solving.

This chapter provided the evidence that the social network surrounding math education contains the interest of human capital. Human capital theory comprises the idea that nations should invest in education for the development in its citizens of those intangible qualities usable by businesses. This is first expressed by the number of actors in the network who stand to gain from investment in human capital. Next were those actors that represent such businesses. Together, these explorations revealed that the financial, energy, militaristic, pharmaceutical and information and communications technology industries believe that math education can develop the human capital they require. Finally, I offered examples from two sets of network actors that adopt the human capital interest including those that state the connection between math education and the US economy, and those that compare US math education to that of other nations. This chapter has not indicated the entirety of those with the human capital interest, however. The next chapter continues the exploration of those actors who adopt the interest to advance their particular pedagogical stance on math education.

Throughout this chapter I have also inserted various considerations regarding human capital theory and its relation to math education. I have drawn from human capital theorists, and its critics, to indicate how national investment in human capital development aids multinational corporations and lowers real wage earning potentials for both professionals and producers in the economy. I suggest the importance of these points given that educating for human capital is the primary interest in national math education. The following two chapters present various network actors, including academics and their research institutes and professional organizations, who adopt the human capital interest so that they can advance their particular perspectives regarding math education. In the next chapter, academics on both sides of the math wars advance their particular agenda because each side, progressive and traditional, contains elements related to human capital development. These considerations might suggest why math education is a place for human capital development, such as the progressivist accordance with the knowledge economy and the traditionalist accordance with a moral education. In chapter 5, I present the academics and their affiliates who target teachers and their supposed lack of mathematical knowledge. As with the math wars, I link these efforts with the idea that math education aids in human capital development.

Chapter 4: The Math Wars and Human Capital

The previous chapter indicated the development of human capital as the primary purpose for national math education. However, it remains to be seen why math education is useful for the development of human capital. Beginning to answer this question comes with a look at those who adopt the human capital interest and argue for a particular type of math education. My primary argument here is that network academics, mostly mathematicians and math education researchers, advance their particular perspectives on math education for the ways that each contributes to the development of human capital. This resonates with Janine Wedel's notion of academic flexians in the social network surrounding a policy domain.[197] These academics take opposing sides in the so-called “Math Wars,” with some actors arguing for traditional pedagogy and others for progressive pedagogy. Here I examine both pedagogical stances in light of educating for human capital, indicating that these academics advance their position by adopting the human capital interest. Secondarily, my analysis in this chapter also reveals possibilities for why mathematics is emphasized by the corporations that use human capital. In particular, math education provides content necessary for the contemporary knowledge economy and a moral of hard work as well as the structure to identify exceptional human capital and increase the number of able employees from which businesses can draw.

I begin my analysis with a review of the math wars. The math wars are an appropriate lens with which to unlock the hidden curriculum of math education because it is the arena in which people actually discuss the particulars of math education. My initial

[197] Janine Wedel, *Shadow Elite: How the World's New Power Brokers Undermine Democracy, Government, and the Free Market* (New York: Basic Books, 2009), 5.

review includes the primary distinctions between the traditional and progressive camps that provides more detail than what I described in the historical sketch of chapter 1. I next identify the network actors who align with the two camps, with special focus on how they are argued to aid in educating for human capital. In this regard, the progressive camp articulates closer alignment with the contemporary needs of human capital; specifically the connections between their pedagogic stance and the knowledge economy are clear to observe. As well, the progressivist emphasis on equity, understood as mathematics for all, dovetails with a corporate interest in increasing the number of able employees.

On the other hand, the traditionalists' perspective does not reveal as clear an association with what businesses need. Instead I use my reading of the network to conclude that the traditionalist perspective provides two important elements to educating for human capital: efficient identification of exceptional human capital and providing a moral education that emphasizes hard work. Regarding the former, I attend to the network's support of gifted education, and the use of Algebra as a gatekeeper to economic success. I demonstrate the connection between morals and math by indicating the similarities between the traditionalist perspective on math education with the conservative perspective on education.

Taking all of this together, I argue that both camps contribute important elements for a successful education for human capital. This provides the reason why both progressivists and traditionalists are included in the conversation on national math education. To conclude, I offer how my analysis complements other research on hidden curriculum, including Joel Spring's *Education and the Rise of the Corporate State* and

Michael Apple's discussions specific to math education.

Traditionalist Mathematicians, Progressivist Math Education Researchers

The social network surrounding national math education contains several actors whose statements and activities commit them to the traditional or progressive side of the math wars. The majority of traditionalists are mathematicians; the majority of progressivists are math education researchers. To begin, I discuss the contemporary debate between the two sides, similar to the qualities of the debate in the 20th century that I described in chapter 1. Informing this discussion are the writings of network actors.

Central points of contention include what and who should be prioritized when teaching math, as summarized in Table 4-1:

Table 4-1 General Differences Between Traditional and Progressive

	Traditional	Progressive
Content Priorities	Learning is evidenced by a students' correct answers on assessments.	Learning is evidenced by a students' mathematical thought process.
Prioritizing Students	Emphasize the needs of elite students	Emphasize the needs of all students

Supporting my observations on their differences comes from a look at particular statements made by the traditionalists who oppose the progressivists.[198] I include the following passage from the Honest Open Logical Debate (HOLD) website. This organization, located in Palo Alto, CA, represents the traditionalist view. It was born out of opposition to progressivist influences on California math standards in the 1990's.

198 The opposite, statements from progressivists who oppose the traditionalists, were not found in my network. This may point to the possibility that the traditionalists create the dichotomy, an interesting possiblity that is beyond the scope of my goals here.

Taking together HOLD Palo Alto and its sister organization HOLD New York City, seven individuals in the social network surrounding math education are affiliated with HOLD. The quote presents not only the positions of the traditionalists, but their opposition to the progressivist positions that I outlined in the table above.

> From the HOLD Palo Alto website, the organization believes that:
>
> - basic mathematical skills are the foundation of an excellent mathematics program.
> - textbooks and standard student materials are important. They ensure quality, consistency across the program, and are necessary for parent involvement.
> - while writing in math may be valuable, the primary emphasis should be on obtaining mathematical skills.
> - declining test scores indicate weaknesses that need to be dealt with.
> - some children want or need a more rigorous math program than others.
> - challenging children of all abilities is not always best done in heterogeneous (mixed ability) classrooms. [199]

This quote begins to suggest how the broader goals I outlined above play out in particular pedagogic practices. To make these differences a bit more concrete, I highlight some of the more particular points in Table 4-2 below. These ideas came from my reading of network actors' statements, such as Hung-Hsi Wu's comments on the National Council of Teachers of Mathematics *Standards.*[200]

Table 4-2 Particular Differences Between Traditional and Progressive

	Traditional	Progressive	Example
Student	Against in most	For, in some cases	Progressivists argue that

[199] Honest Open Logical Debate, "Honest Open Logical Debate On Math Reform," accessed May 26, 2011, http://www.dehnbase.org/hold/.

[200] Hung-Hsi Wu, "The Mathematician and the Mathematics Education Reform, " September 3, 1996, http://www.math.berkeley.edu/∼wu/

Calculator Use	circumstances; generally supportive only when the computation cannot be computed by hand.	including before a student knows how to perform the equivalent computation by hand	comparing different linear functions on a calculator will lead to conceptual understanding of slope. Traditionalists believe such practice prevents students from learning the skill of graphing lines.
Teaching math concepts	Formal proof only. Otherwise, students will not learn what counts as mathematical reasoning.	Formal proof can be modified or sometimes replaced with heuristics, i.e. experience-based discovery that generally does not constitute formal proof.	For the Pythagorean theorem, a formal proof could be President Garfield's algebraic proof. A heuristic might be the Pythagorean theorem "puzzle." (see Appendix D for both)
Mathematically Precise Language	No compromises to mathematical exact language. This leads to student misunderstanding of mathematical precision.	Some compromises to exactness, argued for the sake of greater access to appreciating mathematical ideas.	Patterns: Traditionalists are very upset by progressivists "pattern problems." To a mathematician, these problems are imprecise. For the progressivists, open ended pattern problems present opportunities for hearing a student's mathematical thinking process. See Appendix D.
Mathematical Computation	Emphasis on correct and quickly executed mathematical computation, via traditional algorithms.	Emphasis on use of algorithms accompanied by understanding why they work.	Traditionalists support timed tests of the multiplication tables, progressivists support student understanding
Content Point #2	Mathematical content should progress from one to the next, leading to the learning of	A variety of mathematical content, including statistics, should be available at all grade	1. Traditionalists argue that division of fractions should be mastered before introducing algebra. Progressivists believe that

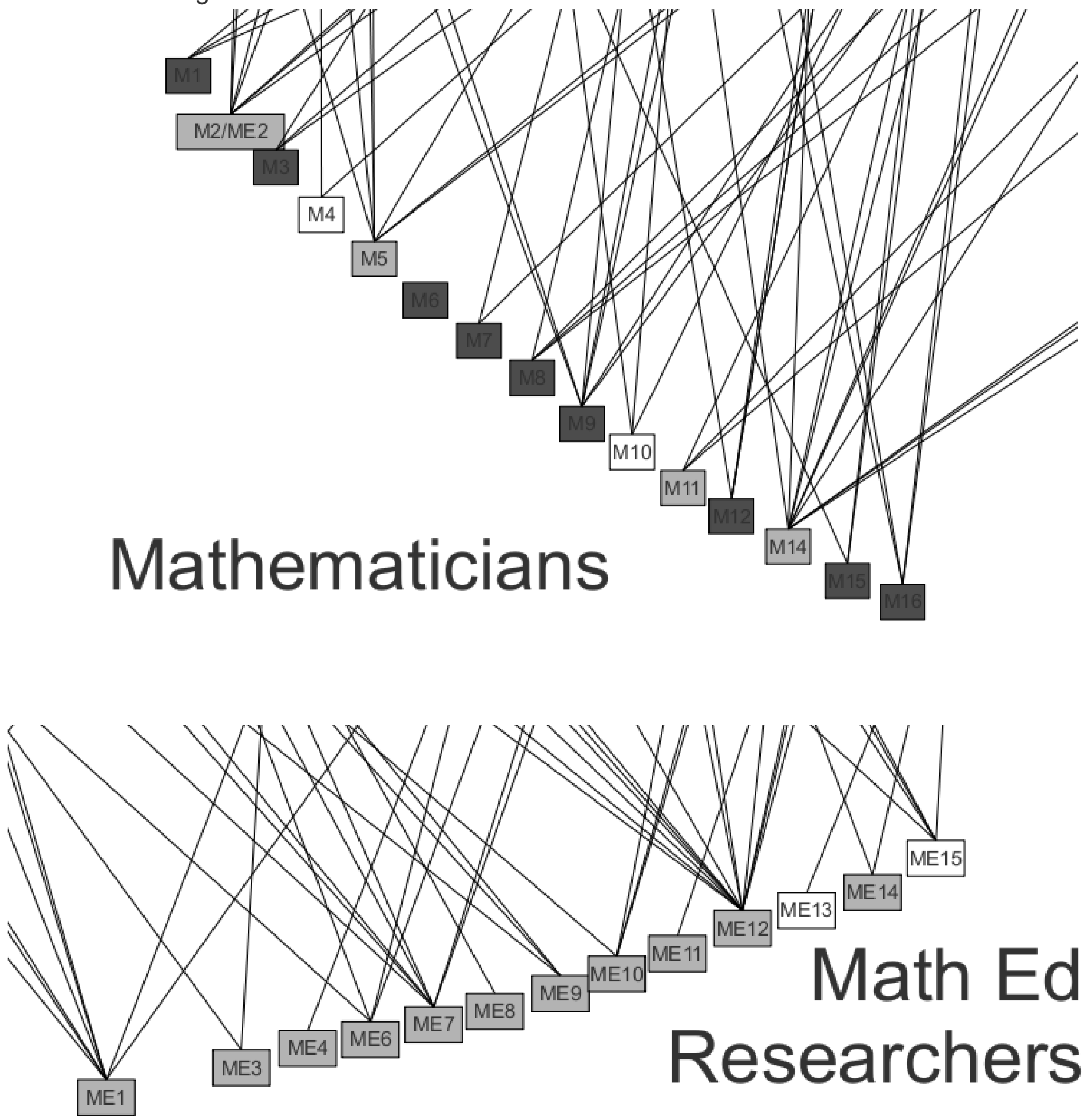
	Algebra and Calculus. De-emphasize topics that do not fit into an overall structured progression.	levels in order to increase the potential for student inquiry and motivation.	both can be taught simultaneously. 2. Traditionalists de-emphasize learning statistics in the early grades because this distracts from the goal of progressing to algebra. Progressivists believe statistics in the early grades will engage students.
Grouping Students	Separate tracks for gifted students.	Some progressivists, not all, support mixed-ability groups.	

Not only do these particulars help to more fully delineate the differences between these two camps, this table also guided my process in identifying which of the network actors belonged to either one. I do not mean to suggest that an actor's affirmation of one of these points committed them to a particular side of the math wars; only when several of such indicators were present did I make the choice to mark an actor on the traditional or progressive side. I also do not suggest that there exist distinct boundaries that clearly mark one person on a particular side, many network actors do indeed express agreement with both sides. However, I claim that many of the actors in the network are more committed to either the traditional or progressive side of the math war.

I now present the actors I found to be committed in such ways. Most of these actors are mathematicians and math education researchers. Therefore, in Figure 4-1 below, I have excerpted these two groups of actors from the sociogram of the representative network surrounding national math education that I presented in chapter 2.

Those with traditionalist tendencies regarding math pedagogy are dark gray, those with progressivist tendencies are light gray.

Figure 4-1 - Math Wars in the National Math Education Network



In juxtaposing these two groups of network actors, immediately apparent is that math education researchers are predominantly progressivists and, while a few mathematicians are progressivist, the majority of them are traditionalists. This comes as no surprise because, as indicated in my historical sketch, efforts to reform math education have previously been put forth by researchers in education and opposed by some, though not all, mathematicians. The reasons for these mathematicians' opposition to math education reform are indicated in the previous tables.

There are also a handful of other individuals who I found to represent the traditionalist perspective. These include education researchers Sandra Stotsky and Tom Loveless, school employee Vern Williams, and psychologists Grover “Russ” Whitehurst and Camilla Benbow. Generally, the significance of their presence indicates how the traditionalist perspective appeals to the broader commitments of educational conservatism, which I highlight later in the section “Traditionalists and Human Capital: Gifted Students and Compassionate Conservatism.” I intend this to give a more complete picture of the mathematicians' traditionalist perspective.

As to the progressivists, their contributions to educating for human capital are clearer. To start, we can see this connection in the figure above with a look at one of the few mathematicians who does take on the progressivist stance, Uri Treisman (M14). In chapter 2, I highlighted his numerous connections to foundations, organizations that I indicated to represent the needs of human capital in chapter 3. Because Treisman is the only mathematician with such strong connections to these business interests, we can at least begin to consider whether the progressivist stance might better serve the needs of human capital, the point I attend to in the next section.

Progressivists Part 1: The Knowledge Economy

The progressivist stance on math education corresponds with the contemporary human capital needs of increasing the number of able workers in today's "knowledge economy." I argue such accordance indicates that the progressivist stance, as opposed to the traditionalist, marks a more explicit attempt at developing a national math education for today's human capital needs. I demonstrate my claim first by comparing the writings of two network organizations that represent the contemporary human capital interest, the Organization for Economic Cooperation and Development (OECD) and the World Bank, with that of the one organization that best resembles the progressivist stance, the National Council of Teachers of Mathematics (NCTM). This comparison shows that the progressivist stance attempts to satisfy the needs of the knowledge economy.

A 2007 OECD document states that "The ability to create, distribute and exploit knowledge is increasingly central to competitive advantage, wealth creation and better standards of living."[201] In response, the OECD claims that rich countries invest in higher education and the production of knowledge related to software, information and communication technology (ICT) and other technologies.[202] A 2003 World Bank document provides further detail on the changes in education required by the new knowledge economy. "Educational systems can no longer emphasize task-specific skills but must focus instead on developing learners' decision making and problem-solving

[201] Organization for Economic Cooperation and Development, *OECD Science, Technology and Industry Scoreboard: Towards a Knowledge-Based Economy*, (Paris: OECD Publishing, 2001), 7.
[202] Ibid., 7-8.

skills and teaching them how to learn on their own and with others."[203] Additionally, because "change in the knowledge economy is so rapid ... lifelong learning is crucial in enabling workers to compete in the global economy."[204] These suggest that a global knowledge economy requires a workforce educated for their capacity to think and learn independently. This opposes an education centered on student performance of specified tasks, i.e. the traditionalist perspective. Specific phrases from these and other similar writings include "lifelong learning," "innovation," "problem-solving" and "collaboration." The progressivist stance on math education addresses these needs by offering a math education that emphasizes the mathematical thinking process. As well, students are expected to do so by working together and less dependently on teacher direction.

The National Council of Teachers of Mathematics (NCTM) is often purported as the biggest proponent of progressivist math education. The *1989 Standards* that I quoted from in the historical sketch was heavily influenced by the knowledge economy, with phrases like "an ever-changing market," a "technologically competent workforce" and "lifelong learning." NCTM's update to the first standards, the *Principles and Standards for School Mathematics* written in 2000, does not have quite the language of its predecessor. Nonetheless, the connections between their approach and the needs of the knowledge economy remain visible. For instance, the document presents a visionary math classroom in which "Students are flexible and resourceful problem solvers. Alone

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203 World Bank, *Lifelong Learning in the Global Knowledge Economy*, (Washington, DC: The World Bank, 2003), 3.

204 World Bank, *Lifelong Learning,* 3.

or in groups with access to technology, they work productively and reflectively..."[205] And, two of four societal goals that drive these standards are "Mathematics for the workplace: ... The level of mathematical thinking and problem solving needed in the workplace ... has increased dramatically" and "Mathematics for the scientific and technical community: More students must pursue an educational path will prepare them for lifelong work as mathematicians, statisticians, engineers, and scientists."[206]

Eric Gutstein, a math education researcher who is not an actor in my representative social network surrounding national math education, has made similar points regarding NCTM's commitments to human capital. He is careful not to suggest that all authors of NCTM documents "themselves advocated mathematical literacy to serve only economic competitiveness."[207] Likewise, I do not suggest that all the people of NCTM, be they leaders or members, believe so strongly in math education for human capital. However, those that are in my representative social network surrounding national math education, do. This is demonstrated by the eleven progressivists who I indicated on chapter 3's sociogram, page 103, as aligning with the human capital interest. This indicates that those progressivists invited to the policy making conversation on national math education are more likely to indicate accordance with the human capital purpose for math education. As indicated by my juxtaposing the OECD and World Bank writings with NCTM's vision for education, the progressivist stance indicates how their pedagogical stance will provide for human capital needs.

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205 National Council of Teachers of Mathematics, *Principles and Standards for School Mathematics,* (Reston, VA: National Council of Teachers of Mathematics, 2000), 3.
206 Ibid., 4
207 Eric Gutstein. *Reading and Writing the World With Mathematics: Toward a Pedagogy for Social Justice. (*New York: Routledge, 2006), 8.

Primarily, the progressivist emphasis on collaboration, problem-solving, and independent learning aligns with the human capital interests as expressed by economic institutions like the OECD. This indicates how progressivist math education contains a content-oriented accordance with developing human capital. In the next section, I suggest the ways that the progressivist stance emphasizes a process-oriented aspect to the development of human capital.

Progressivists, Part 2: Equity

Besides the progressivist curricular alignment with educating for the knowledge economy, the progressivist emphasis on equity also contributes a process-oriented aspect that aides in the development of human capital. By process-oriented, I mean a structural element of the educational process, such as whose education is prioritized. Equity is the process-oriented contribution from the progressivists that aids in the development of human capital because it seeks to educate all for employment in the workforce. The term is used by the progressivist professional organization the National Council of Teachers of Mathematics (NCTM), and is discussed by several network math education researchers as well. It can be generally described as "math education for all." I argue that this position, to educate all students, is not simply in the interest of the people being educated, but instead, if successful, would ultimately increase the quantity of human capital from which contemporary businesses can draw.

This is part of the progressivist stance as indicated by the attempts to motivate a diversity of learners (see table in the previous section). Such an educational goal can fulfill the needs of human capital because it increases the number of able workers to be used in the contemporary economy. NCTM's *1989 Standards* explicitly made such a connection as indicated in the quotations I included in the historical sketch of national math education in chapter 1. The more recent 2000 NCTM do not as clearly indicate why it is important to educate all students in mathematics. This does not suggest that the connection between equity and human capital no longer exists. Rather, I rely on the statements of other network actors who indicate how educating all US students will advance the human capital interest. To begin, I continue an understanding of what is meant by equity, and its connection to the US economy, with the following quote from network mathematician and progressivist Uri Treisman:

> All children should have equal access to high-quality contemporary curricula, and that all students (or in practical terms, nearly all) should be expected to master the content of these challenging curricula and related complex problem- solving skills...Modern reform ideas, as articulated by scholars and policy analysts representing a broad cross-section of political thought, justify this presumption both in economic terms, as necessary for our international economic competitiveness, and in terms of basic justice, as a natural extension of the American equity creed.[208]

Opportunity for all, or equity, are linked to investment in human capital. Businesses need education to provide all students, not just the elite, with the skills that are going to be useful for them. Most often, the skills articulated for the non-elite resonate with the knowledge economy, as indicated in this quote.

Several other progressivist network actors state a concern with math education's role in providing equal opportunity for contemporary jobs. These include math education

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[208] Philip Uri Treisman and Stephanie A. Surles, "Systemic Reform and Minority Student High Achievement," *The Right Thing to Do, the Smart Thing to Do Enhancing Diversity in the Health Professions*. (DC: National Academy Press, 2001): 262.

researchers Deborah Ball, Douglas Clements, and Nora Ramirez; psychologist Wade Boykin; and two funds and fund distribution centers: the Spencer Foundation and Houston Endowment, Inc. In the following paragraphs I quote from these network actors.

Two math education researchers provide clear association between equity and economic opportunity. It should be noted that these statements are not central to these scholars' work or points of view. Deborah Ball describes how education can increase employment opportunities for those "living in poverty or to those who are members of underrepresented groups."[209] Douglas Clements, a math education researcher who writes math education standards for children ages 3 to 6, claims early childhood math education to be a civil right because it will qualify students "for the kinds of careers that should be available to them later on."[210]

On the other hand, Nora Ramirez, a math teacher who also works in a university education department, and Wade Boykin, a psychologist, devote much of their work to issues in equity. Both also tie this issue to human capital or preparation for jobs. For Ramirez, equity "increases when marginalized students use mathematics for their own purposes, which include making decisions, changing the status quo, and learning the mathematics that provides access to higher education and job opportunities."[211] This indicates Ramirez's broadening of equity to include other aspects, including some type of change in society (perhaps political or economic change), but also supports the human capital theme by suggesting that such marginalized students lack the skills that employers

209 Deborah Lowenberg Ball and Francesca M. Forzani, "What Makes Education Research 'Educational?' *Educational Researcher* 36, No. 9 (2007): 529.
210 Douglas H. Clements, "MATH: A Civil Right," *Early Childhood Today* 17, Issue 4 (Jan/Feb 2003).
211 Jacqueline Leonard and Nora Ramirez, "Mathematizing for Empowerment," *NCTM News Bulletin* (May/June 2009).

want them to have. In contrast, Boykin asserts the importance of equity for human capital more strongly: "Until we more successfully educate children who have been placed at risk for educational failure, their communities -- and our society in general -- will fail to cultivate the substantial reservoir of human talent that will be greatly needed in the years ahead."[212]

Turning to the two foundations tying equity with human capital, I include their quotes on equity because these organizations represent corporations that want an education in their interest (as described in chapter 3). I begin with Houston Endowment, Inc. They donate grant monies to a variety of social needs, including education. The organization expresses their concern for education as follows:

> The systematic failure of many youth and young adults to graduate from high school and to succeed in obtaining a postsecondary credential (a degree or certificate) with genuine value in the marketplace is one of the most important long-term challenges facing our city. The foundation is especially interested in initiatives that address the challenges to success confronted by low-income students, students of color and first-generation college students.[213]

Houston Endowment expresses their concern for poor educational outcomes of various groups of students. As the phrase "genuine value in the marketplace" suggests, this is not a problem because of the issues it may cause for the individual, but because too many humans, viewed as a natural resource in economic terms of human capital theory, are going to waste.

The Spencer Foundation awards grants for research that sheds "light on the role

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[212] A. Wade Boykin, "The Talent Development Model of Schooling: Placing Students at Promise for Academic Success," *Journal of Education for Students Placed at Risk* 5, No. 1&2 (2000), 4.

[213] Houston Endowment, "Education," accessed May 1, 2011, http://www.houstonendowment.org/Programs/Education/Overview.aspx

education plays in reducing economic and social inequalities -- as well as, sometimes, re-enforcing them -- and to find ways to more fully realize education's potential to promote more equal opportunity."[214] They support such work because "expanded opportunity is important not only to a society's economic well being but to the character of its civic, cultural and social life as well."[215] Similar to Nora Ramirez, the Spencer Foundation broadens the reasons why education should provide opportunity for all, but not without also mentioning that such opportunity serves the needs of human capital.

These two foundations do not describe a progressivist stance on math education similar to the individuals in the network I included in this section. However, their strong commitment to educating all students resonates with the progressivist position and, as I have shown, they similarly situate such within the development of human capital. Therefore, these organizations that receive support from corporations thus link the human capital interest with mathematics for all. The progressivist position includes equity, and those progressivists in my representation of the social network surrounding national math education clearly align this interest with the needs of human capital. To be sure, I do not indicate that progressivists outside of the national math education arena always connect equity with human capital.

I am highlighting network actors who support equity, or teaching all students mathematics. Some of these, such as mathematician Uri Treisman, have explicitly connected this goal with the needs of businesses. The reasons why corporations want

[214] Spencer Foundation, "Areas of Inquiry," accessed May 1, 2011, http://spencer.org/content.cfm/areas-of-inquiry-essay
[215] Ibid.

math for all are not expressed inside the network, but I will suggest two possibilities from my own readings outside the network. These are to reduce wages and/or to perpetuate a myth of meritocracy.

The first, to reduce wages, comes from analysis by economist Catherine J. Weinberger. Her research presented the possibility that increasing the number of women with mathematical knowledge may not increase their wage earnings but instead lower the wage earning potential of everyone with mathematical knowledge. Assuming that people with advanced mathematics are paid well because they are scarce, an increase in the number of people who know math would "diminish the earnings advantage associated with mathematical training."[216] This argument rests on the laws of supply and demand in the labor market, and could in part be true. Education researcher Walter Secada also put this point within the context of math education and equity: "It would be in the interests of industry to have an oversupply of technically trained workers... In such an event, salaries could be kept low, working conditions can be kept primitive, and career opportunities can remain stratified along lines of race, gender, and social class."[217] Equity in math education could reduce wages.

On the other hand, equity could be a myth promoted by corporations but ultimately not given reasonable chances for success. This second possibility comes from education researcher Michael Apple who considers equity a rhetorical activity:

Powerful economic groups often give only rhetorical support to this

[216] Catherine J. Weinberger. "Is Teaching More Girls More Math the Key to Higher Wages?" *Squaring Up: Policy Strategies to Raise Women's Incomes in the US* ed. Mary C. King, (Anne Arbor: UMichigan Press, 2001).

[217] Walter J. Secada, "Agenda Setting, Englightened Self-Interest, and Equity in Mathematics Education," *Peabody Journal of Education* 66, No. 2: 48-49.

> because they do not see the cost as justified. The fact that the kinds of paid jobs that are largely being created in our more service-oriented economy are very often increasingly de-skilled and have less need for autonomy and high levels of technical knowledge is of considerable import here as well.[218]

Apple's logic pays reference to the fact that the majority of workers in the US economy are producers, not professionals, as I mentioned in chapter 3. The contribution here indicates that perhaps progressivist's emphasis on equity *and* the content necessary for the knowledge economy are a facade offered by the corporations interested in human capital development. Apple implies that this facade furthers the myth of meritocracy. Meritocracy denotes a societal system in which everyone has equal opportunity for economic success, but there are in the end those with economic success and those without. By not actually providing equal opportunity for all, as in Apple's analysis that corporations find the cost too high, the rhetorical support of equity perpetuates the feeling that people are responsible for their personal economic success. In this case, the myth of equity perpetuates the system of reproducing income groups from generation to generation.

By quoting from a variety of network actors, including NCTM and several math education researchers, I have demonstrated that the progressive actors in my representation of the social network surrounding national math education situate their position within the needs of human capital. I highlighted how equity increases the number of people to be employed in the economy. This is the structural contribution from progressivists to the human capital interest. As I outlined earlier, the content-oriented

[218] Michael W. Apple, "Do the Standards Go Far Enough? Power, Policy and Practice in Mathematics Education," *Journal for Research in Mathematics Education* 23, No. 5 (1992): 421.

contribution is an emphasis on problem solving, collaboration and lifelong learning which corresponds to the knowledge economy. I also included others' thoughts on equity and the knowledge economy, indicating that perhaps these interests in national math education are merely rhetorical. As I will explain in the next two sections, the traditionalists contribute both content-oriented and structural elements to the development of human capital as well.

Traditionalists, Part 1: Efficient Identification of Exceptional Human Capital, or, Using Algebra as a Sorting System

As with the progressivists, the traditionalist perspective also satisfies the needs of human capital. However, unlike the progressivists, there are few commonalities between what the traditionalists propose for math education and contemporary human capital needs as expressed by leading economic institutions, such as OECD and the World Bank. Instead, I found commonalities by reading the actors in the network and explicating how the traditionalist perspective contributes to human capital development. First, one pedagogic goal of the traditionalist stance, tracking elite students, serves to identify future elite and is the structural, or process-oriented, contribution to human capital. Second, the traditionalist's perspective resonates with an educational philosophy referred to as "compassionate conservatism." The latter supports human capital by providing a moral education emphasizing hard work, the traditionalist's content-oriented contribution to human capital. Now I focus on the process-oriented contribution of providing an efficient system to identify exceptional human capital.

I begin with a quote from a traditionalist who captures both the human capital interest and her traditionalist perspective on math education. Similar to the progressivists, several of the network's traditionalists state math education's impact on the US economy (e.g. the quote from David Bressoud in chapter 3 on page 121). The most impassioned and elaborate of these statements, however, comes from the network's other education researcher Sandra Stotsky when she connects traditional math education with the US economy. Referring to progressive math education as founded on "baseless pedagogical theories," she writes:

> This form of mathematics stripped of much of its intellectual content has obvious repercussions for higher education and the American economy. Hung-Hsi Wu, a Berkeley mathematician, expressed the view of many of his peers when he wrote in 1997 that the brand of mathematics purveyed by the NCTM's 1989 report "has the potential to change completely the undergraduate mathematics curriculum and to throttle the normal process of producing a competent corps of scientists, engineers, and mathematicians." And Larry Faulkner, the panel's chair and past president of the University of Texas in Austin, warns that if national policy doesn't ensure the development of a large domestic workforce with first-rate technical skills, we risk "technological surprise to our economic viability and to the foundations of our country's security." If the bleak math statistics in the United States don't change soon, such "surprise" may well be imminent. The math wars, which started in debates about pedagogy, may end in questions about the long-term prospects for American prosperity. "[219]

Stotsky's claim that progressivist education will damage the economy is surprising given the explicit accordance between it and writings on the present economy by the most influential global economic institutions. More to my present aim, however, contained in this quote are the foundations for the two arguments in the traditional perspective that could be argued to strengthen the US economy. By referencing mathematician Hung-Hsi

[219] Sandra Stotsky, "Who Needs Mathematicians for Math, Anyway?" November 13, 2009, http://www.city-journal.org/2009/eon1113ss.html.

Wu, she points to the potential a traditional math education has for providing an efficient system to identify exceptional human talent. Secondly, Stotsky herself represents the compassionate conservative perspective on education, which emphasizes a moral education for the production of human capital.

The first, using math education as a means to identify elite students, is hinted at by the writings of several network academics who concern themselves with students of mathematical "promise" or "talent." After providing these examples, I will explain why these concerns appeal to the development of human capital and also refer to using math education as a means to identify exceptional human capital. To begin, network mathematician Hung-Hsi Wu indicates the need for higher and lower tracks in math, and justifies this for the production of "competent corps of scientists, engineers, and mathematicians."[220] Wu makes an admirable claim that who should be in the fast and slow track is a decision left up to the student, rather than an imposition on them by school officials. However, a higher and lower track in the context of traditional math education implies that the higher will not make compromises in pedagogy, i.e., teachers will not adapt their instruction to meet student needs. It is the "sink or swim" metaphor. Therefore, such tracking is intended to advance those students who can perform in the ways expected of them, an elite set of students. I argue Wu's commitment to tracking, despite his claims for student choice, suggests a commitment to the efficient identification of the elite.

Other network actors provide further evidence of the traditionalist emphasis on

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[220] Hung-Hsi Wu, "Invited Comments on the NCTM Standards," accessed May 29, 2011, http://math.berkeley.edu/~wu/, May 29, 2011, 4.

teaching an elite set of students for the needs of human capital. Network psychologist Camilla Benbow describes the human capital interest quite accurately. She has devoted significant study to what she calls “mathematically precocious youth,” a variant on the needs of students commonly referred to as gifted. In one article, “Meeting the Educational Needs of Special Populations: Advanced Placement's Role in Developing Exceptional Human Capital,”[221] she indicates that the needs of the economy motivate her studies in gifted math education. Similar to Wu's “competent corps,” in “Education and US Competitiveness” Benbow states that “We must ... attend to the needs of today's K-12 students and not neglect those who demonstrate potential talent in the science, technology, engineering, and mathematics (STEM) fields. We need both a well-prepared workforce and the future innovators whose ideas could transform the economy. This does not just happen by chance.”[222]

Other traditionalist network actors similarly emphasize a focus on the needs of elite students, this time for the sake of “homegrown engineers.” This notion rests on a claim that historically US engineers were identified through gifted education programs like that of Benbow. Network mathematicians and traditionalists James Milgram and W. Stephen Wilson both present concerns over the fact that US businesses are recruiting their talented human capital from other countries. Milgram noted that “in the late eighties and nineties, the lack of home-grown talent in Silicon Valley was so severe that the

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221 A. Bleske-Rechek, D. Lubinski, & C. P. Benbow, “Meeting the educational needs of special populations: Advanced Placement's role in developing exceptional human capital,” *Psychological Science* 15 (2004), 217-224.

222 Camilla P. Benbow, “Education and US Competitiveness,” *Issues in Science and Technology* 23, Issue 4 (Summer 2007).

technology industries recruited thousands of foreign engineers and programmers,"[223] and Wilson writes that "A very high percentage of the U.S. professional science, technology, engineering, and mathematics personnel are foreign born and were given their K-12 mathematics education in their home country. If we want homegrown engineers, certain things have to take place in our K-12 mathematics education system."[224]

However, this phenomenon is not necessarily the result of a poor mathematics education in the US. Instead, global migration of human capital is a key aspect to the contemporary knowledge economy, in which

> "Knowledge flows also result from migration. In the United States, for instance, the largest number of scientists and engineers (S&Es) with S&E doctorates who were born elsewhere in the OECD area are from the United Kingdom and Canada; relatively few are from Germany or Japan. However, three times as many foreign-born scientists are from China and twice as many from India as from the United Kingdom."[225]

Economic interests are supportive of such human capital migration because it allows for negotiating for lower compensation awarded to those selling their skills.

Therefore, the traditionalist focus on gifted education serves the human capital interest not because it promotes the US economy by developing greater US talent. Instead, emphasizing gifted education represents the global knowledge economy's need for an efficient process to determine the identification of elite students. As I mentioned in chapter 1, Alan Schoenfeld, another math education researcher who is not in my network, calls this aspect of the traditionalist perspective the "social efficiency model." For each

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[223] Jessica Raimi, "When Worlds Collide," May 13, 2003, http://www.nychold/com/let-jessraimi-0305.html.

[224] W. Stephen Wilson, "Elementary School Mathematics Priorities," (2009), http://www.math.jhu.edu/~wsw/papers/PAPERS/ED/ee.pdf, 10.

[225] OECD, "OECD Science, Technology," 10.

student, schools should identify the role that she will have in society and then educate her for that role. As I indicated earlier in this chapter, the traditionalist math education prioritizes the learning outcome as a student's correct answers on tests. This allows for an efficient and objective process to determine an elite set of students, in contrast to the progressivist focus on mathematical thinking. Determining an elite set of students is important to human capital because these elite will become the future stakeholders of the human capital interest. In Schoenfeld's terms, social efficiency "perpetuates privilege."[226] Furthermore, these traditionalists encourage that these identified elite should be removed and educated separately from the rest. This is purported to develop exceptional human capital more efficiently, at the very least it ingrains in students' minds the sense of elite and non-elite and accordingly, the future's professionals and producers in the economy.

Interestingly, my network's traditionalists do not include the possibility that some of these elite students become anything other than tomorrow's engineers, scientists and mathematicians. This ignores the several students in the elite math tracks who do not pursue such careers but other high paying jobs such as doctors, lawyers or corporate executives. In other words, a student's success in mathematics is associated with his earning potential in later life, including both careers that demand knowledge of math and those that do not. Several writings on math education, including progressivists, even specify that the learning of Algebra is a gatekeeper for higher income.[227] This means that success in Algebra will determine one's opportunities for particular jobs later in life. The

226 Alan Schoenfeld, "The Math Wars," *Educational Policy 18*, 1 (January and March 2004): 281.

227 See, for example, Bob Moses and Charles E. Cobb, Jr. *Radical Equations: Civil Rights from Mississippi to the Algebra Project*, (Boston: Beacon, 2001).

justification behind this argument is the statistical association with success in Algebra, and mathematics more broadly defined. There is little research indicating exactly why this association exists. For example, it could exist because math, or Algebra, is needed for doing these advanced jobs, or because math education primarily plays a role in determining or validating elite status.

I argue that the latter possibility should be considered strongly. Traditional math education provides an efficient means for identifying elite because students can be categorized based on their responses to questions that have exactly one correct answer. In other words, evidence of learning in traditional math education is easily quantified and adaptable to psychometric theories. In chapter 6 on education business, I argue this as a possible reason why the testing industry provides services for national math education that resemble traditional, and not progressive, math education. However, here I am suggesting that perhaps the development of human capital is better served by a traditional math education where students are sorted into elite and non-elite. Math education provides a means for organizing people into the professionals and producers in the economy.

As I mentioned, many regard Algebra as the gatekeeper of math education, and in the national math education network the learning of Algebra seems to be the primary goal. This is most clearly seen in the documents that I used to identify the representative network surrounding national math education. For example, from the National Math Advisory Panel's (NMAP) *Foundations for Success*: “A strong grounding in high school mathematics through Algebra II or higher correlates powerfully with access to college, graduation from college, and earning in the top quartile of income from employment."[228] Accordingly, the panel emphasized a commitment to streamlining the content in elementary grades so that math education leads to the learning of Algebra. Answering this call, the *Common Core State Standards* in math indicate a "coherent" curriculum structure that sequentially builds from one topic to the next, ultimately leading to the learning of Algebra. I reviewed this point in detail in chapter 3. For example, statistics education in the earlier grades is less present than in the curricular scope and sequence provided by the National Council of Teachers of Mathematics' (NCTM) *Standards 1989.*

Putting these two points together, Algebra becomes the central goal of a math education because a student's success in it can be used to determine a student's place in the economy, be it as a professional or a producer. As I mentioned, many successful students in math education do not enter math-intensive fields, but instead become professionals in other areas. Similarly, many who succeed in Algebra have no use for the knowledge in their career. Instead, the skills and knowledges that comprise school Algebra can be appropriated into a means to sort people into professionals and producers. Algebra is a gatekeeper not because the knowledge is useful for professional workers, but because it is a knowledge that can function as a means to sort students. Why some students are able to be sorted as professionals and others as producers is beyond the scope of my argument. I only suggest that Algebra does not develop exact qualities useful for the human capital of professionals and instead provides a means to sort students.

To conclude, I have drawn from the traditionalist network actors who emphasize

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[228] US Department of Education, *Foundations for Success: The Final Report of the National Mathematics Advisory Panel,* (2008), http://www2.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf, *xii*.

the education of elite students. They advocate the use of separate tracks for educating elite students and by devoting attention to their specific needs. Their concerns primarily suggest the development of human capital for the professionals in the economy, be they engineers or other math-intensive jobs *or* other jobs like doctors and lawyers. The network's documents admit the role Algebra plays in determining one's future economic situation. Thus I argue that national math education can function as a means to sort students into the professionals and producers in the economy. Given that human capital is now developed by nations for the interest of multinational corporations, as I suggested in chapter 3, this process serves the interest of the global economy and not the US economy. In the next section, I turn to the second, content-oriented, manner in which traditional math education contributes to the development of human capital.

Traditionalists, Part 2: The Moral Education Implicit in National Math Education

I argued how traditional math education offers a process-oriented contribution to the development of human capital. This occurs via national math education's emphasis on Algebra as a gatekeeper that sorts people into the professionals or producers in the economy. In this section, I present how traditional math education also contributes the ethic of hard work, a necessary quality in people for businesses to be able to make profit.

This second point is hinted at in Sandra Stotsky's quotation I included earlier. This association comes not from the words in the quotation, but instead for its author's elsewhere stated beliefs. Stotsky's writings on multicultural education promote a conservatist educational view, defined below. Furthermore, several of the aspects of this conservative view resonate with the writings of other traditionalist network actors.

First, I review the contemporary version of conservatist education. This was famously put forth by President Bush II's notion of compassionate conservatism. Education researcher Joel Spring argues that compassionate conservatism posits that society is best served by an educational system that teaches the ethics of hard-work and self-determination.[229] This is motivated by religious contexts but is also argued to benefit the US economy. As to human capital, educational conservatism considers that changing the values of the poor will lead to harder workers in the economy. These are most likely the producers in the economy, all the more service-oriented workers as Michael Apple describes in the quote earlier in this chapter. A fundamental assumption carrying these goals for education is "that values determine the economic and social systems as compared to the assumption that the social and economic systems determine values."[230] In other words, the view believes that teaching the ethic of hard work will alleviate poverty. I argue that teaching this ethic happens to satisfy the development of human capital.

Sandra Stotsky, another education researcher in the network, indicates her alliance with compassionate conservatism. For example, educational conservatism does not encourage the inclusion of discussing political or economic oppression of groups. Stotsky suggests this point within her critique of multicultural education, *Losing Our Language: How Multicultural Classroom Instruction Is Undermining Our Children's Ability to*

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229 Joel Spring refers to this as "compassionate conservatism" in *Political Agendas for Education, Third Edition*. (Mahwah, NJ: Lawrence Erlbaum Associates, 2005), 3-4.

230 Joel Spring, *Political Agendas,* 5.

Read, Write and Reason.[231] There she claims that the introduction of multicultural content in reading curriculum presents too much sympathy for oppressed groups and "white shame."[232] In the conservative view, emphasizing the "victim" does not lead to the value of self-determination that impoverished people require for relieving themselves of poverty. And, as Stotsky points out, such presentation of victimization also emphasizes the roles of the oppressor. Stotsky's point indicates educational conservatism's clear opposition to changes in economic and political structures, and in its place the providing of a moral character deemed necessary to improve those in poverty and economic health on the whole.

Stotsky's *Losing Our Language* also presents significant support for one particular basal reader used in the teaching of reading: those produced by Open Court Publishing. She singles out Open Court's readers for their commitment to "classic literature" and lack of questions motivated by social and political goals.[233] Open Court readers serve to represent conservatist education. Another network actor, Grover "Russ" Whitehurst has also supported them by indicating their effectiveness as determined by experimental testing.

For now, I bring up Whitehurst's support of Open Court primarily to further indicate the conservatist perspective in the network. However, I briefly sidestep that goal to present the role that experimental studies and psychometrics play in advancing conservative education. In his role at the US Department of Education's Institute of

231 Sandra Stotsky, *Losing Our Language: How Multicultural Classroom Instruction Is Undermining Our Children's Ability to Read, Write and Reason* (New York: Free Press, 1999).
232 Kip Tellez, "Incommensurable Views on Multicultural Education," *Educational Researcher* 30, No. 2 (Mar., 2001): 34.
233 Ibid., 35.

Education Sciences, Whitehurst contributed significantly to increasing the use of experimental studies in federal research education. Experimental studies are controlled studies that compare two educational products by randomly assigning students, classes or schools to either of the products being compared by psychometric testing. Whitehurst has promoted Open Court's readers with such studies.[234] One argument I include in chapter 6 centers on how such use of experimental studies and psychometrics in education similarly promotes the traditionalist math curriculum.

Returning to my claim that traditionalist math education aligns with conservative educational goals, I present several network actors who articulate a notion of perseverance in doing mathematical work. Perseverance corresponds to the conservative perspective that the educational system should foster hard-work and self-determination for students to avail themselves of the political or economic struggles they might consider they face.

In his response to the NCTM standards, network mathematician Hung-Hsi Wu suggests that progressivists fail to assert that mathematics requires hard work. He also claims it uncontroversial in saying that "not much substantive mathematics can be made fun."[235] I was unable to find another traditionalist that so clearly articulated the notion of perseverance. I admit that a lack of other evidence might indicate that the conservative perspective on education is not very influential on national math education. However, I feel the need to provide evidence of the influence not from the actors themselves but

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[234] Grover "Russ" Whitehurst, "Don't Forget Curriculum," October 2009, http://www.brookings.edu/papers/2009/1014_curriculum_whitehurst.aspx

[235] Hung-Hsi Wu, "Invited Comments on the NCTM Standards," 7.

from the documents I used to construct my network.

Another network actor, psychologist David Geary, hints at the notion that math education should include a moral education. In the book chapter "Biology, Culture, and Cross-National Differences in Mathematical Ability,"[236] Geary suggests that the differing performance between East Asian and US students on standardized math tests is the result of cultural differences. Before addressing the connection to moral education, there are two interesting side-notes for this work. For one, the example again indicates Geary's commitments to human capital because he is comparing the math education of US students to that in other countries, an activity I argued in chapter 3 to be deeply embedded with the quest to develop human capital for the global economy. Second, Geary presents his research as "evolutionary based." In a more recent volume,[237] network actors Geary and Dan Berch collaborate using such an approach. Berch uses Geary's framework to counter the student-centered feature of progressivist math education, instead arguing for traditional teacher-directed formats. This indicates Berch's, and perhaps Geary's, commitments to traditional math education.

Back to moral education, in Geary's search for the reason why East Asian students mathematically outperform US students, he considers group IQ differences but ultimately rules this out as a possibility. Ultimately, he suggests differences in schooling, in particular harder curriculum and more hours spent on math in class and at home, as the

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[236] David Geary, "Biology, Culture, and Cross-National Differences in Mathematical Ability," eds. R. J. Sternberg, & T. Ven-Zeev, *The Nature of Mathematical Thinking* (Mahwah, NJ: Lawrence Earlbaum Associates, 1996), 145-171.

[237] Jerry S. Carlson and Joel R. Levin, *Educating the evolved mind: Conceptual foundations for an evolutionary educational psychology*. (Charlotte, NC: Information Age Publishing, 2007).

source of East Asian student performance. These "reflect wider cultural values"[238] in which math knowledge is given high status. Others have more explicitly connected the dots between the points in Geary's argument, such as non-network math education researcher Frederick K.S. Leung.[239] He writes that East Asia's "Confucian Heritage Culture" emphasizes hard work and achievement. In other words, math enjoys a high status in Asian culture because it reflects one's level of dedication and hard work. Geary implies that these cultural values of hard work are a necessary aspect of math education.

The conservative emphasis on a moral education emphasizing hard work is strikingly present in all three of the documents I used to construct my representative social network surrounding national math education. To broaden what is meant by this moral education, and enhance its connection to the conservative perspective, I quote from each below.

From the National Math Advisory Panel's final report:

> Mathematics performance and learning of groups that have traditionally been underrepresented in mathematics fields can be improved by interventions that address social, affective, and motivational factors... Children's goals and beliefs about learning are related to their mathematics performance. Experimental studies have demonstrated that changing children's beliefs from a focus on ability to a focus on effort increases their engagement in mathematics learning.[240]

From the Common Core's *College and Career Readiness Standards for Mathematics*, "Proficient students expect mathematics to make sense. They take an active stance in solving mathematical problems. When faced with a non-routine problem, they have the

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[238] Geary, "Biology, Culture," 164.

[239] Frederick K. S. Leung,"The Socio-cultural Context of Mathematical Thinking," ed. Behiye Ubuz, Behiye, Proceedings of the 35th Conference of the international Group for the Psychology of Mathematics Education 1 (Ankara, Turkey: PME, 2011), 97-102.

[240] US Department of Education, "Foundations for Success," xix-xx

courage to plunge in and try something ... They learn that effort counts in mathematical achievement."[241] And lastly, *Adding It Up* puts forth "productive disposition" as a component to mathematical proficiency. This marks the "habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy."[242] Although actors may not be saying as much on their own, in working together on these documents, the conservative emphasis on hard work is well articulated.

The fact that the moral education occurs in all three documents may be of little surprise given the fact that some progressivists also agree to this point. For example, network educational business executive Phil Daro wrote a document where he describes the characteristics of a successful student. Some of these resonate with the traditionalists' ethics in math education. The student should:

> -approach learning and using mathematics with a sense of efficacy: "I can learn it and use it; mathematics makes sense."
> -approach mathematics with diligence and curiosity, systematically and inventively; with the concentration to execute a procedure accurately and the courage to use initiative and imagination.[243]

Notably, Daro wrote these in a "Math Wars Peace Treaty." I revisit this document in the next chapter where I focus on the major point of agreement between the two camps. For now, I am indicating how some progressives, like Daro, also agree that a moral education is a part of learning math.

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241 *College and Career Readiness Standards for Mathematics: Draft for Review and Comment*, September 21, 2009, accessed July 31, 2011, http://www.gatesfoundation.org/united-states/Documents/MathStandardsSources.pdf, 8.

242 National Research Council, *Adding It Up: Helping Children Learn Mathematics*, eds. Jeremy Kilpatrick, Jane Swafford and Bradford Findell (Washington, DC: National Academy Press, 2001), 116.

243 The Toolkit Team, Mathematics Assessment Resource Service, "Math Wars Peace Treaty," accessed June 1, 2011, http://toolkitforchange.org/toolkit/documents/77_4_tlapt_peacetreaty_nov23.pdf, 3-4.

In considering the implicit moral education in national math education, I revisit that the need for a moral education comes from the compassionate conservatist view. This indicates a deficit view of the morals of those living in poverty. This opposes other viewpoints, such as that political and economic structures push people into poverty. In other words, by highlighting the implicit moral education in national math education, I am not endorsing the view that people in poverty lack the moral of hard-work and self-determination. I am, however, suggesting that such an emphasis within math education resonates with the development of human capital. Math education's role in inculcating a productive disposition is very useful for corporate profit. This is the traditionalist's content-oriented contribution to the goal. Due to the human capital interest's power in national math education, emphasizing morals becomes a focus of national math education.

I have thus explained that the traditionalists, just like the progressivists, have a content-oriented contribution to educating for human capital. Specifically, national math education includes a moral education that emphasizes hard work and self-determination. This is a necessary quality for human capital that produces profit. In the previous section, I also discussed how the traditionalists offer a process-oriented circumstance of national math education that serves the needs of human capital. The use of Algebra as a gatekeeper for sorting professionals from producers in the economy provides a much needed structure in the economy of labor.

To summarize my discussion of the traditionalist view and its contributions to human capital, I quote extensively from the one practicing math teacher to be found in my representation of the social network surrounding national math education. Vern Williams is a strong proponent of traditionalist math education who, in the quote below, indicates commitments to both the attention of gifted students and the conservative perspective I outlined here. Again, this traditionalist asserts himself via oppositions to the progressivist position. Williams claims he used to believe the following points:

> - We should write about math but never do math.
> - Correcting students' papers using red ink is a threat to children's self esteem and that red pens should be banned from all public schools.
> - Howard Gardner was right about his multiple intelligence theory (I think that he claims about nine at the moment) and that schools should value bodily-kinesthetic ability and the intelligence of self as much as mathematical and linguistic ability.
> - The war on intellectual excellence is a great thing. It will make us all equal.
> - Teachers Unions are actually concerned about students.
> - Advanced courses and gifted programs should be banned because they are elitist and unfair. Since everyone is gifted in their own way (see Howard Gardner), why have special gifted programs?
> - There are no bored students in US public schools.
> - We can teach thinking even when there is no content to think about.
> - We should treat members of politically protected minority groups as victims.
> - We should never view our students as individuals but as members of racial and ethnic groups.
> - We should buy into the latest educational fad even if it's based on political correctness and has nothing to do with learning or common sense.
> - There is no money wasted on administration, specialists, and useless programs. In fact, we should have more of each.
> - I should join the NCTM.
> - I should join the NEA.
> - I should feel guilty because I teach smart kids.
> - I should feel really guilty because I enjoy teaching smart kids. [244]

This passage indicates Williams' opposition to mixed-ability classrooms, to

[244] Vern Williams, "Teaching Philosophy," accessed January 21, 2011, http://www.mathreasoning.com/Middle_School_Teacher_Teaching/middle_school_teacher_teaching.php

pedagogical methods that specifically address differing learning styles and to the progressivist emphasis on process over content. These indicate his commitments to traditional math education. He also clearly supports the identification and separation of an elite group of students and the compassionate conservatist de-emphasis of the "victim." The traditionalist elements that support the development of human capital include the emphasis on moral education and on sorting students into their future roles as professionals and producers in the economy. Notably, he does not agree with the human capital need to develop the problem-solving, lifelong learning and collaboration required by the knowledge economy and advanced by the progressivists.

The significance of William's quotation is that he is the only teacher in my representative network surrounding national math education and he overtly asserts his position as a traditionalist. School practitioners representing the progressive stance do not exist in this network. This may suggest that the traditionalists have greater success in advancing their position, perhaps because its structure to identify elite and moral education provide more important contributions to human capital. As I included earlier in this chapter, Michael Apple believes that the progressivist elements in national math education are only given rhetorical support by corporations. Other explanations for the traditionalist triumph come in chapter 6, where I argue that traditional math education finds a happy home in the testing industry.

The Hidden Curriculum of Math Education

As I outlined in the beginning of this chapter, my primary goal is to demonstrate how academics in the network advance their particular stance on math education by aligning certain aspects with the development of human capital. Human capital is the dominant interest in the social network surrounding national math education. An auxiliary objective of this chapter, however, answers a related question: Because they do not often say it, why do corporations think that math education is useful for human capital development? The obvious answer is that math education leads to a host of professionals in the economy, such as engineers and scientists. However, this could not adequately answer the importance of math education for all. Looking at the math wars, where academics most often discuss the particulars of math education, reveals a handful of possibilities as I described above. These are outlined in the Table 4-3 below:

Table 4-3 Math Wars and the Hidden Curriculum

	Progressivist Contribution	Traditionalist Contribution
Content Oriented	Collaboration, Lifelong Learning, Problem-Solving	Moral Education Emphasizing Hard-Work, Self-Determination
Process Oriented	Mathematics for All (increases the number of able employees)	Efficient Means to Sort Professionals from Producers

In a sense, through this analysis I have identified aspects of the hidden curriculum of math education. I now review previous work on hidden curriculum to give greater meaning to these findings. The connection I draw between progressivist math education and the knowledge economy recapitulates Joel Spring's discussion of progressivist education's contribution to the corporate state.[245] And specific to math, my analysis seeks to explain in more detail what Michael Apple means by mathematics' "administrative,

[245] Joel Spring, *Education and the Rise of the Corporate State*. Boston: Beacon, 1972.

technical relevance" to corporate needs.[246]

As for defining what I mean by hidden curriculum, this can come from representing the inconsistency in national math education: the network claims it for the production of human capital relevant for math-intensive careers, yet several who are subjected to national math education will not end up in said careers. As I indicated in chapter 3, businesses desire math education for the development of human capital. Generally, these businesses do not articulate the reasons why math education will develop human capital. At most, they refer to the fact that mathematics is a tool for advancements in technology. For example, I quoted statements from Exxon indicating the role innovative technology plays in their extraction of energy from previously formidable sources. This is an example of the work of engineers who require sophisticated math knowledge for applications to physics or computer programming.

Indeed, several network actors suggest math education's role in developing successful engineers. However, national math education is very clear about providing math education for everyone, as I describe in this chapter's section on equity, and it is also clear that not all students will become engineers. Therefore, given the human capital interest in math education, it must provide intangible qualities usable in other fields. This chapter provided the other, hidden, contributions from math education for human capital development.

Most using the term hidden curriculum describe the ways that education socializes

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[246] Michael W. Apple, "Do the Standards Go Far Enough? Power, Policy and Practice in Mathematics Education," *Journal for Research in Mathematics Education* 23, No. 5 (1992), 412-431.

people for the benefit of the powerful in society. For example, Philip Jackson,[247] who coined the term, indicated the use of tracking (ability grouping) in schools as a means to socialize people into their particular roles in adult life. In this sense, hidden curriculum corresponds to the two process-oriented contributions I discussed in this chapter. Equity supports the notion of meritocracy, that all have a chance at economic improvement, as well as increasing the number of able workers in the labor market. Second, traditional math education provides a means to sort people into income groups, much like Jackson's analysis of tracking.

However, I am expanding the use of the term hidden curriculum to also include specific skills and knowledge that are not the stated intent of a specific curriculum, but are indeed an intent as indicated by readings of the social network surrounding the curriculum. The examples of these are my content-oriented contributions to the development of human capital: the qualities needed for the knowledge economy and the moral education from traditional math education.

I also want to highlight how these considerations of a hidden curriculum in math education resonate with earlier, related work. The connection between the progressivist position and the knowledge economy centered on fostering in people the notions of problem-solving, lifelong learning and collaboration. These similarities recapitulate the findings of Joel Spring in *Education and the Rise of the Corporate State*. Spring argues that the following as the educational response to the needs of a highly organized society with corporations at its core:

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[247] Philip Jackson, *Life in Classrooms*, (New York: Teachers College Press, 1990).

> On the one hand education adopted the goal of training the type of man required by this type of organization. This meant teaching the student how to cooperate with others and work in groups. This resulted in class and school programs designed to socialize the student and prepare him for a life of cooperation. On the other hand education was viewed as one institution working with others to assure the progress and efficient operation of the social system. This meant that the schools trained pupils in the specialized skills required by the new corporate organization. [248]

Spring connects this form of schooling with the Progressives, or those societal leaders, such as corporate executives and labor leaders, who desired a smoothly functioning corporate state.

In my analysis here, I find similar connections between the progressivist math education perspective and the needs of the knowledge economy, as expressed by economic institutions like the Organization for Economic Cooperation and Development (OECD) and the World Bank. I do not suggest that my use of the term progressivist means the same as Spring's Progressives. However, the two do relate to each other in the sense that both are suggestive of the oxymoronic view of a capitalism with equal opportunity for all. Accordingly, my work also indicates how such a notion suggests the necessity for collaboration as did Spring's analysis. Furthermore, my analysis refers to the same skills as does Spring, such as problem-solving and the ability to learn independently.

On the other hand, as I mentioned earlier in this chapter, Michael Apple considers the corporate alliance with progressivist position as largely rhetorical. He states that corporations find such endeavors too costly and not justified given that the majority of labor in the market are producers and not professionals. Apple also suggests the reason

[248] Spring, *Education and Corporate State,* xii.

why mathematics is valued by society: for its "technical/administrative knowledge ... upon which the expansion and control of markets and products, cultural and economic control, and basic and applied research to support them are dependent."[249] Apple suggests that such valuation of mathematical knowledge then requires those in power to control it, and also to prevent it from coming into the hands of people with less power. I do not dispute Apple's claims, but I suggest that my analysis of the network provides complementary considerations for the ways that national math education works in the interest of corporations. Namely, the hidden curricula of equity, hard work and efficient identification of the elite work in tandem to develop corporate workforce needs.

In conclusion, the hidden curriculum of national math education includes those types of processes that aid corporate society, such as increasing the number of able employees and identifying the elite. I suggest that also hidden in national math education are learning goals not necessarily associated with math, such as the moral of hard work and collaboration, problem solving and independent learning. These considerations indicate possible reasons why the primary interest in national math education is the development of human capital, as I identified in my reading of the representative network surrounding national math education.

This chapter has identified several network actors who have either traditionalist or progressivist tendencies towards math education. In my examination of these actors' points of view, I have demonstrated that both sides of this math war contribute to

[249] Apple, "Do the Standards," 421.

important aspects of educating for human capital. Progressivists' claims for emphasizing mathematical thinking over computation align with the present human capital needs of the knowledge economy. They also seek to educate all students, which increases the number of humans that can be used by corporations. I also argued that traditionalists' focus on the separation of the mathematically gifted and an emphasis on perseverance for the rest provide a method to identify the future elite and the types of employees businesses need to make profit, respectively. I conclude that elements from both stances support the notion of educating for human capital, and also that these findings indicate some possible reasons why math education is important for the development of human capital. I call these findings the hidden curriculum of national math education. I continue the next chapter by presenting the math war's resolution. There is one point on which traditionalists and progressivists agree: US math teachers do not know math.

Chapter 5: The Content Knowledge Deficits of Math Teachers

In the previous chapter I indicated the ways that progressivist and traditionalist pedagogic stances differ, but how both contribute to an education for human capital. Now I will discuss that, despite their many points of contention, the two groups also find "common ground" over a deficit perspective on the content knowledge of math teachers. As it turns out, this perspective is a strong theme within the network surrounding national math education. The math wars' striking agreement on this point represents the significance of the theme's existence in the network. The claim, essentially that math teachers do not know enough mathematics, comes from several network actors, including traditionalist mathematicians, progressivist math educators and also several organizations without ties to the math wars but who represent the human capital interest. Here I will argue how emphasizing math teachers' content knowledge deficits contributes to efficiently educating for human capital, as I did with both sides of the math wars.

One of my central arguments in this chapter is that the content knowledge of US math teachers is comparable to that of other developed countries. In other words, the teacher content knowledge deficit is a myth. Support for this claim comes from a study I will highlight later in this chapter that was conducted by various members of my network. They sought to compare the content knowledge of US math teachers to that in other countries. They use their data to argue that US math teachers need to know more math, yet I argue that the same data leads to the opposite conclusion. For example, there was no statistically significant difference between US, German, Russian and Norwegian elementary school math teacher performance on tests measuring their content knowledge.[250]

I begin by presenting two documents representing a truce in the math wars in which agreement is in part founded on a deficit view of math teacher knowledge, thereby indicating the broad commitment to this theme. I next focus on some of the strands within the teacher content knowledge deficits theme, including several network actors' attention to "pedagogical content knowledge" and others' work in comparing US teacher knowledge to that of other countries. The latter begins to suggest how the theme connects with educating for human capital. Surprisingly, despite the fact that the network suggests a deficit of math teachers' knowledge, the network actors I highlight actually provide research that indicates such knowledge to be comparable to that of other countries.

Despite such evidence to indicate that math teachers' content knowledge deficits is a myth, the theme remains strong in the network. This is especially true as it relates to human capital, with evidence from the other network actors that contribute to the theme. First, I present the network actors who hold an interest in human capital and express the deficits theme by funding programs that aim to increase the content knowledge of math teachers. Using the deficits theme in this way serves those with the human capital interest to educate math teachers in the specific math education required for human capital. Next, I discuss the emerging prevalence of two similar activities: the recruitment of the "mathematically talented" for teaching and "math specialists" in the primary grades.

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250 Center for Research in Mathematics and Science Education, 2010, *Breaking the Cycle: An International Comparison of U.S. Mathematics Teacher Preparation,* East Lansing: Michigan State University, 13.

Finally, I discuss policy advocacy in the network that connects with the teacher deficits theme and suggest the relevance each has to efficiently educating for human capital. These include removing from the classroom teachers who cannot or do not efficiently educate for human capital efficiently and otherwise tailoring the investment in national math education so as to provide the greatest returns.

Math Wars Peace Treaties Target Teachers

To begin I discuss that despite the incredibly contentious debate in the math wars, the two sides overwhelmingly agree that US math teachers do not know math. Those calling the debate over the progressivist and traditionalist stances a war are not without good reason. While traditionalists may have felt attacked by the power of the National Science Foundation's (NSF) alliance with the National Council of Mathematics Teachers (NCTM) *Standards 1989*, they responded with more deliberate intentions to make their opposition look foolish.[251] Recognition of this contention worried those who saw the good from both stances, especially as it might relate to the development of human capital. Alan Schoenfeld noted that in 1998 ,Secretary of Education Richard Riley pleaded “for civility and respectful behavior in what had become a knock-down-drag-out battle between”[252] the two stances. Riley represents the government's role in developing human capital. As I indicated previously, both progressivists and traditionalists contribute to this goal. Thus Riley urged the two sides to calm down and reach resolution because he found them both to contribute to the development of human capital.

[251] For example, see the writings of David Klein, Ralph Raimi, or Dick Askey.
[252] Alan Schoenfeld, “The Math Wars,” *Educational Policy 18*, 1 (January and March 2004), 254.

In response, documents were written that called for a truce to the unhealthy debate. I suggest these were to move onward with a national math education that develops human capital. Several individuals in my representative social network surrounding math education wrote such calls. Network math education researcher and educational services employee Phil Daro wrote a "Math Wars Peace Treaty." A similar document "Reaching for Common Ground in K-12 Mathematics Education," was authored by network math education researchers Deborah Ball, Joan Ferrini-Mundy and Jeremy Kilpatrick and network mathematicians Wilfried Schmid and James Milgram. Both documents attend to some of the sticking points in the war, but more interestingly they both declare that progressivists and traditionalists agree that US math teachers do not know mathematics.

Phil Daro produced the "Math Wars Peace Treaty" as a tool distributed by the Mathematics Assessment Resource Service (MARS) at Michigan State University. The document intends to be used by progressivists in planning their discussions regarding math education with traditionalists, primarily parents. Many parents, particularly elite parents such as those in Palo Alto and New York City, have led the opposition to progressive math education. Therefore, this treaty intends to target these reactions by summarizing "the large area of common ground to which most people will subscribe, and to establish a thorough and respectful process for working on disagreements. "[253]

This treaty addresses several of the sticking points between traditionalists and progressivists, such as basic number facts and calculator use in math instruction. These

[253] p. 2. Math Wars Peace Treaty, The Toolkit Team. available at http://toolkitforchange.org/toolkit/view.php?obj=1025&link=41

are presented in ways that appeal to both sides of the math wars. For instance, Daro states both sides agree that students should learn to “add, subtract, multiply and divide integers, decimals and fractions accurately, efficiently, and flexibly without calculators. ”[254] This appeals to the traditionalist emphasis on exclusion of calculators from math instruction. However, students should also “use the mathematics they know to solve problems with calculators and computers,” thereby indicating commitment to the progressivist stance on the use of calculators in the classroom.[255]

Beyond these expected points, however, Daro claims that progressivists and traditionalists agree that teachers of math do not know mathematics. He writes, “We agree [that] teachers, especially K-8 teachers, should learn more mathematics throughout their careers.”[256] Daro's attention to elementary teachers' knowledge of mathematics is a major focus in the concern over content knowledge deficits of math teachers. More generally, Daro also states that the progressivists and traditionalists agree that “no students should be denied a fair chance to learn mathematics because they have been assigned unqualified mathematics teachers.” Taken together with the first quotation from this document, what qualifies a math teacher is her knowledge of mathematical content. And as assumed by the context of this document, Daro considers both sides of the wars to agree on this point. However, Daro primarily represents the progressivist stance, so his assertion of agreement on this point remains a touch tenuous.

However, “Reaching for Common Ground in K-12 Mathematics Education” was

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254 The Toolkit Team, Mathematics Assessment Resource Service, “Math Wars Peace Treaty,” accessed June 1, 2011, http://toolkitforchange.org/toolkit/documents/77_4_tlapt_peacetreaty_nov23.pdf, 3.

255 Some progressivists would disagree that calculator use should only happen after students learn the mathematics the calculator is performing for them.

256 Tookit Team, “Math Wars Peace Treaty,” 3.

coauthored by opposing sides of the math wars. The mathematicians (Schmid and Milgram) opposed the math education researchers (Ferrini-Mundy, Ball, Kilpatrick) along the lines of traditionalist and progressivist, respectively. Their process in writing the document indicates that the opposing sides were drawn together and that nothing contained in the document was disagreeable to any author:

> We began with summary statements drawn from prior exchanges among the members of our group. We affirmed some agreements in this meeting and "discovered" others. We listened closely to one another, frequently asking for clarification or for examples. We tested our understanding of others' points of view by proposing statements that we then examined collectively. We drafted this document as a group, composing actual text as we worked. One of us typed, and our emerging draft was projected onto a screen in the meeting room. The process enabled us to take issue with particular words and terms and then reshape them until all of us were satisfied. We were forced to look closely at our own language and to seek common ground, not only in the terms we used but even in their nuanced meaning. [257]

Similar to Daro's "Peace Treaty," this document attends to several of the sticking points in the wars, such as calculators. Perhaps one of the "discovered" agreements was that both agreed math teachers do not know math. As with Daro, "Common Ground" also emphasizes the content knowledge of math teachers, a point that does not usually come up in the math wars debate. However, this time the authors elaborate on this point more carefully than Daro:

> *Teacher knowledge:* Teaching mathematics effectively depends on a solid understanding of the material. Teachers must be able to do the mathematics they are teaching, but that is not sufficient knowledge for teaching. Effective teaching requires an understanding of the underlying meaning and justifications for the ideas and procedures to be taught and

[257] Deborah Loewenberg Ball, Joan Ferrini-Mundy, Jeremy Kilpatrick, R. James Milgram, Wilfried Schmid, and Richard Schaar, "Reaching for Common Ground," *Notices of the AMS* 52, No. 9 (October 2005), 1055.

> the ability to make connections among topics. Fluency, accuracy, and precision in the use of mathematical terms and symbolic notation are also crucial. Teaching demands knowing appropriate representations for a particular mathematical idea, deploying these with precision, and bridging between teachers' and students' understanding. It requires judgment about how to reduce mathematical complexity and manage precision in ways that make the mathematics accessible to students while preserving its integrity. Well-designed instructional materials, such as textbooks, teachers' manuals, and software, may provide significant mathematical support, but they cannot substitute for highly qualified, knowledgeable teachers. Teachers' mathematical knowledge must be developed through solid initial teacher preparation and ongoing, systematic professional learning opportunities. [258]

This quotation demonstrates that both sides of the war, as represented by network actors Ball, Ferrini-Mundy, Kilpatrick, Schmid and Milgram, are concerned with the content knowledge of math teachers. The elaboration contained here also indicates a few strands within this concern, such as a distinction between content knowledge and pedagogical content knowledge. In this case, content knowledge would be knowledge of the math itself, and pedagogical content knowledge as additional knowledge required to make this content accessible to students. For example, "understanding of the underlying meaning and justifications for the ideas and procedures to be taught" and "fluency, accuracy, and precision in the use of mathematical terms" refer to knowledge of math, incidentally paying tribute to both the progressivist and traditional stances regarding math education. On the other hand "judgment about how to reduce mathematical complexity" describes a notion of pedagogical content knowledge, something that actor Ball has worked on significantly.

The final phrases of this passage also suggest that content knowledge is the

[258] Ball et al., "Reaching for Common Ground," 1058.

primary component of a highly qualified teacher and the role teacher education and professional development can play in filling the deficits of knowledge. I devote attention to these two strands of the content knowledge deficits themes, as well as to Balls' focus on pedagogical content knowledge, in forthcoming sections of this chapter.

Thus far, I have intended to highlight that both sides of the contentious debate on math pedagogy target teachers for their supposed lack of mathematical knowledge. This is significant in part due to the magnitude of opposition between mathematicians and math education researchers. At times these debates turned into battles. Secretary of Education Riley's call for a truce resulted in a collective action to blame teachers for their supposed lack of mathematical knowledge. As I will explain later in this chapter, this focus is not true yet is supported because it can be a tool for shaping math education's role in developing human capital. Before elaborating on these two points, I continue by next presenting the actors that engage in perpetuating the myth.

Teacher Content Knowledge Deficits in The Network

Excerpts from the sociogram that represents the social network surrounding national math education will indicate the extent to which the network commits to the content knowledge deficits theme. Involved actors include the mathematicians and math education researchers whose battles come to a truce over this exact point (see previous section) and organizations who seek to reshape teacher education and teacher professional development. Here I will also provide a few examples from among the variety of ways that network actors express the teacher content knowledge deficits theme.

To begin, I focus on the mathematicians and math education researchers. As I suggested in the previous section, mathematicians and math educators resolved their differences with agreement that math teachers do not know mathematics. As with most arguments in this dissertation, I do not claim that all mathematicians and math educators, or all traditionalists and progressivists with respect to math education, agree on the content knowledge deficits of math teachers. Rather, I suggest that those individuals in my representative social network surrounding national math education clearly exhibit such accordance. In so doing, I suggest that the complete social network surrounding national math education would indicate such accordance between mathematicians and math education researchers.

The following Figures 5-1a and 5-1b excerpts the mathematicians and math education researchers from my network. Those actors that are gray expressed the content knowledge deficits themes through their writings or other actions. Ten of the sixteen mathematicians are gray as are nine of the fifteen math ed researchers. Therefore, the sociogram further indicates the truce I described in the previous section.

Figure 5-1a - Network Mathematicians and Content Knowledge Deficits

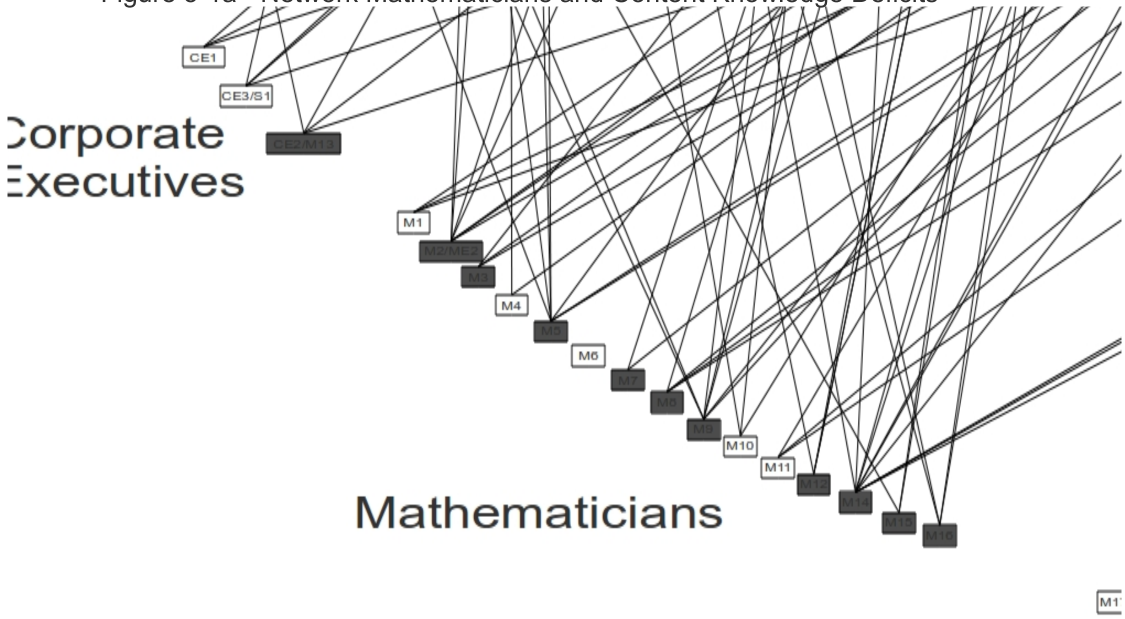
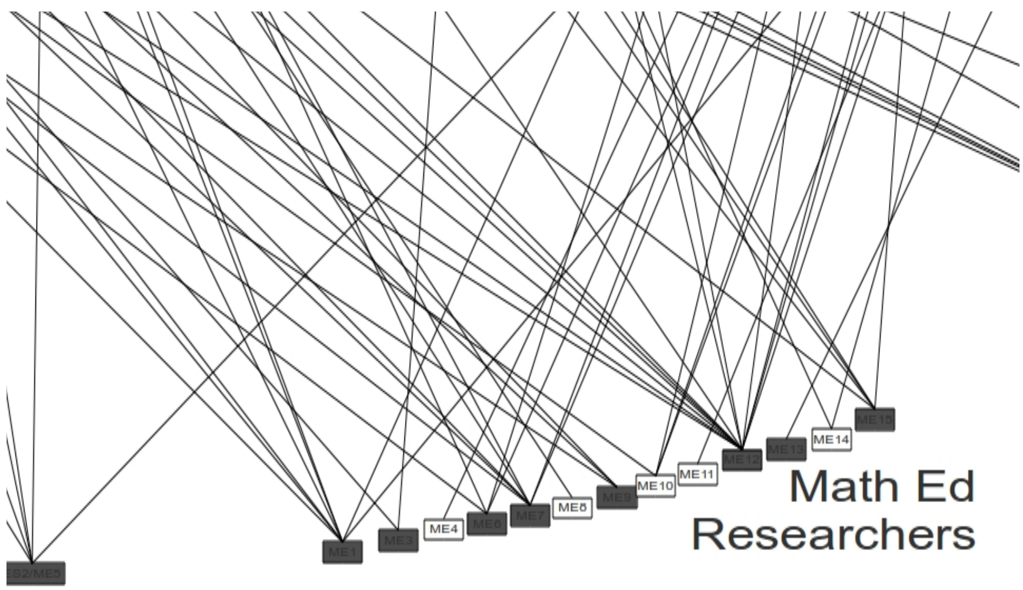


Figure 5-1b - Network Math Ed Researchers and Content Knowledge Deficits



A few math ed researchers, like Deborah Ball, dedicate their work in carefully defining what is meant by content knowledge. Amongst others in the network, Ball emphasizes the careful distinction between content knowledge and pedagogical content knowledge that I began to discuss in the previous section. The phrase “pedagogical content knowledge” was introduced by Lee Shulman, a psychologist not in my network but who was a past president of a network organization, Carnegie Foundation for the Advancement of Teaching. Shulman describes this knowledge as a discipline-specific set of ideas that goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge for teaching.” Examples of this type of teacher knowledge include, “for the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations -- in a word, the ways of representing and formulating the subject that makes it comprehensible to others.”[259]

Emphasizing pedagogical content knowledge means that it is not enough for a math teacher to have a deep understanding of mathematics; he must also know the ways to make this knowledge accessible to his students. Shulman's influence on national math education also indicates that this knowledge must be taught in a content specific setting. This signifies a break from a teacher preparation that provided future teachers with content knowledge and a separate, general, education in pedagogic methods. Pedagogical content knowledge implies that the teacher knowledge of making something accessible to students is a non-transferable entity. Knowing how to do it in one context does not mean that a teacher can do it in another. In other words, Shulman's influence on network actors

[259] Lee Shulman, “Those Who Understand: Knowledge Growth in Teaching,” *Educational Researcher* 15, No. 2 (Feb. 1986): 9.

Ball and others indicates a commitment to content-specific teacher preparation, as will be the case with other interests I discuss in this chapter.

Shulman's pedagogical content knowledge also influenced the work of some network actors who express the teacher knowledge deficits theme by their participation in or citation of work comparing the knowledge of US teachers to that of other countries. The most famous of these mathematicians and math educators is Liping Ma,[260] a math ed researcher, who in her book *Knowing and Teaching Elementary Mathematics* compared the knowledge of teachers in China with those in the United States and determined that Chinese teachers knew more math. Several network actors cite Ma's study as proof of the content knowledge deficits of math teachers, e.g. mathematician Roger Howe's review of the book published by American Mathematical Society.[261] On the other hand, a group of mathematicians and math ed researchers work on the US Teacher Education Study in Mathematics (US TEDS-M),[262] which indicated in 2010 that US teachers compared favorably on international tests of teacher mathematical knowledge. Despite the results of their research, the group continues the goal to improve teacher knowledge. The international comparison of math teachers in more detail under the assumption that such comparison is born out of the human capital interest.

Before moving to the organizations expressing the teacher content knowledge deficits theme, I introduce one network individual who also suggests the connection

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[260] Liping Ma, *Knowing and Teaching Elementary School Mathematics,* (Mahwah, NJ: Lawrence Erlbaum Associates, 1999).

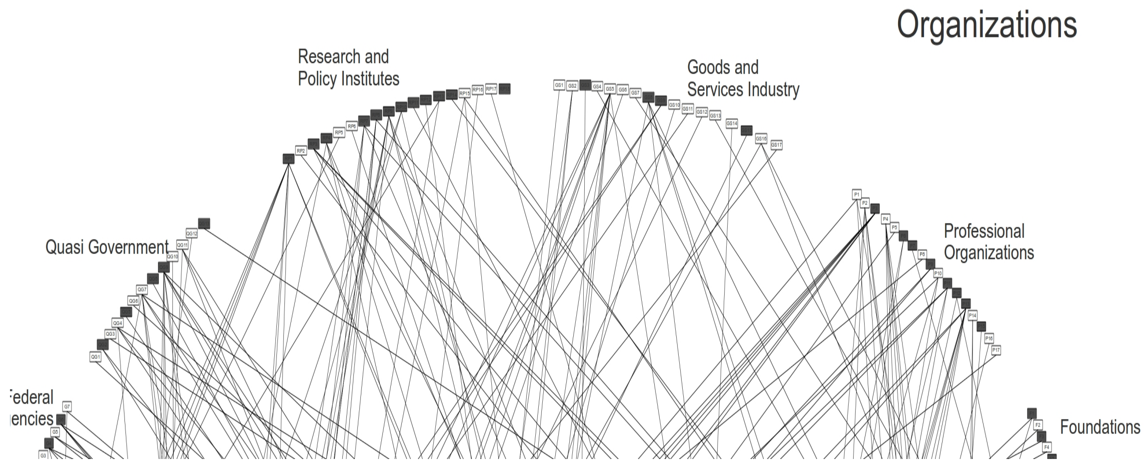
[261] Roger Howe, "Knowing and Teaching Elementary Mathematics Reviewed by Roger Howe," *Notices of the AMS*, September 1999, 881-887.

[262] US Teacher Education Study in Mathematics' website: http://www.educ.msu.edu/content/default.asp?contentID=710.

between this theme and human capital, as does the international comparison of teacher knowledge. James Simons, a mathematician and corporate executive, offers the view that knowing math content is the primary requirement for effective teaching of math. He founded and finances Math for America, a program that pays stipends to public school math teachers who demonstrate a high level of mathematical knowledge by scoring well on math tests.

Now that I have introduced the variety of network individuals that express the content knowledge deficits theme, I move to the variety of organizations in my network that express the theme. This is indicated in the sociogram below. Examining these expressions elaborates both on the ways that actors commit to this theme and on the other ideas that connect with it. One example of these connections comes from the research and policy institutes who use this theme to replace schools of education with alternative methods for teacher licensing, a goal that I will later argue to aid in the development of human capital.

Figure 5-2 - Network Organizations and Content Knowledge Deficits



Many of the federal agencies and quasi-government organizations talk of highly qualified teachers defined by a teacher's content knowledge and background, similar to James Simons' Math for America. This most famously occurred with the federal No Child Left Behind Act. Other of the quasi government agencies provide professional development for teachers to fill in their gaps of mathematical knowledge, as do several of the goods and services industries that provide them (e.g. America's Choice), and the Foundations that fund these activities (e.g. Noyce Foundation). Another educational services company, Educational Testing Services (ETS), is interested in this theme because they provide the standardized assessments for testing teacher knowledge. I will return to ETS' contributions in chapter 6, dedicated to educational business.

Other actors indicate the ties between this theme and human capital, as I first indicated with the network actors who compare US math teacher knowledge to that of other countries and also corporate executive and world's 80th richest man James

Simons.[263] The US Teacher Education Study in Mathematics (US TEDS-M) is funded by Boeing, Bill and Melinda Gates Foundation and GE. ExxonMobil provided the funding for a 2001 conference hosted by the Conference Board of Mathematical Sciences (CBMS), the umbrella organization of most of the professional mathematics organizations. The title of this conference was "National Summit on the Mathematical Education of Teachers: Meeting the Demand for High Quality Math Education in America."[264] Not only does this conference indicate Exxon's interest in the deficits theme, it also supports the range of academics who commit to it. CBMS includes the National Council of Teachers of Mathematics (NCTM), which represents the progressivist stance on math education, and the American Mathematical Society (AMS), which represents the traditionalist.

Throughout my representative network surrounding national math education there exists a belief that math teachers need to know more mathematics. Network actors demonstrate this theme primarily by comparing US math teacher knowledge to that of other countries and by providing ways that this knowledge can be enhanced through teacher education and professional development. Several actors that represent the human capital interest also devote attention to the theme. This begins to suggest that emphasizing teacher content knowledge enhances educating for human capital. To continue, I delve deeper into the details of the above actors who express a deficit perspective on math teacher content knowledge. Ultimately, I will use this exploration to

263 Forbes, "The world's billionaires: #80, James Simons," November 19, 2010, http://www.forbes.com/lists/2010/10/billionaires-2010_James-Simons_5GZ7.html.

264 The summary of this conference can be viewed at Conference Board of Mathematical Sciences, "National Summit on the Mathematical Education of Teachers: Meeting the Demand for High Quality Mathematics Education in America," http://www.cbmsweb.org/NationalSummit/national_summit.htm.

justify why the human capital interest is furthered by the claim that math teachers do not know mathematics.

A Global Competition of Teacher Knowledge

Several actors in the network work on or cite research comparing the content knowledge of math teachers to that of other countries. In chapter 3, I emphasized the connection between educating for human capital and the international comparative math tests for students. Similarly, the efforts to compare US math teachers' content knowledge to those abroad indicates a commitment to math education for human capital. This is most easily expressed with the corporate funding for the US Teacher Education Study in Mathematics (US TEDS-M), but first I will address the most influential of these works.

In 1999, network actor and math education researcher Liping Ma published *Knowing and Teaching Elementary Mathematics*.[265] The influential book centering on the content knowledge deficits of math teachers was reviewed by a range of individuals and organizations. Notably, the New York Times stated that “Both sides of the math wars claim Dr. Ma as their own”[266] thus furthering my earlier claim that both sides are concerned with content knowledge deficits. The research contained in the book involves interviewing US and Chinese elementary school teachers, asking them questions about teaching math and specifically four questions that test their knowledge of mathematics. Ma was specifically interested in both whether the teachers could compute the mathematics correctly and explain the concepts behind it. For example, one question

265 Ma, *Knowing and Teaching.*
266 Richard Rothstein, “Lessons: To Peace on Math's Battlefield,” *New York Times*, June 27, 2001.

required teachers to accurately divide fractions and come up with a story problem that corresponds to the mathematical computation.

In the words of network actor and mathematician Roger Howe, Ma found that "the Chinese teachers responded more or less as one would hope that a mathematics teacher would, while the American teachers revealed disturbing deficiencies."[267] In most cases, the US teachers could not offer sound explanations for the concepts behind mathematics. In some cases, the US teachers could not perform the computations correctly. On the other hand, most Chinese teachers could do both of these things. Ma suggests these differences are the primary reasons behind the better scores Chinese students receive on math assessments.[268]

However, Ma's implication that Chinese teachers are on the whole more knowledgeable than US teachers rests on shaky ground. For one, the work does not properly sample from among the Chinese teacher population or from the US teacher population. Her data for US teachers comes from a previous study by Deborah Ball on 23 US teachers of various experience levels; however, in the work, Ma reports these 23 as "above average" for representing US teachers. As for the Chinese teachers, Ma indicates that the sample of 72 teachers comes from five schools "chosen to represent the range of Chinese teaching experience and expertise: urban schools and rural, stronger schools and weaker."[269] However, the breakdown of the number of teachers from each type of schools is not indicated, nor is there any attempt to address the proportion of schools in China

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267 Howe, "Knowing and Teaching," 883.
268 Ibid., 883.
269 Ibid., 882,

that fall into these categories of stronger and weaker.

Second, it does not properly sample from among all the mathematical knowledge that elementary teachers may know. Three of the four questions she used involved arithmetical operations and the conceptual understanding behind them. The fourth came from geometry with a conceptual understanding of perimeter and area. For example, elementary teachers knowledge of statistics was not tested. The broad claim that US math teachers know less math is not well justified.

In fact, more recent research in this area favorably compares US math teachers to a variety of other countries. It should be clearly emphasized that the involved researchers make the claim that their data supports the notion that US math teachers need to know more math. However, in looking at their data, I find that their conclusions rest on shaking grounds. Instead, I argue their data suggests that the math knowledge of US math teachers is comparable to that of teachers in other developed countries with strong educational systems.

The work does not compare US math teachers to Chinese teachers, as Ma attempted, so this work does not directly contradict her findings. However, I argue that Ma's work has catapulted significant concern that US math teachers fair poorly on international competitions. Therefore, in a sense, this new data contradicts the urgency that many took from Ma's study. This work was developed by the US Teacher Education Study in Mathematics (US TEDS-M), a group that involves several network actors, including mathematicians Roger Howe, James Milgram and Hung-Hsi Wu; math education researchers Francis (Skip) Fennell and Jeremy Kilpatrick; and other ed researcher Tom Loveless. The organization works with the International Association for the Evaluation of Educational Achievement (IEA), the organization that also runs the Trends in International Math and Science Study (TIMSS) that I noted in chapter 3. IEA's international Teacher Education and Development Study compares the preparation of future math teachers across the globe by looking at the courses taken and future teachers' scores on content exams.

US TEDS-M executes the sampling and data collection process in the US for IEA's international study of future math teachers. They draw an accurate sample of future US math teachers by using a more appropriate sampling technique than Ma, as indicated in the following:

> About 100 colleges/universities have been randomly selected to represent the United States in this international study. Strata were used in the random selection process to ensure that these institutions represent a range of states, institution size, and Carnegie Foundation classification. Two rounds of data collection will occur in the U.S. with about 50 institutions participating each time.[270]

Also, US TEDS-M provides the US interpretation of the results from IEA's international comparison of math teacher preparation. Interestingly, their major findings from the 2010 study presents evidence that US math teachers, or at least future math teachers, do not have a deficit of math knowledge. The first two bullet points from their FAQ on the study are:

> -Related to mathematics knowledge, future middle school mathematics teachers were in the middle of the international distribution of countries – straddling the divide between those whose eighth grade students do better than the U.S. on international mathematics assessments and those who

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270 US Teacher Education Study in Mathematics, “Project Overview,” accessed June 21, 2011, http://www.educ.msu.edu/content/default.asp?contentID=714.

don't.
-U.S. future elementary teachers' mathematics knowledge isn't distinctively high or low...[271]

A more detailed US-TEDS M report indicates that future elementary US math teachers knew as much math as those from the Russian Federation, Norway and Germany.[272] As for pedagogical content knowledge, that is, the type of knowledge for teaching that extends beyond simply knowing the math to also include the ways to teach such math, future US elementary teachers knew as much as future teachers in Norway and Switzerland, and more of this knowledge than teachers in the Russian Federation and Germany.[273] With regard to future middle school teachers, the same report indicates that future middle school math teachers in the US know as much content as those in Switzerland and Germany, and more pedagogical content knowledge than those in Norway.[274] While it is true that Singapore and Taiwan bested the US in all comparisons, it is clear that the US favored adequately when compared to other developed countries such as Norway, Germany and Switzerland. The following are the data tables are from the report "Breaking the Cycle: An International Comparison of US Mathematics Teacher Preparation."

Table 5-1 TEDS-M Countries' Overall Performance with Respect to Mathematics

[271] US Teacher Education Study in Mathematics, "Frequently Asked Questions," accessed June 1, 2011 http://www.educ.msu.edu/content/sites/usteds/documents/USTEDS-FAQ.pdf.
[272] Center for Research in Mathematics and Science Education, "Breaking the Cycle: An International Comparison of US Mathematics Teacher Preparation," East Lansing: Michigan State University, http://www.educ.msu.edu/content/sites/usteds/documents/Breaking-the-Cycle.pdf., 12.
[273] Ibid., 13.
[274] Ibid., 26-27.

Content Knowledge at the Primary Level[275]

Country	Mean Score
Taiwan	623
Singapore	590
Switzerland	543
Russian Federation	535
Thailand	528
United States-Private	527
Norway	519
United States-Public	518
Germany	510
Poland	490
Malaysia	488
Spain	481
Botswana	441
Philippines	440
Chile	413
Georgia	345

Table 5-2 TEDS-M Countries' Overall Performance with Respect to Pedagogical Content Knowledge at the Primary Level [276]

Country	Mean Score
Singapore	593
Taiwan	592
Norway	545
United States-Private	545
United States-Public	544
Switzerland	537

[275] Ibid., p. 12.
[276] Ibid., p. 13.

Russian Federation	512
Thailand	506
Malaysia	503
Germany	502
Spain	492
Poland	478
Philippines	457
Botswana	448
Chile	425
Georgia	345

Table 5-3 TEDS-M Countries' Overall Performance with Respect to Mathematics

Content Knowledge at the Lower Secondary Level[277]

Country	Mean Score
Taiwan	667
Russian Federation	594
Singapore	570
Poland	540
Switzerland	531
Germany	519
United States-Private	512
United States-Public	505
Malaysia	493
Thailand	479
Oman	472
Norway	444
Philippines	442

[277] Ibid., p. 26.

Botswana	441
Georgia	424
Chile	354

Table 5-4 TEDS-M Countries' Overall Performance with Respect to Pedagogical Content Knowledge at the Lower Secondary Level[278]

Country	Mean Score
Taiwan	649
Russian Federation	566
Singapore	553
Switzerland	549
Germany	540
Poland	524
United States-Private	505
United States-Public	502
Thailand	476
Oman	474
Malaysia	472
Norway	463
Philippines	450
Georgia	443
Botswana	425
Chile	394

The results of this study suggest that perhaps US math teachers' content knowledge is not poor. To be sure, the limitation of my claim comes from the fact that this study only compares future teachers, and not practicing teachers. The content

[278] Ibid., p. 27.

knowledge deficits theme indicates that both future and practicing teachers need more math knowledge. However, my exact point here is that despite the evidence from TEDS-M, network actors continue to further the deficits theme for both future and practicing teachers. In fact, the full quotation from US TEDS-M's second bullet point above is that teacher math knowledge is not “distinctively high or low but certainly isn't at the level we as a nation would like.”[279] The deficits theme remains strong, no matter the evidence to the contrary. This strength comes from the fact that the human capital interest, the dominant interest in the network, supports this theme.

I understand that many do take issue with the content knowledge of those charged to teach math to students across the grade levels. This is an important aspect to research in math education, and I do believe essential for successful math education. However, this is not the only issue attended to by research in math education, yet it is a primary theme in the social network surrounding national math education. I argue its significance in the network is due to the private interests with which it aligns. In particular, emphasizing math teacher content knowledge deficits amounts to placing emphasis on teachers and their role in education's failures, whatever these might be. This corresponds significantly to the private interests in national math education, specifically the interest in developing human capital.

I start examining the connection between education for human capital and the teacher knowledge deficits theme with a look at the activity and funding of US TEDS-M. As with math students' global competition, this activity is born out of the human capital

[279] US TEDS-M, “Frequently Asked Questions,” 1.

interest as suggested by network actor Robert Linn.[280] What's more, the funding for US TEDS M includes Bill and Melinda Gates, GE, and Boeing. Each of these hold an interest in investment that develops in people the intangible qualities usable by business. As I discussed in chapter 4, these qualities include problem solving, collaboration and the moral of perseverance. Therefore, the network actors working on US TEDS-M are doing so with significant encouragement from the human capital interest.

The other funder of US TEDS-M is the Carnegie Foundation for the Advancement of Teaching (CFAT). Historically, the human capital interest is suggested by this organizations' founder, Andrew Carnegie. Today, the board includes a director from Education Trust, an educational research and policy think tank that is funded by human capital interests such as Bill and Melinda Gates, the Waltons (owners of Walmart), and the Hewletts. Therefore, CFAT represents the human capital interest for its connections to such businesses.

In this section I have explained the phenomenon of an international competition of math teachers. A noteworthy point is that US teachers actually fair well in this competition, yet the contention that US math teachers should know more math remains strong. Part of this strength is evidenced by the attempts of network actors and their affiliates to fill in these knowledge gaps. Particularly interesting, as I demonstrate in the following section, is that these attempts are largely funded by organizations that hold or represent the human capital interest.

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[280] see chapter 3, page 127-128.

The Human Capital Interest Fills in Teacher Knowledge Gaps

As I indicated earlier in this chapter, a connection between human capital and the deficits theme is suggested by the fact that ExxonMobil financed the Conference Board of Mathematical Sciences' (CBMS) "national summit" on how to provide for math teachers a mathematical education. Furthermore, in the previous section, I highlighted how the global competition of math teachers connects to the human capital interest both in its actions and the funding that enables these actions. Contained here are the network actors who either hold or represent the human capital interest, as I discussed in chapter 3, and who also express the teacher content knowledge deficits theme by offering programs that aim to fill in these supposed deficits. For each actor, I will briefly describe why the organization holds or represents the human capital interest (many of these I discussed in greater detail in chapter 3). Then I describe the programs that these organizations offer to eradicate the mythological content knowledge deficits. Viewed broadly, these programs use the myth to re-educate teachers for preparation in teaching a math education that develops human capital.

To begin, I revisit the Carnegie Foundation for the Advancement of Teaching (CFAT). Beyond funding the work of US Teacher Education Study in Mathematics (US TEDS-M) as described in the previous section, CRAT also expresses the teacher knowledge deficits theme in other ways. Lee Shulman was president of CFAT from 1997 to 2008. Shulman, a psychologist, led teacher education studies in the new direction with his notion of pedagogical content knowledge which I earlier described as a variant on the notion of teacher content knowledge deficits. During his time at CFAT, he established their advanced study program for teachers. This "became the perfect setting for teachers from all levels of education, from kindergarten through the doctorate, to join with resident scholars to examine their practice and build new knowledge."[281] As I expressed in the previous section, CFAT represents the human capital interest, and, through Shulman's advanced study program for teachers, provides my first example of the interests activities attempting to teach more math to math teachers.

A similar activity comes from the Noyce Foundation, a network organization that in chapter 3 I suggested represents the human capital interest. From 2006 to 2009, the Foundation ran the "Silicon Valley Mathematics Initiative" (SVMI) a program designed to "improve the teaching and learning of mathematics in grades K-12. " Although the professional development program includes activities geared towards other active members of the math education process, e.g. principals, SVMI primarily involves increasing the content knowledge of math teachers. For example, in 2007 "fourteen middle school and K-8 principals participated in seven professional development sessions during the year. The project supported middle school teachers in improving their content knowledge and instructional strategies for teaching algebra ."[282] In the same year, "Forty teachers ... attended a week-long summer institute on algebraic reasoning. Starting in September, 85 teachers attended monthly professional development sessions on algebra instruction."[283] Additionally, SVMI provided "math coaches" that worked in the

281 Carnegie Foundation for the Advancement of Teaching, "Foundation History," accessed June 22, 2011, http://www.carnegiefoundation.org/about-us/foundation-history.
282 Noyce Foundation, "Noyce Foundation 2007 Annual Report," http://www.noycefdn.org/documents/annualreport2007.pdf, 7.
283 Ibid., 7.

classroom alongside teachers to provide help with both content and pedagogy.[284] In other words, a major focus for SVMI was to increase the supposed poor knowledge of mathematics held by math teachers.

Another program with the same type of activity and funding exists in Arizona. Intel Math is a program run through the Institute of Mathematics and Education (IME) and provides "an 80-hour professional development course in mathematics content for K-8 teachers ... One of the goals of Intel Math is that teacher participants deepen their own understanding of math through problem-solving."[285] As suggested by the program title, the course offerings are paid for by the Intel Foundation and thus represent the information and communications technology sectors' human capital needs. IME, an organization tied to several mathematicians and math education researchers in my representative network, also runs "Knowledge for Teaching Secondary School."[286] This program aims to bring together mathematicians and math education researchers for determining the content that secondary teachers must know in order to teach effectively. The program is not funded directly by businesses with the human capital interest, but instead by the National Science Foundation,[287] whose Directorate for Education and Human Resources (EHR) I argued to represent the human capital interest in chapter 3.

Yet another example of this type of professional development comes from America's Choice, a for profit educational services company that initially was founded by

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284 Ibid., 7.
285 Institute of Mathematics and Education, "Intel Math Program," accessed Jun 22, 2011, http://ime.math.arizona.edu/intelmath/.
286 Institute of Mathematics and Education, "IME Annual Report 08-09," accessed July 1, 2011, http://ime.math.arizona.edu/Files/IME_Annual_Report_08_09.pdf, 3.
287 Ibid., 3

the National Center on Education and the Economy (NCEE). In chapter 3, I detailed how NCEE epitomizes the educating for human capital interest both by its context and words. America's Choice professional development program for math teachers "strengthens teachers' content knowledge and pedagogy. By focusing on the most important concepts students must learn to succeed in algebra and beyond, we help teachers expand their math knowledge and become more effective."[288] I also note that network math educator and educational services employee Phil Daro runs this program.

Like America's Choice and the Intel, Noyce and Carnegie Foundations, two network quasi-governmental organizations also aim to fill in the teacher content knowledge deficits with professional development programs. These are the Center for Proficiency in Teaching Mathematics (CPTM) and Mid-Atlantic Center for Mathematics Teaching and Learning. Both are funded by the National Science Foundation (NSF), thus I classify them as organizations dependent on federal agencies.[289] NSF represents the human capital interest because its education branch, the Directorate for Education and Human Resources (EHR), represents the government's role in developing human capital for business as I discussed in chapter 3. Each of these organizations addresses the content knowledge deficits theme by providing professional development to increase math knowledge.

> The Center for Proficiency in Teaching Mathematics (CPTM) aims to strengthen the system of professional education that supports teachers of mathematics throughout their careers ... [and] focuses on two questions: What mathematical knowledge and skill is needed for effective teaching of

[288] America's Choice, "Professional Development" accessed June 2, 2011, americaschoice.org/professionaldevelopment.
[289] See chapter 2, pages x.

> mathematics? How can teachers develop and learn to use this knowledge and skill in their professional practice?[290]

Similarly, the Mid-Atlantic Center for Mathematics Teaching and Learning "Conducts research on the development, application and influence of teacher knowledge in K-12 mathematics [and] Develops models for the mathematical education of pre-service teachers and the professional development of in-service mathematics teachers."[291] These quotations indicate that both centers' research supports the content knowledge deficits theme.

These two quasi-government research centers, along with America's Choice and Noyce, Carnegie and Intel Foundations, represents the human capital interests' quest to provide content knowledge to math teachers. The quasi-government centers primarily provide research and development, whereas the others primarily provide the actual programs for teachers to learn more math. However, my earlier claim that the content knowledge deficits of math teachers is a myth stimulates an inquiry into the ulterior motives behind these programs.

Besides perpetuating the myth that teachers do not know math, one possible motive is that these programs narrow the definition of math. For example, Intel Math describes their program with a focus on problem solving. "One of the goals of Intel Math is that teacher participants deepen their own understanding of math through problem-solving."[292] In chapter 4 I connected this emphasis on problem solving with the needs of

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290 Center for Proficiency in Teaching Math, "About cptm," accessed February 17, 2011 http://www.cptm.us/about_cptm.html.

291 Mid-Atlantic Center for Mathematics Teaching and Learning, "Home," accessed June 24, 2011, http://www.education.umd.edu/mac-mtl/.

292 Institute of Mathematics and Education, "Intel Math."

human capital as expressed by organizations such as the World Bank and Organization for Economic Cooperation and Development (OECD). This example shows how the content knowledge deficits myth serves to re-educate teachers for the mathematics that the human capital interest desires.

Another way these programs define math is with their emphasis on Algebra. As the quotes included above indicate, America's Choice and the Noyce Foundation's SVMI professional development programs focus on algebra or algebraic reasoning and do not mention other content areas within mathematics. As I also argued in chapter 4, emphasizing Algebra possible works in the interest of human capital in two ways. It represents the moral of perseverance and functions as the center piece of a hierarchical curriculum used in identifying elite students.

I have provided examples of the those actors in my network who hold the human capital interest and act to fill in the supposed teacher content knowledge deficits. Primarily these actors are private Foundations and the National Science Foundation (NSF). They use the content knowledge deficits myth to re-educate teachers in the mathematics that is most useful for developing modern human capital, such as in problem solving and Algebra.

Recruiting the "Mathematically Talented"

The previous section discussed programs that provide professional development for practicing math teachers to increase their content knowledge. In a slightly different way, other network actors with the human capital interest aim to fill in the mythical teacher knowledge gap by recruiting the "mathematically talented." The assumption behind these efforts is that math teachers are not knowledgeable in mathematics because the people who are knowledgeable in mathematics do not become math teachers. Here I review the activities of two network organizations: the National Math and Science Initiative and Math for America.

The US National Math and Science Initiative (NMSI) connects the human capital interest with an aim to increase the content knowledge of math teachers. As I discussed in chapter 3, NMSI represents the human capital interest for its funding from Exxon, Dell, Gates and IBM and for its assertion of math education's role in US economic competitiveness. NMSI runs the UTeach program at the University of Texas, Austin. The program seeks to recruit undergraduate math majors for the teaching profession and help them acquire "deep content knowledge." "The UTeach program produces teachers that are confident and competent in their subject matter."[293] Therefore, NMSI's UTeach program targets the preparation of future math teachers in its quest to increase content knowledge in teachers, rather than through the professional development of practicing math teachers. NMSI believes that recruiting people with an inclination for math, i.e. math majors, will augment math teacher knowledge.

Similarly, Math for America (MFA) addresses the supposed content knowledge deficits of math teachers by increasing "the number of mathematically talented individuals entering teaching and to support those outstanding mathematics teachers already in the classroom." James Simons, mathematician and CEO of Renaissance

[293] National Math and Science Initiative, "UTeach Program," accessed April 29, 2011, nationalmathandscience.org/programs/uteach.

Technologies, founded and finances this organization that pays math teachers stipends above their salaries. In their mission statement, MFA declares that "One has to know a subject in order to teach it, particularly mathematics. Our goal is to have knowledgeable and creative teachers – teachers who inspire students with their own enthusiasm and love of mathematics. "[294] To that end, the program identifies future and practicing teachers with strong content knowledge, in part based on their scores on standardized assessments designed to test a teachers' content knowledge. Those that qualify are eligible for the generous stipends, in some cases $70,000 over five years.

Looking at the statements from MFA's website presents an interesting possibility regarding mathematics teaching and learning to which I will now devote some attention. In one of the quotations I included in the preceding paragraph, the program indicates that teacher content knowledge is more important in mathematics than in other disciplines. I am sure this failed to capture what MFA's website authors intended, because it seems foolish to suggest that in other content areas teachers do not need to know what they are teaching. For instance, how would a history teacher effectively convey to his students the millet system and religious pluralism without having a solid understanding of the Ottoman Empire's history? Instead, I believe it possible that MFA meant to state that having talent for mathematics is more important than in other disciplines, and that having talent for mathematics leads to a person's knowledge of math. In contrast, historians do not have a talent for history, but instead learn the knowledge because they can read. This suggests that math is a discipline unique for the fact that people are either innately

[294] Math for America, "Mission and Vision," March 8, 2011, http://www.mathforamerica.org/about-us/mission-and-vision.

predisposed to it or not.

I suggest that MFA's mistake reveals a possibility of something else going on amongst the content knowledge deficits theme. Namely, it seems likely that many involved in the debate on national math education believe people are either innately talented in math or not. This is evidenced by the fact that both MFA and NMSI's UTeach program seek to recruit “mathematically talented” individuals. To some this may mean individuals who have taken several courses in mathematics. However, MFA states that knowing math is more important for teaching it than knowing it for other disciplines and I posit this implies they think people are predisposed to having math knowledge. I hesitate to claim this point as anything greater than a possibility because I did not find other statements in the network that helped to support this idea. That stated, the significance of this possibility presents a striking irony in the goals of national math education for if people are predisposed to math knowledge, then why are we talking about teaching the discipline at all?

More to MFA's activity, I suggest that paying math teachers more money is less about recruitment than it is about control. Math teachers who are paid above their salaries, as often determined by collective-bargaining agreements, are less likely to advocate for others in the teaching profession. It privileges the teaching of math above other areas, as math education should be emphasized for its role in developing human capital. This allows math teachers to put up with less autonomy over their work as well as less solidarity with the teaching community.

In this and the previous section, I have reviewed the corporate-sponsored uses of the math teacher knowledge myth. These activities primarily divide into two types: business-funded programs aim to recruit "mathematically talented" individuals into becoming math teachers, but actually privilege the teaching of math; and programs that re-educate math teachers in line with the most promising elements of math education with regards to human capital development. These points have also revealed perhaps the most ironic idea in national math education's social network: that mathematical talent is innate and cannot be obtained through study.

Specializing the Teaching of Math, or, Is Math the New Special?

Some in my network believe math teachers should be those with an innate talent in math. This resonates with the introduction of "math specialists," another trend I discovered in the network that expresses the content knowledge deficits of math teachers. This emerging type of employee works primarily in elementary and middle schools as an auxiliary to the grade school teacher. The trend indicates that such generalist teachers cannot provide adequate mathematics instruction either for their lack of mathematical talent or knowledge. In this section I present the several network actors, including those that hold or represent the human capital interest, who suggest this type of employee or work on it in some way.

The first example of math specialists was presented in the previous section. The math coaches of the Noyce funded Silicon Valley Mathematics Initiative (SVMI) are a type of math specialist. This type of employee is not a regular teacher of students but an auxiliary employee who teaches exemplary lessons and monitors the mathematical education offered by the generalist elementary teacher. As the Noyce Foundation is entangled with the information and communications technology (ICT) industry, this example of the math teacher specialist trend comes directly from the human capital interest.

The second example comes from a return to network mathematician Roger Howe's review of network math education researcher Liping Ma's work *Knowing and Teaching Elementary Mathematics*. As follows, Howe highlights that Chinese students have separate teachers for math in the primary grades:

> Chinese mathematics teachers are specialists. Making mathematics teaching a specialty can be expected to increase the mathematical aptitude of the teaching corps in two ways: it reduces the manpower requirements for mathematics education by concentrating it in the hands of the mathematically most qualified teachers, and it raises the incentives for mathematically inclined people to become teachers. [295]

Therefore, Howe suggests that US math specialists in the elementary grades can improve math instruction. A couple of interesting points emerge from Howe's quote. For one, he clearly articulates how math specialists will combat the content knowledge deficits of US teachers. Second, he suggests the importance of recruiting the "mathematically inclined," similar to the words of Math for America. Although inclination can connote enthusiasm, it could also indicate a belief in innate talent for mathematics as the primary determinant of mathematical knowledge as opposed to the learning of such knowledge. As I stated in my discussion of Math for America in this chapter, such an assumption about innate talent for mathematics presents significant irony in discussing math education.

Answering Howe's call for math specialists are the several network actors who

[295] Howe, "Knowing and Teaching," 884-885.

describe in more detail the math specialists that do exist in the US, such as network math education researcher Joan Ferrini-Mundy. One of her publications details the effect that math specialists had on math instruction.[296] Another network math education researcher, Francis (Skip) Fennell, coauthored an article detailing the emerging use of these employees in the US. The article opens with the problems he faces when teaching generalist elementary teachers how to teach math; notably he implies that these teachers do not understand the content.[297] He also indicates the connection between these specialists and the human capital interest: "The Exxon/Mobil Educational Foundation has supported the creation of a national network of district projects that are highlighted by the development of mathematics specialists and leaders at the elementary school level."[298] The article also describes a variety of uses for the math specialists, such as the coaches I described earlier and lead teachers, generalist teachers who teach math well and then mentor the rest of the staff. Fennell describes the "specialized-assignment" model as well, in which math specialists are elementary school teachers of only that subject.[299] Fennell argues for the latter because there will be not be an increase in the number of employees, and thus expense, as does the addition of lead teachers or coaches. This circumstance will only occur, however, if all subjects are specialized, a trend that to my knowledge does not exist with the fervor of math specialists. Likely, schools that add math specialists cut their

296 Joan Ferrini-Mundy and Loren Johnson. *Highlights and Implications*. The Recognizing and Recording Reform in Mathematics Education Project: Insights, Issues and Implications, JRME Monograph Series, no. 8, edited by Joan Ferrini-Mundy and Thomas Shram. (Reston, VA: National Council of Teachers of Mathematics, 1997).

297 Barbara J. Reys and Francis (Skip) Fennell, "Who Should Lead Mathematics Instruction at the Elementary School Level? A Case for Mathematics Specialists," *Teaching Children Mathematics* 8, No.5 (2003): 277.

298 Ibid., 278.

299 Ibid., 280.

other specialist teachers, like those in art and music.

More than merely documenting these changes and calling for greater numbers of math specialists, Fennell has taken the lead in making this happen. Fennell holds a professorship at McDaniel College, where he founded and heads the "Elementary Mathematics Specialists and Teacher Leaders Project."[300] The primary project goal is running a master's in science program that leads to a Maryland state certification as an "Elementary Mathematics Instruction Leader." Other goals include research addressing the "the growth, development, and ongoing needs relative to elementary mathematics specialists" and pushing other states to create credentialing policies for math specialists like Maryland's.[301] The project is funded by Brookhill Foundation, for whom I found it difficult to connect the human capital interest. However, in 2009 Brookhill helped to finance several other organizations seeking a math education for human capital, such as Achieve, Inc. and National Council on Teacher Quality.[302]

So far, I have demonstrated the growing call and response for the specialization of teaching math. This predominantly centers on introducing designated math coaches or teachers in the elementary grades. Although some of the actors supporting this trend hold the human capital interest, some do not, such as the mathematicians and math education researchers I have discussed. However, I next argue that the introduction of math specialists is clearly committed to human capital. For one, the math education described

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300 The Elementary Mathematics Specialsts and Teacher Leaders Project is on the web at ttp://www2.mcdaniel.edu/emstl/index.html.

301 The Elementary Mathematics Specialsts and Teacher Leaders Project, "About The Elementary Mathematics Specialsts and Teacher Leaders Project," http://www2.mcdaniel.edu/emstl/project.html.

302 Brookhill's 990 form, year 2009, accessed June 1, 2011, http://nccsdataweb.urban.org/orgs/profile/205818635?popup=.

in the network connects with human capital for the reasons I described in chapter 4 on the Math Wars. Therefore, having designated teachers that exclusively focus on math would increase the efficiency of such instruction. In their writings on the subject, both Howe and Fennell suggest that such specialization will allow a focus that leads to increased competency within the domain.[303]

On another note, I suggest the possibility that "math specialists" signify the human capital interest by replacing other education that is less usable by business. In my years in elementary school, we referred to the classroom experiences for which we had separate teachers as "specials," typically these were art, music, and physical education. As I stated before, the trend for specialists in other content domains does not exist like that in math. In fact, the trend is to eradicate the specialists that exist for a variety of domains, such as art or music. In other words, if these ideas and actions in the network strengthen, I predict math to be the "new special" in elementary schools. The human capital interest would appreciate such significant, focused attention on the math education that develops in people the intangible qualities they find valuable.

Thus far, I have described how the human capital interest attempts to correct a supposed deficit of math teacher knowledge by providing professional development for practicing teachers, recruiting "mathematically talented" to become math teachers, privileging math instruction by paying math teachers more and specializing math instruction in the elementary schools. In the general sense, each of these aims to increase the efficiency of a math education that businesses can use. However, I argue that the myth

303 Howe, "Knowing and Teaching," 884 and Reys and Fennell, "Who Should Lead," 281.

of math teachers' content knowledge deficits on its own aids in the achievement of educating efficiently for human capital. I turn to this point in the next section, where I posit that the teacher deficits theme fuels the fire of an attack on a political teacher education, teacher compensation and collective bargaining.

Removing Teachers Who Cannot or Do Not Develop Human Capital

I have argued that the human capital interest in math education uses the teacher knowledge deficits myth to develop teacher knowledge for its own purposes and prioritizes the teaching of math over other subjects in the elementary years. Both of these aim to increase the effectiveness of math instruction, a goal related to Gary Becker's quest for efficiently educating for human capital.[304] Here I examine network actors that use the myth in a more subtle manner to increase educational efficiency. The network includes the following themes that are associated with perpetuation of a content knowledge deficits myth: erasing those aspects from teacher education that oppose education for human capital, changing firing practices of teachers, and altering the compensation provided for teachers' work. In essence, each of these relies on emphasizing poor teacher quality to achieve the respective goal. In the following, I will present the network actors who perpetuate the content knowledges myth and suggest one or more of these three goals related to educating for human capital.

The first of these is removing a political education from teacher education that would encourage future teachers to question an education for human capital. In other

[304] See chapter 3.

words, some teacher education programs emphasize other purposes for education besides those needed by businesses to make greater profit, such as education for personal happiness or education for a strong democracy. Some aspects of these purposes for education will contradict an education for human capital. This concern is best expressed by organizations like the Fordham Institute, a Research and Policy Institute in my network. As I argued in chapter 3, Fordham represents the human capital interest with board members such as those from the Walton Family Foundation. Fordham expresses the content knowledge deficits theme by consistent advocacy in teacher preparation emphasizing content over pedagogy[305], often doing so because they believe teachers do not know the knowledge of their designated content areas. Hence, Fordham expressed the math teachers content knowledge deficits myth. As well, they advocate for alternative teacher licensing that circumvents the needs of University based instruction, such as New Jersey's alternate route program.[306] Again, such advocacy is in part justified because this will fill in the knowledge gap of math teachers. However, I argue that an ulterior motive for removing University based teacher education exists in Fordham's work. Escaping such teacher preparation results in a different knowledge gap for math teachers, specifically, the knowledge of the ideologies contrary to educating for human capital.

To justify my claim, Fordham's advocacy for licensing teachers outside of

305 For example, see Fordham's 2001 report by David L. Angus and Jeffrey Mirel, "Professionalism and the Public Good: A Brief History of Teacher Certification," accessed May 26, 2011, http://www.edexcellence.net/publications-issues/teacher-quality.html?page=2

306 Diane Ravitch and Chester E. Finn, Jr., "Alternative Cert isn't Alternative," Thomas B. Fordham Institute, September 18, 2007, http://www.edexcellence.net/publications-issues/publications/alternativecert.html. Leo Klagholz, "Growing Better Teachers in the Garden State," Thomas B. Fordham Institute, January 1, 2000, http://www.edexcellence.net/publications-issues/publications/growingbetterteachers.html

University's takes particular issue with the setting's potential for an ideological education. Expressing this contention, one of Fordham's publications[307] concerns the particulars of National Council for Accreditation of Teacher Education's (NCATE) methods for accrediting schools of education. Primarily, Fordham is troubled by NCATE's standard for schools of education that ensures teachers have the right "dispositions" to teach effectively. They argue that such a term leaves room for ideological bias. The NCATE document elaborates on their meaning of the term dispositions, and Fordham takes particular issue with NCATE's inclusion of the phrase "social justice" in their elaboration on what they mean by teacher dispositions. While social justice is an "umbrella slogan"[308] in the education world, Fordham is correct in worrying over the term. For example, math education researcher Eric Gutstein uses the term to describe a math education born out of Marxist critical pedagogy.[309] Critical pedagogy presents a purpose for education diametrically opposed to educating for human capital. The former is framed by revealing the exploitation of labor and, particular to Gutstein, laissez-faire capitalism's contribution to economic inequality.[310] Gutstein's ideology counters that of those with the human capital interest and exposure to such ideology would counter educating efficiently for human capital.

The following quote summarizes Fordham's position on content knowledge and

307 William Damon, "Forward: Personality Test, The Dispositional Dispute in Teacher Preparation Today, and What to Do About It," Thomas B. Fordham Institute, September 8, 2005, http://www.edexcellence.net/publications-issues/publications/personalitytest.html.

308 phrase courtesy of Michael Apple, "Do the Standards Go Far Enough? Power, Policy and Practice in Mathematics Education," *Journal for Research in Mathematics Education* 23, No. 5 (1992): 413-414.

309 Eric Gutstein. *Reading and Writing the World With Mathematics: Toward a Pedagogy for Social Justice. (*New York: Routledge, 2006).

310 Ibid., 1-19.

political ideology in teacher education. In it, they describe appropriate and inappropriate principles for assessing teachers:

> 1) It is acceptable to assess skills, knowledge, and understandings that are imparted in training and derive from the established knowledge base of education. For example, an aspiring math teacher needs to know math and have the skill to communicate it to novices, all of which can be learned and tested. Such knowledge and skill may be examined. 2) It is not acceptable to assess particular attitudes and beliefs related to social/political ideologies. For example, a candidate's belief systems regarding economic redistribution, the politics of multi-culturalism, the implications of religious faith and its expression, whom we should vote for in the next election, or even whether all our national wildernesses should be turned into golf courses, are none of an assessor's business. General beliefs directly related to the candidate's capacity and motivation to teach are appropriate to examine: for example, Teach for America quite reasonably questions its candidates about whether or not they truly believe that all children can learn. But when such questioning wanders into the realm of social/political ideology, it is out of bounds. [311]

In other words, Fordham emphasizes content knowledge in teacher preparation because it will take the place of teacher's exposure to ideologies that oppose capitalism. I am careful to distinguish that Fordham is particularly concerned with exposure to these ideologies rather than whether future teachers actually hold them. This is because their primary advocacy involves erasing schools of education, the University setting where such ideas are more likely expressed, from the teacher licensing process.

As I turn now to my network's emphasis on changing the practices of teacher firing, I am specifically addressing the network actors who want to allow schools to fire any teacher at any time. Ultimately, I will make the claim that such changes result in reducing the presence of teacher opposition to educating for human capital, similar to the goal regarding teacher education, as well as generally reducing teacher autonomy over

[311] Damon, "Forward: Personality Test," 2.

content. I begin again with the Fordham Institute who, as I justified above, aligns with the human capital interest and with the math teacher content knowledge deficits myth. Fordham is also a major proponent of charter schools, in part for the reason I attend to now. In a 2001 report,[312] Fordham champions charter schools because their teacher hiring and firing practices would enhance teacher quality. Specific differences for Charter schools include:

> -Very few charter school teachers have tenure. Most work under one-year contracts or are at-will employees.
> -Very few charter schools are covered by collective bargaining agreements.
> -The average length of the teacher work day and work year is greater in charter schools than in traditional public schools.
> -Dismissals of teachers for poor performance are commonplace in charter schools.[313]

Fordham takes issue with tenure, for one, because it provides a job security that disallows teachers to be fired without justifiable cause by their employers. This suggestion that employers should have greater authority to fire teachers is articulated in the last bullet point I quoted above. Given the significance presence of the human capital interest in the network, I take "poor teacher performance" to mean any teacher performance that either opposes educating for human capital or educates for human capital inefficiently.

Another network organization, The New Teacher Project(TNTP), similarly targets teacher firing practices to increase efficiency in educating for human capital. TNTP represents the human capital interest because they have several corporate executives on

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312 Dale Ballou and Michael Podgursky, "Personnel Policy in Charter Schools," August 1, 2001, Thomas B. Fordham Institute, http://www.edexcellence.net/publications-issues/publications/personnelpolicy.html.
313 Ballou and Podgursky, "Personnel Policy in Charter Schools," vii.

their board of directors, such as a partner from Bain and Company which, in part, consults for industrial clients in "performance improvement."[314] In a similar vein, TNTP's mission focuses on policy advocacy that provides "excellent teachers in every classroom."[315] They themselves do not express explicitly the teacher content knowledges deficit, but instead a general description of poor teacher quality motivates their entire project. I argue their concern with teacher quality resonates with the theme, given that so many other network actors agree on the content knowledge deficits of math teachers. One of these, network mathematician Uri Treisman, is both on TNTP's board and developed the UTeach program I described earlier in this chapter.

As for TNTP's commitment to improving teacher quality, they oppose the current practice of teacher job security, commonly called tenure. They target this in a policy brief titled "A Smarter Teacher Layoff System,"[316] and provide greater detail on the dangers of teacher job security. The brief disguises their troubles with teacher job security by instead calling attention to the phenomenon of "last hired, first fired." Because teachers with tenure are to be fired for a documented reason, teachers without tenure are fired at a greater rate than those that have tenure. Most commonly, as this brief suggests, the reason for teacher firings is "reduction in staff (RIF)," and nothing to do with teacher quality. The root of the "last hired, first fired" problem is instead the de-funding of public schools.

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314 Bain and Company, "Performance Improvement," accessed June 24, 2011, http://www.bain.com/consulting-services/performance-improvement/index.aspx.

315 The New Teacher Project, "What Drives Us," accessed August 1, 2011, http://tntp.org/about-us/what-drives-us/.

316 The New Teacher Project, "A Smarter Teacher Layoff System: How Quality-Based Layoffs Can Help Schools Keep Great Teachers," March 2010, http://tntp.org/publications/issue-analysis/view/quality-based-layoffs/.

Because TNTP targets teacher quality and job security for a problem unrelated to either, I suggest that their advocacy for reducing teacher job security represents the ulterior motive to increase efficiently educating for human capital. In their view, a qualified teacher means one who supports educating for human capital and can develop in her students those intangible qualities usable by businesses. As with Fordham, this suggests a teacher that knows mathematics and is not exposed to ideologies opposing educating for human capital. Knowledge of content and ideas can change throughout one's life, therefore teachers should be able to be fired at any time throughout their career. For example, later in his career a teacher may be exposed to an ideology that opposes educating for human capital, and if tenured he could remain employed but educate in a way that does not further human capital development.

Beyond teacher firing practices, altering teacher compensation packages provides another example of policy directives tied to the content knowledge deficits myth. One example comes from network mathematician James Simons' program Math for America (MFA), whose ties to human capital and the math teacher deficits myth I have already made clear in this chapter. MFA's program works against the standard salary practices for teachers in the US because, typically, teachers are paid per their collective bargaining agreement emphasizing a teachers' years of experiences and schooling. However, MFA pays math teachers with advanced content knowledge monies above their salaries.

The reasons for this are embedded in educating for human capital. MFA's website indicates that “It’s become abundantly clear the basic rules of supply and demand need to be applied to our education system."[317] This notion is better expressed by former FCC Chairman, Alan Greenspan:

> Different pay scales for high school teachers in different disciplines may go against the ethos of teaching. Perhaps money should not be an incentive. But it is. . . . It is becoming increasingly clear that a flat pay scale when demand is far from flat is a form of price fixing that undermines the ability to attract qualified math teachers. Since the financial opportunities for experts in math or science outside of teaching are vast, and for English literature teachers outside of teaching, limited, math teachers are likely to be a cut below the average teaching professional at the same pay grade. Teaching math is likely being left to those who are unable to claim more lucrative jobs. That is far less true of English literature or history teachers. [318]

MFA attracts people with mathematical backgrounds into teaching by offering them more money. This assumes that such people have other career opportunities that make more money and would actually choose this. Many of these supposed career options, such as a career in engineering, are connected to the business interest of human capital. Thus, by offering greater pay, MFA is attracting teachers with less opposition to educating for human capital.

More generally, MFA's actions suggest teacher pay differentiation where teachers of different content areas should be paid more. Efficiently educating for human capital requires tailored investment in it. As I argued in chapter 4, math education develops intangible qualities usable by businesses and also serves to identify exceptional human capital. Therefore, investment in education should pay a premium for math education much higher than education in other areas. Programs like MFA, do just that, by increasing

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317 James Simons, "James Simons founder and director: Building a corps of strong math teachers [video file]," November 19, 2010, http://www.mathforamerica.org/about-us/mission-and-vision.

318 Alan Greenspan, *The Age of Turbulence: Adventures in a New World*. (New York: Penguin, 2007), 404.

the pay of math teachers and not art teachers. Arts education, for example, is less easily tied to developing the intangible qualities usable by businesses. And teachers with a strong content knowledge in philosophy or sociology, for example, might introduce to students ideas that oppose educating for human capital. I speculate that such examples of teachers that cannot or do not educate for human capital will not enjoy similar increases in salary while math teachers of a particular type will continue to see increased salaries.

In this section I have described examples of how the content knowledge deficits theme advances policy directives for increasing the efficiency of educating for human capital. Each of the examples comes from organizations that hold or represent the human capital interest. Generally, these examples remove from or prevent the existence of classroom teachers who oppose educating for human capital or who are not very good at it. They also place greater value on math education than education in other content areas.

I began this chapter indicating the extent to which the network's academics, mostly mathematicians and math education researchers, agree that US math teachers do not know math. I next presented that in their efforts to demonstrate this, these actors actually pointed to this notion's mythological quality. I continued the chapter by discussing the ways that perpetuating this myth helps to achieve an efficient education for human capital. Each of these examples came from network actors who hold or represent the human capital interest and also express the math teacher deficits myth. First, I described the programs that provide a specific math education to practicing and future teachers. Second, I highlighted how the recruitment of mathematical talent ironically suggests that mathematics content cannot be learned, but at least indicates the prioritizing of math education. Third, I noted the emergence of “math specialists” in the primary grades. Lastly and similar to the specialists, I offered examples of other ways that the content knowledge deficits myth aids in educational efficiency. These included differentiating teacher pay to align with the values education for human capital affords each educational domain (e.g. arts vs. math). As well, the network's programs and policy advocacy seek to prevent teaching that is oppositional to educating for human capital.

Chapter 6: Achieving Efficiency? Educational Business and National Math Education

In the previous chapter, I outlined how several network actors increase the efficiency of educating for human capital by using the myth that math teachers do not know mathematics. Here, I continue exploring this quest for greater efficiency as expressed by an auxiliary interest in the network: educational business. If, generally speaking, educating for human capital supports the needs of business, then it makes sense that education be run on the business model. This growing trend is evidenced by the presence of several network actors who hold an interest in providing educational services, rather than holding the human capital interest themselves. These companies do, of course, employ people and hold the human capital interest to a certain extent, but their interest is for national math education to provide opportunities for them to make profit. Primarily, testing companies dominate from among the educational services in my representative social network surrounding national math education. In this sense, I identified educational assessment services as an auxiliary private interest that accompanies the human capital interest in the context surrounding national math education. As I will demonstrate, the variety of other educational businesses in the network relate to the testing industry, such as instructional resources or teacher professional development to increase student achievement on tests.

I begin by connecting educational business with the growing trend of outsourcing government services to private companies. This discussion leads to my identification of perhaps the best example of the educational assessment businesses' current power: testing megacontracts in which one company provides the assessment services for all the students in not one the majority of states. I also indicate the possibility of the awarding of megacontracts for teacher accountability services, an industry related to assessment. This service uses student testing to evaluate teacher and school performance. At the time of this writing, we have yet to see this type of megacontract. These examples indicate the scope of the educational assessment industry and also its connections to the other themes in the network, such as teacher quality, a matter related to the content knowledge deficits I discussed in the last chapter.

The remainder of the chapter indicates the extent to which the network surrounding national math education supports the testing industry. I introduce the variety of network organizations that hold or represent the educational business interest. For the most part, these include companies that provide testing services, e.g. Educational Testing Services (ETS), to determine the effectiveness of education and programs that deliver math content to students or teachers, such as Pearson's "digital instructional resources" that teach for better performance on standardized tests. Some network organizations do not themselves provide educational services, but instead represent those that do. For example, Achieve, Inc. is a research and policy institute that began the American Diploma Project, an educational assessment service that is now provided by Pearson. Following this I present the network's individuals that support the educational business industry, primarily by having worked for the assessment services sector. These individuals cover a broad range of academics, from mathematicians, math education researchers, psychologists, and institute and education services employees, most of whom worked for either Pearson, College Board, ETS or ACT. My findings indicate the extent to which the network agrees that testing services are an appropriate means for determining educational effectiveness. Thereby, the network affirms educational business' place in government education.

After examining the network support of educational businesses and its specific domain, testing, I offer in more detail the writings or activities of these educational service companies and network actors that align with them. Examining these actions reveals a host of considerations regarding educational business' presence in the network. First, I argue that the educational business presence asserts the push for experimental study of educational programs which further supports the interest to educate for human capital. Second, I remind the reader how testing companies offer their services in the spirit of educating for human capital. Third, in revisiting the contributions that progressive and traditional math education make to educating for human capital, I conclude that the assessment industry presence mitigates efforts in the progressive vein yet enhances those in the traditional. This presents two interesting possibilities: that educational business and the human capital interest conflict one another, or that the progressivist math education is not as important to the human capital interest as they make it seem. Both options introduce such conflict in national math education, and will lead into my final chapter where I argue that the dominance and undermining of particular interests in the network ultimately fail to increase the knowledge and use of mathematics by people living in the United States.

"US Government, Inc." and Educational Business

The presence of educational business in my network indicates a broader trend in government today. In the US and elsewhere, there exists a growing trend that shifts the work formerly done by governments to the hands of private companies. Writing curriculum and assessments, training teachers, and writing and executing lesson plans were all the work of government education and done by relevant politicians and state employees subject to oversight from elected officials. Now, private companies execute these and other aspects of educational work. In this section I provide some context for this phenomenon. In further introducing this chapter's focus, I use this context to discuss two examples of math educational business that are contained within my representative network surrounding national math education.

Anthropologist Janine Wedel, whose work influenced my dissertation's mode of inquiry,[319] provides substantial commentary on the outsourcing trend in government today. Her phrase "US Government, Inc." refers to the fact that "Government agencies are now faced with justifying *not* contracting out a government program, project, or function, rather than the other way around."[320] For example, Wedel recounts the government's Competitive Sourcing Initiative which "mandates competition with the private sector and encourages the outsourcing of government work."[321]

The drive behind the push for outsourcing is a belief that competition in the private sector results in greater efficiency. The Competitive Sourcing Initiative was

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[319] See chapter 2.

[320] Janine Wedel, *Shadow Elite: How the World's New Power Brokers Undermine Democracy, Government, and the Free Market* (New York: Basic Books, 2009), 73.

[321] Ibid., 73.

argued to “generate savings and improve performance.”[322] Although this initiative is credited to President George W. Bush, it was President Bill Clinton and his administration who “paved the road for the actions of his successor.... George H. W. Bush, Bill Clinton, and George W. Bush, said it succinctly: 'Clinton laid the framework and set the speed limit at 500 miles per hour but never drove the car past 250. Bush tested the limit.'”[323]

Ironically, the policies that allowed for greater outsourcing of government work to contractors did not satisfy the motivation of competition. Instead, they made the process “friendlier”[324] for contractors. The Federal Acquisition Streamlining Act (FASA) and the Federal Acquisition Reform Act (FARA)

> removed many of the traditional competition and oversight mechanisms that had been in place for decades and provided the statutory basis for new kinds of megacontracts, such as the 'Multiple Award' Indefinite Delivery/Indefinite Quantity (IDIQ) system, under which an estimated 40 percent of all federal government contracts are now awarded in areas ranging from computer support to analysis of intelligence ... Like the euphemisms of politicians obscuring their intentions, the language of these [contract] awards is telling: “contracts” that aren't really contracts; 'competitions' without real competition; 'task' orders that may sound like small potatoes but can net billions of dollars for the contractor.[325]

Wedel highlights the tension between the motivations and effects of these policies calling for greater outsourcing of government work. This hypocrisy requires a look at possible ulterior motives behind the push to outsource.

The motives are those of the companies that seek to gain contracts with the

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[322] Department of Health and Human Services, “President's Management Agenda,” accessed June 29, 2011, http://www.hhs.gov/pma/.

[323] Wedel, *Shadow Elite,* 93.

[324] Ibid., 93.

[325] Ibid., 93.

government. These contracts can be hugely rewarding, as evidenced by the "megacontracts" Wedel cites above. A company that provides government services via a stable contract with the government secures the demand of that company's services. As Wedel suggests, government outsourcing also "enhances executive power"[326] and "privatizes policy."[327] Eradicating checks and balances enables such contractors to change the government work to ensure they can continue providing it, or possibly to increase the government need of more work from the company. Later in this chapter, I present an example of a megacontract in math education.

The often used phrase "educational entrepreneurs" describes a type of venture capitalist unique to education. They especially thrive on contracting the work of government schools out to companies. Here I offer an example from my network when "educational entrepreneurs" wrote educational policy to serve the interests of their educational business. Two entrepreneurial partners, David Coleman and network mathematician Jason Zimba, are the founders of two educational businesses in my network, The Grow Network (acquired by McGraw-Hill) and Student Achievement Partners. The former is an assessment services company and the latter played a silent role in writing the new national math standards, the *Common Core State Standards.*[328] In 2009, Coleman gave a talk at the Alliance for Excellent Education[329] where he described

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326 Ibid., 106-107.

327 Ibid., 108-109.

328 David Coleman's "quiet work behind the scenes on the proposed Common Core standards make him among the most influential figures in American education today." From Andrew J. Rotherham, "School of Thought: 11 Education Activists for 2011," *Time,* January 6, 2011.

329 Alliance for Excellent Education, "Meaningful Measurement: The Role of Assessments in Improving High School Education in the Twenty-First Century," accessed July 1, 2011, http://www.all4ed.org/node/2531.

the mission of the Grow Network: “assessment should be the opportunity for meaningful instruction.” The company seeks to provide more detailed interpretations of results on educational assessments. Written for parents, students and teachers, these materials imply what is necessary for further student instruction. Formerly, deciding on appropriate student instruction was the work of teachers or other school district employees, such as curriculum writers.

In this talk Coleman reflects on the difficulty he endured in providing these services, mostly due to the variety of different states' educational standards, which he generally describes as vague. This frustration led him to his current work at Student Achievement Partners, which helped in creating one set of standards which has now been adopted by over 40 states. At the 2010 CEO Roundtable of the Association of Education Publishers, Coleman “discussed how the Standards could change the instructional materials needed in the classroom and how a more unified market could affect [educational publishing companies'] sales and product development strategies.”[330]

Creating one set of national standards allows educational assessment businesses to increase their profit margins. Coleman complained that in the No Child Left Behind (NCLB) years, his company expended too much effort in tailoring their services to each particular state. With national standards, the number of clients increases and at the same time, the amount of labor necessary to provide these services decreases. National math education is interesting to educational businesses and educational entrepreneurs, like Coleman, because it enhances the profitability of educational services.

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[330] The Association of Educational Publishers, “Invisible Competitors: Threats and Opportunities,” accessed June 29, 2011, http://www.aepweb.org/ceo/schedule.htm.

I now turn to Pearson, the second example of a network organization that presents significant interest in a national math education for its business potential. Pearson is connected to the network directly because network math education researcher Phil Daro is working on the company's new product aimed to help teach the *Common Core State Standards* in math.[331] From the Pearson Foundation website, the product:

> will be made available in 2013, before the Common Core Standards are implemented. Funding from the Bill & Melinda Gates Foundation will support four courses to be offered as free, open educational resources, with the intent of widening access and spurring innovation around the Common Core. Pearson, the nation's leading education technology company, will offer these courses to school districts, complete with new services for in-person professional development for teacher transition to the Common Core and next-generation assessment. The Pearson Foundation will also work with other partners to explore opportunities for additional commercial development and distribution.[332]

In this case, Pearson is providing instructional content that replaces the content formerly planned by teachers. Similar to the educational assessment business of Coleman and Zimba, Pearson is using the Common Core to increase the number of clients who will purchase these instructional materials.

Another noteworthy consideration regarding Pearson's new instructional content is the fact that this content will be delivered in digital form. The reason for this format choice comes from the funding by the Gates Foundation. This is another example of the ways that the human capital interest reshapes public education so that it efficiently educates for human capital, as I presented in chapter 5. Using a digital format for instructional content will ready students for work in technological fields. In addition, as

[331] Pearson, "Pearson Foundation partners with the Bill & Melinda Gates Foundation to create digital learning programs," April 27, 2011, http://www.pearson.com/media-1/announcements/?i=1429.

[332] Ibid.

educational researcher Joel Spring[333] argues, the Gates Foundation considers education for its potential in preparing a digital mind ready for a long life of consuming digital products. In the preceding chapters, I have suggested that the information and communications technology industry has an interest in national math education for the development of human capital. However, examining the educational businesses in this chapter more fully answers their underlying interests in national math education. The information and communications industry uses math education to ready the mind for work and consumption in the digital age.

My digression back to human capital, the primary private interest in national math education, serves to indicate how the human capital interest entangles the interest of educational businesses. This point signifies the necessity that, if education is for businesses needing human capital, then educational businesses are the best equipped system to run education. Their like minded interest in perpetuating the current economic system, in circumventing oversight from the public and in maximizing efficiency toward the goal all contribute to their successful partnership.

So far, I have indicated how the increase of educational business in government education represents the broader trend of outsourcing government work. The two introductory examples of educational business I included here indicate how interpretation of results on assessments and the delivery of instructional content are educational activities that in some cases is now provided by businesses, rather than by teachers. These examples also suggested the power that educational business has on developing

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[333] This is the thesis in Joel Spring, *Power, Wealth, Cyberspace and the Digital Mind*, (New York: Routledge, in press).

educational policy to suit its needs. In the next section I further this point by presenting how federal policy and think tanks played a role in awarding megacontracts to Pearson.

The Federal and Quasi-Government's Role in Testing Megacontracts

As I quoted in the previous section, Janine Wedel writes of the megacontracts that exist in the outsourcing of government work. Discussing the influence that research and policy institute Achieve, Inc. and the federal Race to the Top (RTTT) grant program had on securing testing megacontracts for Pearson further supports the following points from the previous section: national math education is interesting to educational business because it increases the efficiency in providing their service and educational business aids in the efficiency of educating for human capital primarily by outsourcing the work of teachers. Lastly, I will argue Pearson's megacontracts that revolutionize testing from paper and pencil to digital form again serves the interest of the information and communications technology industry.

In 2007, Pearson was awarded a megacontract to administer the American Diploma Project (ADP), an educational assessment, to students in several states. ADP began as a network of states conceived by Achieve. In chapter 3, I argued that Achieve epitomizes the blurring of the private/public boundary because Achieve's board divides into equal parts elected officials and corporate executives. Funding for Achieve comes from Intel, GE, Boeing, Microsoft, Hewlett Packard, JP Morgan Chase, Prudential, and Washington Mutual, among others. This funding represents the human capital interest specific to the information and communications technology and financial sectors.

Achieve began ADP as a network of states that would adopt new standardized tests for secondary mathematics. These are "end-of-course" exams for Algebra 1 and Algebra 2. Most states in the ADP network are replacing or adding to their other standardized assessments for secondary math with the ADP exams. One significance of the ADP program is its emphasis on Algebra, which I argued in chapter 4 to streamline educating for human capital. More to my current focus on educational business, in 2007 Pearson was awarded a four and a half year contract to develop, administer and score the assessment. At the awarding of the contract, the project marked "the largest effort ever undertaken by a group of states to develop a common assessment based on common standards."[334] Thus, I consider this an example of Wedel's "megacontracts" in the realm of educational business.

Pearson's handsome megacontract should continue to thrive with the new national math standards, *Common Core State Standards Initiative(CCSSI),* because Pearson's products align well with the new national standards for math. Achieve, who played a major role in the development of *CCSSI*, indicates this as below:

> When the CCSS are compared to the ADP Benchmarks in mathematics, there is excellent alignment. All but one of the ADP Benchmarks are matched by one or more of the CCSS. The high school CCSS as well as some CCSS at a grade level below high school align with the ADP Benchmarks, which is appropriate given the differences between the purposes of the two documents. The ADP Benchmarks were developed to describe end-of-high-school expectations for college and career readiness, while the CCSS specify K-8 grade-level expectations along with the 9-12 grade span leading to college and career readiness.[335]

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334 Pearson, "Pearson Educational Measurement Awarded American Diploma Project Assessment Contract," accessed June 30, 2011 http://www.pearsonassessments.com/pai/ai/about/news/NewsItem/2007/NewsRelease041007_ea.htm

335 Achieve, Inc., "A Comparison of the Common Core State Standards (CCSS) for Mathematics to the American Diploma Project (ADP) Benchmarks for Mathematics," accessed July 30, 2011,

The ADP network and awarding of the Pearson contract predated the development and adoption of *CCSSI.* Possibly, this indicates that the standards were written after the test was created and adopted by several states. This would suggest again educational business' power in shaping policy. Primarily, I highlight Achieve's role in ensuring Pearson's megacontract because Achieve facilitated the network of states participating in ADP.

Facilitating the coalitions of states to adopt the same standardized test is a trend that has continued, this time by the help of the federal government. Two such groups of states have formed because the Race to the Top (RTTT) program included funds for consortia of states to develop common assessments for the new national math standards, the *Common Core State Standards Initiative (CCSSI)*. The two groups of states are The Partnership for Assessment of Readiness for College and Career (PARCC) and Smarter Balanced Assessment Consortium (SBAC). Both groups of states are planning to adopt online "through course assessments." These types of student standardized testing are given multiple times throughout the year and take place at a computer.

In this case, RTTT is responsible for both the creation of SBAC and PARCC as well as their choice in the type of standardized testing. This comes from a look at the call for applications to the Race to the Top Assessment Program. First, the application specifies the creation of consortia of states as follows::

> Authorized under the American Recovery and Reinvestment Act of 2009 (ARRA), the Race to the Top Assessment Program provides funding to consortia of States to develop assessments that are valid, support and inform instruction, provide accurate information about what students know and can do, and measure student achievement against standards

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http://www.achieve.org/files/AchieveCCSSMathematicscomparisonwithADPBenchmarks061610.pdf

> designed to ensure that all students gain the knowledge and skills needed to succeed in college and the workplace. These assessments are intended to play a critical role in educational systems; provide administrators, educators, parents, and students with the data and information needed to continuously improve teaching and learning; and help meet the President's goal of restoring, by 2020, the nation's position as the world leader in college graduates.[336]

Therefore, the RTTT assessment program used grant moneys as a way for states to adopt the same standardized testing programs. This will lead to a megacontract for some educational business providing the testing service, most likely to Pearson as I will indicate later.

Second, RTTT imposed on these new consortia of states the use of through course assessments, defined as "an assessment system component or set of assessment system components that is administered periodically during the academic year. A student's results from through-course summative assessments must be combined to produce the student's total summative assessment score for that academic year."[337] As for PARCC, the 24-state consortium plans to adopt a math standardized test in which students in grades 3 to 11 will be tested 4 times throughout the year to measure their progress.[338] SBAC's 29 states assert the need to test students three times a year. They also argue for "computer adaptive assessment," or online assessments that tailor questions to the participants' prior performance, much like the computer form of the Graduate Record Exam (GRE).

Both PARCC and SBAC are separate networks of states that have agreed to use

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336 Federal Register, The Daily Journal of the United States Government, "Overview Information; Race to the Top Fund Assessment Program; Notice Inviting Applications for New Awards for Fiscal Year (FY) 2010," accessed July 1, 2011, http://www.federalregister.gov/articles/2010/04/09/2010-8176/overview-information-race-to-the-top-fund-assessment-program-notice-inviting-applications-for-new

337 Ibid.

338 Partnership for the Assessment of College and Career Readiness, accessed June 30, 2011, http://www.parcconline.org/.

the same standardized tests for the *Common Core State Standards (CCSS)* in math. However, focusing on their participation in the Federal Race to the Top (RTTT) grant program indicates that the federal government played a large role in the development of both PARCC and SBAC. Each received grants close to $200 million from the Federal Race to the Top (RTTT) program for research and development on assessments linked with the *CCSS*. This is in addition to the fact that RTTT used the competition for grant moneys as a means for states to adopt the *CCSS,* as I mentioned in the introductory chapter. Both are examples of how the federal government uses grant money to change public schools in the national interest, a theme from my historical sketch of national math education, also in the introductory chapter.

I do not suggest that the federal government has an interest in mandating most states to have one of two tests and that both of these tests are through course assessments. Instead, the federal government is acting out the private interests that are increasingly affecting policy and government work. These private interests are first the goal to educate for human capital, the subject of chapter 3, and second the interests of the educational businesses that can execute this goal. National testing in math will ensure that all math teachers and students are efficiently working towards the human capital goals. Educational business, in this case Pearson, enjoys the megacontracts that such government policy affords.

The educational business interest presents itself in the work of SBAC and PARCC. Both PARCC and SBAC have Technical Advisory Committees with representation from Educational Testing Service (ETS). SBAC's committee includes network educational business executive Brian Gong who worked at ETS for several years and now directs the company National Center for the Improvement of Educational Assessment. Further delving into these two consortia of states, both are managed by third parties: SBAC by WestEd and PARCC by Achieve, Inc. Achieve, as I described earlier, represents the human capital interest strongly by its funding sources. WestEd, a research and development center for education, does as well, with funding from Gates, Hewlett and JP Morgan Chase, and several educational businesses, including Pearson Educational Measurement.[339]

Therefore, the federal government played a significant role in several states' participation in PARCC and SBAC. Eventually, each network will award a megacontract, just like the American Diploma Project's (ADP) award to Pearson, to provide the through course standardized tests for all the public school students (grades 3-11) in the respective states of each network. This megacontract multiplies the services provided in the previous ADP megacontract to Pearson because it includes tests for 9 grades taken 3 or 4 times a year, instead of tests for 2 grade levels taken one time a year. Similarly, through course testing outsources more teacher work than before. The teacher work of writing tests, interpreting results and designing instruction will now be outsourced to companies like Pearson. Now, through course assessments will decide how the teacher should teach next. In the interest of human capital, this increases the efficiency of educating for human capital because teachers are now required to focus only on what these assessments cover. In the interest of educational business, Pearson now provides a much greater service than

339 WestEd, "Funding Sources," accessed June 30, 2011, http://www.wested.org/cs/we/print/docs/we/fund.htm.

simply one test per year.

Although the contract for these testing services has not yet been officially awarded at the time of this writing, it seems that the research and development for both PARCC and SBAC involves Educational Testing Services (ETS) and Pearson. However, I predict the contract will be awarded to Pearson for a host of reasons. For one, the ADP network awarded Pearson the previous megacontract and ETS provides a slightly different service (see next section). Next, I elaborate on other reasons for Pearson's interest in SBAC and PARCC below, including Pearson's shift towards online testing and their identification of the challenges for the SBAC and PARCC services.

Pearson is transitioning from paper and pencil to online tests as is the case, for example, with the American Diploma Project (ADP) which is administered online and in paper and pencil format. On their website, Pearson suggests the formidable presence of online testing in the future, as well as the benefits of this testing format:

> Most students will be taking assessments online, and be given multiple opportunities throughout the year to demonstrate progress. Innovative approaches to item development and scoring, such as the expanded use of performance tasks, computer adaptive testing and automated scoring, will more effectively measure what students know and can do. These next generation assessments will move beyond snapshots of student achievement. The new assessments will capture complex performance and track student growth over time. The new assessments will leverage new digital technologies to provide richer, timelier feedback to teachers, students, parents, and policymakers. Ultimately, these new assessments will be integrated into a next generation teaching and learning system.[340]

The image accompanying this quote is of a child holding an apple with a USB cable for its stem. Coupled with their digital online instruction materials I covered earlier in the

[340] Pearson, "Next Generation Assessments," accessed July 20, 2011, http://www.pearsonassessments.com/pai/ai/Products/NextGeneration/NextGenerationHome.htm

chapter, Pearson truly imagines a comprehensive digital education system. Students will be taught and tested by a computer running Pearson software.

Pearson is actively involved in the research and development of SBAC and PARCC. For example, a webinar on Pearson's website[341] provides further clarification on “through course assessments (TCAs).” They provide provides insight in the challenges facing these types of assessments. For one, they recognize the imposition they might be placing on teachers, school districts or states to follow a prescribed sequence of teaching within each year. However, the *CCSS* clearly specifies that it does not suggest anything more than grade by grade standards and thereby allows for freedom in the delivery of content. To resolve the conflict of through course assessments and the political negotiation of adopting the standards, Pearson suggests that each years' standards should be grouped into four “modules”[342] of content, from among which states or school districts can choose the order. Such a limited freedom suggests that, despite the intention of *CCSS*, states, school districts and teachers will be far from free to choose their delivery of content.

Another challenge Pearson considers important is the technological infrastructure required by states to deliver online testing. They provide a “Five Step Roadmap” for PARCC and SBAC states to prepare for online assessments, beginning with a survey of the technological infrastructure at each school or school district. For example: “A common challenge for schools is verifying their connectivity to the Internet, level of

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341 Katie McClarty and Sherri Miller, “Through Course Common Core Assessments: A Modular Design for Mathematics,” May 4, 2011, http://www.pearsonassessments.com/pai/ai/Products/NextGeneration/NextGenWebinar.htm

342 Ibid., 5.

technical assistance, or firewall protection. As such, a survey is also a good way to establish local protocols, procedures, and investments. "[343] Here, Pearson is suggesting that states pay for these systems to be in place. Likely, Pearson will be awarded the contract to provide the services that require them. Therefore, states will invest in the infrastructure needed to allow for teacher work to be outsourced to Pearson.

I have heard before of companies like Walmart strong-arming county and municipal governments to create the infrastructure (roads, intersections) needed for a successful store location. The infrastructure is paid for by public tax dollars. Pearson is arguing similarly and on a much grander scale. The federal government has imposed on states the need to choose one of two megacontracted testing services, and now each state and school district must make sure the infrastructure is in place to carry out the mandate for online testing. In this case, the technological infrastructure represents another interest lurking amongst national math education: the information and communications technology industry. This begins to explain why Gates, Hewlett, Apple, Dell and the like are such significant funders of national math education.

In this section I have presented how the networking of states by research and policy institutes and the federal Government results in testing megacontracts for Pearson. Pearson's role in developing online through course assessments, coupled with their digital instructional resources I covered earlier, indicates that national math education may be delivered online. This outsources the work of teachers in lesson planning and deciding on

[343] Pearson, "Considerations for Next-Generation Assessments: A Roadmap to 2014," accessed June 30, 2011, http://www.pearsonassessments.com/hai/images/nextgen/Downloads/NextGen_Roadmap_FINAL_web.pdf, 14.

content, and reduces their role to executing the exact instruction spelled out by these formats. In this way, national math education is megastandardized. Determining the effectiveness of teachers in carrying out this exact instruction will be the work of another educational business sector, euphemized as performance management, the subject of the next section.

Performance Management: A Megacontract for ETS?

In the previous section on Pearson's Testing Megacontracts, I mentioned that Educational Testing Service (ETS) also presents research on the Smarter Balanced Assessment Consortium (SBAC) and Partnership for Assessment of Readiness for College and Career (PARCC). However, ETS's attention is in a direction different from Pearson's emphasis on the actual student tests. Here I present some of their research indicating how Pearson's online tests can be used to measure student learning and thereby teacher and school effectiveness in educating for human capital. I also highlight that ETS currently provides the service to test teacher content knowledge. Given their research and current activities, I claim that the ETS interest in national math education is to provide the service for such performance ratings of teachers.

ETS runs the “Center for K-12 Assessment and Performance Management,” which has hosted webinars for both PARCC and SBAC's assessment strategies.[344] At the time of this writing, ETS does not hold contracts for testing services related to the new standards. However, I suggest that the activities of these centers indicates their interest,

[344] The webinars can be found at the center's website: http://www.k12center.org/events.html.

and likely future role, in providing related services. Their phrase “Performance Management” indicates ETS' educational business interest: megacontracts that provide the service of using Pearson's student tests to evaluate teachers. They also have prepared several papers related to PARCC and SBAC's through course assessments that generally focus on how such assessments can measure student growth. In one such paper, ETS argues against “status measures” as follows:

> Most current state assessments are designed to answer the basic question of whether students are performing at expected levels. Status measures are needed to answer key policy questions such as whether our overall investment in education is sufficient or whether programs and instruction in particular schools are good enough. Note, however, that status measures do not provide direct information on the source of student learning. Students may have already mastered most or all of the required skills in prior years or significant learning may be taking place outside of the classroom. Thus, status measures are not ideal for comparing the effectiveness schools, programs, and even teachers that serve different populations of students. [345]

Instead, ETS argues that growth models, which track the progress of students on their through course tests, can effectively identify the source of student learning. The emphasis among this paper and others at ETS' “Invitational Symposium on Through Course Assessments” is on using these systems to measure teacher and school effectiveness. I argue this symposium and its contents suggest that ETS is interested in providing the service that uses Pearson's assessments to measure teacher effectiveness.

My claim is further supported by ETS' current service that focuses on teachers. For many years, ETS has provided the Praxis tests for beginning teachers. These are “a

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[345] Lauress L. Wise, HumRRO, “Picking up the Pieces: Aggregating Results from Through Course Assessments” Invitational Symposium on Through Course Assessments, Educational Testing Service, accessed July 15, 2011, http://www.k12center.org/rsc/pdf/TCSA_Symposium_Final_Paper_Wise.pdf, 8. (HumRRO consults for ETS on Education and Accountability.)

set of rigorous and carefully validated assessments that provide accurate, reliable information for use by state education agencies in making teacher-licensing decisions."[346] For example, in order to be licensed to teach math in the state of New Jersey, a teacher must receive a score of 137 on the "Praxis Mathematics: Content Knowledge" test. Therefore, ETS has a history in providing services that help government's decide whether teachers have the content knowledge for effective teaching. Notably, this connects with the content knowledge deficits theme of chapter 5.

This history suggests the possibility that among others, one of ETS' niche markets in educational testing focuses on teachers. To this point, ETS has begun their new service called *Praxis III*, which utilizes "direct observation to measure the instructional skills of first-year teachers."[347] Again, this example indicates the possibility for outsourcing the government work of supervising teachers to companies like ETS. Fundamentally I am suggesting that *Praxis III* supports the ETS interest in providing services that evaluate teachers. Together with ETS' center on "Performance Management," and its emphasis on how through course tests indicate student growth, ETS has a clear interest in providing services that use Pearson's tests to evaluate teachers.

An outsourced evaluation of teachers serves the educational business interest because it provides them contracts. I have yet to find an indication that the federal government will enable a megacontract with ETS, as it seems to be doing with Pearson's student testing. However, this type of megacontract is likely as was the case for the Praxis

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[346] Educational Testing Service, "Leaders in Developing Performance Assessments," accessed July 1, 2011, http://www.ets.org/about/who/leaders/.

[347] Ibid.

series, the result of the teacher knowledge deficits myth regarding national math education. I believe this megacontract is likely because of the emphasis on teacher quality existing in my network, as I discussed in chapter 5. In other words, the human capital interest concerns itself with teachers who are teaching only for that goal. Teachers cannot deviate from it or teach inefficiently.

Other Network Educational Businesses or Organizations Representing Their Interests

The previous sections have presented the most prominent educational businesses that are present in my network surrounding national math education. Some network actors are also educational businesses and many other network actors support their interest as well, either by representing the interest via funding or executive interlocks with educational business companies, or by aligning with the interest. This section provides examples of network actors, primarily organizations, who either hold or represent the interest of educational businesses. For further clarity, I remind the reader that I provided examples of organizations that either hold or represent the human capital interest in chapter 3. As before, considering these examples serves to indicate the strength educational business maintains in the context surrounding national math education.

I begin with the network organizations that are educational businesses themselves, other than the companies I have already discussed in this chapter, such as ETS and Pearson. These are ACT, College Board, Academic Benchmarks, and the National Center for the Improvement of Educational Assessment. As I will demonstrate, all of these companies provide assessment services, or services related to educational assessment and standards including using assessments for designing classroom instruction or measuring teacher quality.

ACT, Inc. is best known for its college entrance examination of the same name. The company also provides an assessment service, called WorkKeys, for measuring an individual's competence in job related skills.[348] “Applied mathematics” is one of three content areas for the test and requires “the examinee to set up and solve the types of problems and do the types of calculations that actually occur in the workplace.”[349]This service is offered to employers wanting to screen potential hires or for the training and development of current employees, but the company also promotes WorkKeys for use in schools as a measure for life readiness. States have outsourced their educational assessments to ACT. For example, the state of Illinois currently runs an assessment program for all high schools students, called the Prairie State Achievement Exam, that includes items from both ACT's college exam and ACT's WorkKeys exam.[350]

ACT also provides research related to educational assessment and policy in general. As I mentioned in chapter 3, Math Education and Human Capital, ACT prepared the research that is often cited as the evidence that public school students wishing to enter either the workforce or college directly after 12th grade have the same learning needs. Thus ACT can be given credit for the phrase “College and Career Readiness” that circulates throughout these conversations on national math education. I state again that the evidence for ACT's claim comes from their own juxtaposition of the WorkKeys and

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348 ACT, “WorkKeys,” accessed July 22, 2011, http://www.act.org/workkeys/.

349 ACT, “Applied Mathematics,” accessed July 22, 2011, http://www.act.org/workkeys/assess/math/index.html.

350 Chicago Public Schools, “Prairie State Achievement Exam,” accessed July 22, 2011, http://research.cps.k12.il.us/cps/accountweb/Assessment/PSAE/.

ACT exam. They concluded that the two exams test the same kinds of knowledge and skills with respect to mathematics. For example, in their research report they compare the WorkKey and ACT standards for "Data Representation and Statistical Thinking" as follows in Table 6-1[351]:

ACT Mathematics Test College Readiness Standards (20-23 Range):	WorkKeys Applied Mathematics Test Skills (Level 5):
-Calculate the missing data value, given the average and all data values but one. -Translate from one representation of data to another (e.g., a bar graph .to a circle graph). -Determine the probability of a simple event. Exhibit knowledge of simple counting techniques .	-Average hours and minutes or other mixed units in one system . -Solve problems that include a considerable amount of extraneous information. -Calculate using several steps of logic sometimes involving graphs, charts, or tables.

Table 6-1

The connections ACT makes between the two tests are not very strong arguments. The first connection, about averaging, indicates this. Calculating a missing value involves the knowledge of averaging but requires the examinee to work backwards, or uncalculate an average. On the other hand, the WorkKeys "equivalent" of averaging is merely applying the skill of averaging in one particular context: time. The two test different things and require different levels of cognition and application. Similar errors in these comparisons can be highlighted throughout the ACT research document. Therefore, I argue that this research, and most of ACT's, acts in the interest of their assessment

351 ACT, Inc., "Ready for College and Ready for Work: Same or Different?" 2006, http://www.act.org/research/policymakers/reports/workready.html, 6.

services. As I have mentioned in this chapter, having national standards increases the efficiency of educational business. ACT presents research that provides the "evidence" for one set of standards and instruction for all students.

Another large educational assessment business in the network is the College Board. The College Board provides two famous educational assessment services: the SAT program, for college entrance, and the Advanced Placement Program, for high school students to receive college credit by taking a test. In reality, this organization is intertwined with Educational Testing Services (ETS) because ETS develops and administers these programs on behalf of the College Board. The College Board is ETS' largest client.[352] Although they are legally distinct entities, it makes sense to view College Board as connected to, and part of, ETS, because College Board does not provide any services. Instead, College Board provides work for ETS.

Moving to the smaller educational businesses in my network that also provide assessment and assessment related services, Academic Benchmarks is an educational business that provides educational standards services. Their clients are both publishers of textbooks, such as McGraw-Hill, and educational testing companies, such as ETS and the College Board.[353] Primarily, the company provides a database of various educational standards but also helps other educational businesses to align their content with educational standards.[354] Although many state educational standards are merging to

352 Educational Testing Service, "Frequently Asked Questions," accessed July 22, 2011, http://www.ets.org/about/faq/.

353 Academic Benchmarks, "Clients," accessed July 21, 2011, http://www.academicbenchmarks.com/clients.

354 Academic Benchmarks, "Standards Data," accessed July 21, 2011, http://www.academicbenchmarks.com/standards-data and Academic Benchmarks, "Alignment Services," accessed July 21, 2011, http://www.academicbenchmarks.com/alignment-services.

become national standards, Academic Benchmarks' services prove relevant so long as educational standards remain a driving force behind educational practice.

Another educational business in the network provides similar consulting services. Contrary to the sound of its name, the National Center for the Improvement of Educational Assessment (NCIEA) is a private company, not a government or quasi-government agency, that consults primarily for states in the development of their assessment and accountability practices. Recently NCIEA has directed its efforts towards services that plan for math instruction that lines up with *Common Core State Standards.* They collaborated with other centers on the development of "learning progressions frameworks" that break down the content in the *Standards* to series of 4-6 detailed lessons.[355] Therefore, NCIEA's work also outsources the teacher work of lesson planning, and in so doing compromises teacher autonomy.

The third and last educational business in the network that is related to the assessment industry is McGraw-Hill's Grow Network. This company provides individually tailored materials for each student that are composed as a result of their performance on standardized tests.[356] The production of these materials uses computer programs to identify a student's weak testing areas, and to then print out the lessons that this student and her parents or teachers can use.

A handful of educational businesses in the network do not connect as clearly to the testing theme. Primarily, these businesses provide instructional materials or

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355 Karin K. Hess and Jacqui Kearns, "An Introduction to the Learning Progressions Frameworks Designed for Use with The Common Core State Standards in Mathematics K-12," National Center for the Improvement of Educational Assessment, accessed July 22, 2011, http://www.nciea.org/cgi-bin/pubspage.cgi?sortby=pub_date retrieved July 22, 2011

356 Grow Network, "Products," accessed July 22, 2011, http://www.grownetwork.com/products/index.html.

professional development for teachers. Network goods and services organization Holt-Rinehart publishes textbooks that align with the *Common Core State Standards* in math.[357] Another network publisher, Sadlier-Oxford publishes traditional type math textbooks.[358] Some network businesses provide professional development for teachers, such as America's Choice, the for-profit company that was created by the research and policy institute National Center On Education and the Economy (NCEE). In the chapter "The Content Knowledge Deficits of Math Teachers" I discussed how this service focuses professional development for teachers within the interest of human capital. In this context, I highlight how America's Choice relies on the educational assessment industry. Besides providing professional development, the company also provides instructional resources for superintendents and curriculum specialists of school districts. These resources align with the *Common Core State Standards* in math, thus America's Choice provides an assessment related service.

Primarily, the educational businesses in my network offer services related to the new national math standards, the *Common Core State Standards*. These businesses therefore thrive off of the existence of these standards. Also, these services can support the success of the standards. I remind the reader that the *Standards* came to be policy by the cooperation of the federal government and research and policy institutes, especially Achieve, Inc., the National Governors Association Center for Best Practices and the Council of Chiefs of School State Officers. This policy process did not come from the

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357 Holt McDougal, "Mathematics Middle School," accessed July 22, 2011, http://holtmcdougal.hmhco.com/hm/series.htm?level2Code=MSIB10010&level3Code=3_MM.

358 These textbooks are a favorite of Honest Open Logical Debate (HOLD), the traditionalist math education organization I discussed in chapter 4, Math Wars and Human Capital.

ground up and such imposition may cause teachers and other school employees to rise against this, especially since they are required to do their work differently than before. However, the educational businesses provide services to develop teachers or offset their workload with instructional materials and tests. By providing such services, these businesses give the appearance to school employees that the imposition of the *Standards* is less problematic.

In other words, the educational assessment industry can be considered a complex of various services that support each other in the efforts to gain more government contracts. Further evidence of this complex comes from two network organizations that represent the assessment industry interest instead of holding the interest themselves. These are the quasi-governmental organization National Center for Research on Evaluation, Standards and Student Testing (CRESST) and the professional organization the National Council on Measurement in Education (NCME). CRESST is an agency dependent upon federal funding and NCME is one professional organization for psychometricians. The activities of both include research and development in the area of psychometrics, or assessments that measure intelligence or learning. Therefore, these two organizations indicate the government and academic involvement in furthering the educational assessment industry.

I have provided examples of the educational businesses in the network and network organizations that represent education businesses. For the most part, these examples indicate that the primary educational industry centers on standards and assessment. Also, in many cases these businesses provide instructional resources that are designed for students to succeed on the tests that the businesses provide. Additionally, I began to introduce the notion of an educational industry complex, where governmental agencies and academics support the industry. Further evidence of this complex comes from the significant number of network academics who are connected to the industry, which I will present in the next section.

Network Individuals Aligning with Educational Business

Thus far in this chapter I have indicated that the dominant educational business present in national math education is the testing industry. In addition, network individuals support this industry, mostly because they worked on committees for ETS, Pearson, College Board or ACT. Many of these individuals are employees from among the network's educational businesses. Beyond such trivial examples, however, the set of individuals I include here also contains six network mathematicians, six network math education researchers, and, perhaps less surprisingly, nine psychologists. The sociogram below reproduces the individuals in my representative social network surrounding national math education, with network individuals that are gray as those aligning with the testing industry.

sociogram

The educational business employees include Phil Daro, working with Pearson, and Jason Zimba who co-founded the aforementioned Grow Network and Student Achievement Partners, the company that played a silent role in writing the *Common Core State Standards Initiative (CCSSI)* in math. The ACT employees are Sarah Clough, Sheri

Miller and Ken Mullen. The College Board employees are Marci Ladd, Robin O'Callaghan, Andrew Schwartz and Natasha Vasavada. Brian Gong was formerly a researcher at Educational Testing Service (ETS) and now directs the company National Center for the Improvement of Educational Assessment that I covered in the previous section.

As for those individuals who are not primarily educational business employees, several network mathematicians and math education researchers worked for Pearson/Achieve's American Diploma Project (ADP) or the Educational Testing Service (ETS). Network mathematicians Roxy Peck, David Bressoud, Uri Treisman, John Dossey, and Fabio Milner contracted for College Board, as did network math education researchers Jeremy Kilpatrick and Joan Ferrini-Mundy. Working on the ADP were mathematicians David Bressoud, Uri Treisman, William McCallum, and Henry Kepner, in addition to math education researchers William Schmidt and Francis (Skip) Fennell. As for ETS, math education researchers Jeremy Kilpatrick contracted with them and Deborah Ball gave an invited presentation on teacher content knowledge deficits.

Some of the nine psychologists who align with the educational business emphasis on testing do so because they too have contracted for these companies. Network psychologist Robert Linn was on the ADP committee, thereby working for Pearson/Achieve. Network psychologists Susan Embretson and Suzanne Lane worked for ETS and Suzanne Lane also presents much research on psychometrics, the science behind the testing industry. The remaining psychologists in the network align with the testing industry because they similarly research psychometrics or they incorporate such theory in their work. For example, some of Lane's research in psychometrics attempts to provide for valid measurements of the learning associated with progressive math education. The remaining psychologists use psychometrics in determining intelligence in mathematics, such as the methods in identifying children who are mathematically precocious[359] and disabled.[360]

My intention in this section has been to show the amount of network individuals who support the educational assessment industry. By working for these companies or enhancing psychometric research, these mathematicians, math education researchers and psychologists at the least find no objections to the use of testing services and at most find them a necessity in determining educational effectiveness. Further evidence of psychometrics' value comes from the network's reliance on international testing to motivates the entire project to reform US math education (see chapter 3). In all cases, national math education provides a happy home for the educational assessment business.

Educational Business and Experimental Testing

The educational business, specifically the testing industry, is aided in the network surrounding math education in another way. This is due to the support for experimental research in education offered by governmental agencies, organizations and various

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359 Network psychologist Camilla Benbow identifies such students with psychometrics similar to the College Board's SAT. See her collaborative "Study of Mathematically Precocious Youth" at http://www.vanderbilt.edu/Peabody/SMPY/ for more information.

360 Network psychologist David Geary identifies such students as those falling below certain cutoffs scores on achievement tests. See Geary, Mary K. Hoard, Jennifer Byrd-Craven, Lara Nugent, and Chattavee Numtee, "Cognitive Mechanism Underlying Achievement Deficits in Children with Mathematical Learning Disability," *Child Development* 78, No. 4 (July/August 2007), 1343-1359.

academics. Experimental research involves the controlled study of comparing two types of educational processes that are randomly assigned to students. The data and analysis for comparison rests on the differences in standardized test scores between the two groups of students. Therefore, using such research will promote the educational processes that leads to success on tests, thereby validating the testing industry's business. In this section, I review the relevant network actors who validate experimental research as an effective method to determine educational effectiveness. I primarily focus on the largest contributor, the federal government and US Department of Education. This begins to reveal that experimental testing promotes the use of traditional math education programs, especially those delivered online.

In 2001, the No Child Left Behind Act (NCLB) required states to use standardized tests to measure student learning. As I mentioned earlier, this policy paved the way for several testing companies to provide these services, such as ACT's contract to provide the Illinois' Prairie State Achievement Exam. Also contained in the NCLB policy is a consistent push for educational research to be "scientifically based," meaning either controlled experimental or quasi-experimental studies. Experimental studies are in which an educational material (e.g. textbook) or method is randomly assigned to half of the students being studied, and the remaining students do not receive the new material or method. If it proves difficult to randomly assign students in this manner, then a quasi-experimental research design involves selecting some groups of students (e.g. classes) to receive the material or method and other like groups of students to not receive the method. In both cases, all students must perform on the same learning outcomes, and the results of students receiving the new material or method are compared to those that did not. Typically, the preferred measurement of learning involves psychometrics and the analysis involves determining the expected difference in score between a student receiving the new material or method to one not receiving it.[361]

The push for experimental research in education is seen across federal agencies. Another example comes from network psychologist Dan Berch, who led a government task force that assessed the type and quality of federally funded research in Science, Technology, Engineering and Math (STEM) education.[362] The group worked on the project within the National Science and Technology Council's Subcommittee on Education and the Workforce. Therefore, this document indicates a commitment to the human capital interest. As for its commitment to experimental research, the document describes the variety of federally funded research in STEM education, with specific attention to projects funded by the National Science Foundation (NSF), the National Institutes of Health (NIH) and the US Department of Education (DOE). In combing through the funded projects, the task force identified the focus of each project and its research methods. To the latter point, their report indicates that "During the past several years, issues concerning the appropriateness of research designs and methods have become especially prominent in the educational research community as well as in educational policy circles."[363] The document is referencing the new commitment to

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361 Joshua D. Angrist, "Randomized Trials and Quasi-Experiments in Education Research," *NBER Reporter* (Summer 2003), http://www.nber.org/reporter/summer03/angrist.html.

362 The National Science and Technology Council Committee on Science, Subcommittee on Education and Workforce, "Review and Appraisal of the Federal Investment in STEM Education Research," October 6, 2006, http://www.whitehouse.gov/files/documents/ostp/NSTC %20Reports/STEMEducationResearchOctober06.pdf

363 Ibid., 3.

experimental research as indicated elsewhere, such as the No Child Left Behind policy. This emphasis is made clearer when the task force's report recommends the government

> Establish innovative pre-doctoral and post-doctoral training programs in STEM education and evaluation research... The goal of this program is to increase the supply of scientists and researchers in education who are well-trained to conduct a new generation of rigorous evaluation studies, develop new products and approaches to education which are grounded in the science of learning, design valid assessments and measures, and explore data with sophisticated statistical techniques.[364]

In other words, the federal government should enact policy to develop the kinds of researchers that will perform experimental studies in education research.

I am highlighting this work of network psychologist Dan Berch primarily because it provides an example of another federal context in which experimental research is promoted for math education. I argue that this type of research promotes the educational testing industry because such experimental research relies on quantitative measures of learning. In addition, another interesting connection is made with this example from the National Science and Technology Council because the context indicates a commitment to human capital. In other words, the human capital interest also supports the use of experimental research in math education. This may be because the human capital interest believes educational business to be the most efficient means to achieve the development of the intangible qualities usable by business.

Some examples of experimental research in math education may help illuminate this discussion. There are several publications from which to choose on the US Department of Education's (DOE) website, and I will highlight two examples from the

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[364] Ibid., 48.

DOE's Institute of Education Sciences' (IES) What Works Clearinghouse (WWC). WWC is an ongoing project that identifies experimental research in education and disseminates this with the government's seal of approval. Network psychologist Robert Linn served on the WWC's initial technical advisory group and the project is outsourced to the American Institutes for Research and the Campbell Collaboration.[365] Therefore, outsourcing of government work also occurs with its efforts regarding educational research. The two examples are chosen from among the WWC research on math education in particular because the WWC identifies them with "medium to large extent of effectiveness." In other words, these reports indicate strong evidence according to their standards of research, specifically of their use of experimental design to test curricular programs. Interestingly, these two examples consider traditional math education, in the case of Saxon math, and online education, in the case of I CAN Learn. As I will explain, the WWC indicates the DOE's commitment to traditional and online math education.

"Saxon Elementary School Math"[366] considers 19 studies on the textbook series and deems only one to meet the WWC's "evidence standards." The report paraphrases this study's methodology as follows:

> Resendez and Azin (2006) conducted a randomized controlled trial to investigate the effect of Saxon Math on math achievement in one northeastern Ohio middle school and one southwestern Ohio junior high school.7 The schools served sixth-, seventh-, and eighth-grade students living in urban and suburban locations; classes were randomly assigned to use Saxon Math or control curricula during the 2005–06 school year. The analysis sample included 14 Saxon Math

[365] US Department of Education, "What Works Clearinghouse Technical Advisory Group Holds First Meeting," November 18, 2002, http://findarticles.com/p/articles/mi_puca/is_200211/ai_2201251852/.

[366] US Department of Education, Institute of Education Sciences, "What Works Clearinghouse: Saxon Elementary School Math," April 2007, http://ies.ed.gov/ncee/wwc/pdf/WWC_Saxon_Math_043007.pdf.

> classrooms (approximately 260 students)
> and 11 control classrooms (more than 200 students). Classes in the intervention group used one of four Saxon Math curricula (Saxon 7/6, 2004-4th Ed.; Saxon 8/7, 2004-4th Ed.; Saxon Algebra 1⁄2, 2004-3rd Ed.; or Saxon Algebra 1, 2003-3rd Ed.); classes in the control group used either a traditional basal program or a mixed curriculum consisting primarily of teacher-created materials. [367]

This quote provides an example of the type of education research the Department of Education considers appropriate. It also provides a nice example of the methodology involved in an experimental research design. Using this research, the report indicates that Saxon has a "rating of mixed effect", with a "rating of effectiveness improvement index" of "average: +9 points, range: +6 to +16 points."[368] In other words, WWC indicates that, on average, a student using Saxon Math will improve their performance on standardized tests. I note that the entire range of expected change in student performance is positive, and yet the WWC indicates that the Saxon math program has a rating of "mixed effect."

Although WWC does not present Saxon with an entirely positive review, the positive average score does indicate a modest stamp of approval from the US Department of Education. A clearer stamp of approval comes from another of WWC's reports on an online Algebra course, I CAN Learn.[369] After compiling the experimental studies on the program, WWC determined the following "average: +5 percentile points; range: -7 to +15 percentile point." Surprisingly and in contrast to the review of Saxon's program, these scores prompt the WWC to award I CAN Learn with a "Positive Rating of Effectiveness" as opposed to "Mixed." In other words, I CAN Learn performed worse in

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367 Ibid., 3.

368 Ibid., 2.

369 US Department of Education, Institute of Education Sciences, "What Works Clearinghouse: Intervention I CAN Learn Algebra and Pre-Algebra," March, 2009, http://ies.ed.gov/ncee/wwc/pdf/wwc_icanlearn_031009.pdf.

experimental studies as compared with Saxon, and yet the WWC gives a higher rating to I CAN Learn. Such inconsistency possibly indicates the DOE's commitment to online instruction and assessment, a phenomenon I have discussed in this chapter on educational business. I also point out the hypocrisy contained in such inconsistency. The WWC's push for experimental testing is contained within a quest for “scientifically valid” research free from ideology, yet here the WWC makes claims that indicate potential bias in analysis.

The primary purpose for these examples is to illustrate the nature of experimental research in education, and the ways that federal agencies are promoting this research through the What Works Clearinghouse. The example also indicates a relationship between such experimental research and the promotion of traditional and online math education. Both are reviewed favorably, with the online I CAN Learn program very favorably. The two programs also happen to emphasize the procedures of math and knowing of math facts as opposed to the independent thinking and problem solving of the progressive math pedagogy. In this sense, the DOE emphasizes traditional math education. Furthermore, contrasting WWC's reviews of Saxon, a physical textbook, with I CAN Learn, a virtual textbook, indicates the DOE's support of online instruction. This shift to digital instruction is a theme in national math education that I have discussed elsewhere in this chapter.

Another network psychologist, Grover Whitehurst, represents the government push for experimental research and its connection to traditional education. This occurs outside the realm of math education, but in literacy education where Whitehurst cites experimental studies claiming the superiority of Open Court, a traditional reading program. [370] I mention this here to indicate that this trend, the association between experimental studies in education research and traditional programs, exists more broadly.

I further demonstrated the network support for educational businesses research by focusing on the federal government's push for experimental studies in education research. No Child Left Behind (NCLB) and the What Works Clearinghouse (WWC) aim to provide “scientifically credible” research. With a careful look at the types of programs promoted by such research, it seems that these efforts support traditional math education, and in particular the traditional math education that is delivered in a digital format. As I mentioned earlier in this chapter, companies like Pearson are aiming to be awarded megacontracts for online testing services. The government's use of experimental testing as a means to promote online instruction supports these aims. The favoring of traditional over progressive math education comes in the following section, where I argue that educational businesses find providing the service of progressive education too costly.

The Conflict Between Educational Business and Developing Human Capital

Thus far I have indicated the types of educational business that exist in my network, revealing that the testing business plays a significant role in national math education. I have also indicated the significant network support of this business, from academics to the government's push for experimental research. Keeping in mind the primary interest in the network, the development of human capital, the call is thus answered by companies such as ETS and Pearson to efficiently develop in people the

[370] Grover “Russ” Whitehurst, “Don't Forget Curriculum,” October 2009, http://www.brookings.edu/papers/2009/1014_curriculum_whitehurst.aspx

intangible qualities usable by businesses. They do so with megacontracts that provide educational assessment products and services that narrow the scope of math education to those aspects most useful in developing human capital. Academics contract for these companies, thereby agreeing that this activity supports efficient education. Or so it would seem. Rather, I argue that the educational assessment business mitigates some features of math education's potential to educate for human capital. Specifically, the human capital goals of independent thinking and problem solving are severely compromised when the educational assessment business becomes the driving force behind the teaching of mathematics. This is due to the fact that the assessment industry finds it too costly to assess independent thinking and problem solving, and would instead prefer to provide services that measure traditional math education. Evidence for my claim comes when juxtaposing network actors' psychometric research work with the American Diploma Project's (ADP) Algebra 1 exam.

To begin, I want to remind the reader that the educational testing industry responds to the call to educate for human capital. I indicated this in chapter 3 with quotations from testing companies that present their concern over equal opportunity. When read within the context of educating for human capital, this is taken to mean an increase in the number of employable people, an interest of businesses in their efficiency and capacity to lower wages. Therefore, the educational assessment industry agrees with the primary purpose of national math education: for human capital. However, the following discussion indicates how particular aspects related to its services fail to provide the full range of education for this aim. I now turn to the research showing the amount of labor required to provide this.

Network psychologist Suzanne Lane researches, among other things, on how to assess the progressivist math education program that I outlined in chapter 4. There I suggested this program represents commitments to teaching students to think about mathematics and face non-routine problems; such pedagogy corresponds to the human capital needs of independent thinking and problem solving. Referring to the progressivists as “math education reformers,” Lane describes the motivation for her psychometric research in this area as follows:

> Mathematics reformers ... suggest that the intent of mathematics instruction should be to promote the acquisition of knowledge in a broad range of mathematical topics and to promote the acquisition of mathematical thinking and reasoning skills. To ensure that assessment in mathematics reflect the goals of instruction espoused by mathematics reformers, assessments need to be developed to measure students' proficiency in solving complex mathematics problems, reasoning mathematically, and communicating mathematically. Open-ended assessment tasks that allow students to display their thinking, reasoning, and strategic processes that underlie their performance have the potential to ensure more valid inferences regarding the nature and level of students' understanding.[371]

The article summarizing Lane's research in this area indicates that two important qualities regarding the assessment are essential for it to be valid. These qualities are intertask and inter-rater consistency. Intertask consistency concerns the selection of open ended problems that will appropriately assess from among those knowledge areas in which a student is prepared. The other problem is making sure that the graders of the student responses are able to do so with minor deviation from each other, inter-rater consistency.

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[371] Suzanne Lane, “Generalizability and Validity of a Mathematics Performance Assessment,” *Journal of Educational Measurement* 33, No. 1 (Spring 1996): 71-72.

Lane and her colleagues conclude that it requires significant resources to ensure the validity of tests that match the emphases of progressivist math education. First, selecting appropriate open ended problems requires significant research and development. Second, grading these student responses accurately and evenly amongst all graders requires the following labor intensive process:

> The development and use of a specific rubric for each task, which reflects the criteria specified in the general rubric but provides detailed examples of the more general criteria based on the cognitive demands of the specific task, provides the raters with enough guidance to ensure accuracy in scoring. Further, the training procedure, which involves (a) detailed review of the rubrics and examples of student responses at each score level and (b) rating student responses that have been prescored, helps ensure that the raters understand and internalize the scoring criteria.[372]

Lane's research demonstrates the costly endeavor to provide valid assessment services that indicate a student's advancement with regard to independent mathematical thinking and problem solving. These are the primary progressivist math education goals, and as I argued in chapter 4, seem to be an essential component of using a national math education to develop human capital.

However, the educational businesses that provide these assessment services presentsan obstacle for this aspect of educating for human capital. Educational businesses run on the same efficiency model that businesses do, so they must find ways to limit their investment in the labor for research, development and grading (and all that goes with grading) while still providing the service they are contracted to provide. This results in their services' de-emphasis of the human capital goals that relate to progressivist math education. In other words, Pearson and others' assessment services will not assess

372 Ibid., 87.

students for their ability to solve the open ended tasks that involve independent thinking and problem solving.

It may seem that I am making predictions, but in actuality there is already truth to my claim concerning the de-emphasis of progressivist math education contained in Pearson's test services. This comes with a look at the American Diploma Project's (ADP) Algebra 1 assessment. Earlier I pointed out that Achieve, Inc. played a role in developing this network of states that would adopt the same end-of-course assessments for Algebra 1 and 2. Pearson was then awarded a megacontract to research, develop, administer and grade these tests.

Pearson's website includes a page[373] on ADP that contains information about the exam and one practice exam.[374] The exam "is designed to simulate the Algebra 1 testing experience,"[375] therefore I consider this to be a representative example of an ADP algebra test. The ADP Algebra 1 practice test consists of 47 questions, 7 of which are open ended problems and the remainder are multiple choice questions. Three of the 7 open ended problems test a student's ability to perform algebraic skills. Contrary to the progressivist open-ended type problem, what seems to make these problems open ended is merely that students do not select from among multiple choice answers and that they must show their work. For example, one of these algebraic procedure type questions is number 30: "Write

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373 Pearson, "American Diploma Project," accessed June 27, 2011, http://www.pearsonaccess.com/cs/Satellite?c=Page&childpagename=ADP%2FadpPALPLayout&cid=1175826860834&pagename=adpPALPWrapper.

374 Pearson, "ADP Algebra 1 Practice Test," accessed June 30, 2011, http://www.pearsonaccess.com/cs/Satellite?blobcol=urlblob&blobheader=application%2Fforce-download&blobheadername1=Content-Disposition&blobheadername2=Content-Transfer-Encoding&blobheadervalue1=attachment%3B+filename%3D%22ADP+Algebra+I+Practice+Test%2C3.pdf.

375 Ibid., unpaginated introductory page.

$x(x+2)-3x(x+2)+2(x+7)$ as a simplified polynomial. Show or explain your work. "[376] These three questions are not the type of open ended task that corresponds to the progressivist emphasis on independent thinking and problem solving. Rather, they iterate the type of exercises that an Algebra student practices.

The remaining 4 open ended tasks do not fair much better as progressivist open ended tasks. One requires students to fill in a missing value on a table of an exponential function, another asks them to perform algebraic manipulations in a geometric context, and a third to interpret the meaning from a linear equation problem, using the classic form $y=mx+b$. Each of these questions has only one correct answer and standard Algebra instruction will practice these types of problems on a consistent basis. In other words, these questions will not require a student to problem solve or think, but to perform what she has been practicing. Only one question, number 24, allows for students to provide a range of answers, but could be answered without significant algebraic problem solving or independent thinking.

All seven open ended questions on ADP's Algebra 1 Practice Test do not represent the type of progressivist open ended questions that involve independent thinking or problem solving, as would match the type of progressivist pedagogy I outlined in chapter 4. Instead, the open ended tasks that are included in Pearson's ADP exams have single answers or are otherwise very straightforward in their development and grading. Psychologist Suzanne Lane indicated the amount of labor involved in the development and grading of progressivist open ended test items. Therefore, I argue that Pearson did

[376] Ibid., 23.

not include these because of the labor involved in providing these services. Running an educational business requires providing a satisfactory level of service at minimum investment.

On the other hand, the de-emphasis of progressivist items on Pearson's assessment occurs alongside greater emphasis of the traditionalist perspective on math education. In chapter 4, I outlined the traditionalist perspective's influence on limiting calculator use and emphasizing the practice of algorithms to arrive at one and only one correct answer. The ADP Algebra 1 exam is broken into two parts, the first of which is to be taken by students without the use of calculators. This pays reference to the traditionalist perspective. Many of the open ended items I discussed above also emphasize the procedural aspect of math, such as performing the multiplication of polynomials. These are aspects of traditional math education that are downplayed by the progressivist.

In other words, examining Pearson's testing product reveals that the traditionalist perspective is enhanced by the educational business interest. In chapter 4, I argued how the traditionalist perspective aids in the identification of exceptional human capital and in providing a moral education for all students. Therefore, educational business furthers these aspects of educating for human capital and to the detriment of the human capital interest in independent thinking and problem solving. Given my methods for inquiry, it is difficult to ascertain whether the human capital interest is therefore compromised, or whether the progressivist human capital interest is less important than the traditionalist. Only time will tell whether the human capital interest accepts the educational business focus on traditionalist math education.

In this section I have suggested how the costliness of assessments aligned with progressivist math education prevents the testing services from including them in their services. Pearson's megacontract, the ADP Algebra 1 exam, does not include such progressivist questions. This presents one of two interesting possibilities: that the progressivist math education is less important in educating for human capital than is the traditionalist, or that educational business undermines the interest for which it serves.

This chapter has presented educational business as the auxiliary interest in national math education. Primarily the businesses in the network center on testing and testing-related services. Especially intriguing are the potential for testing megacontracts and the outsourcing of teacher work, such as lesson planning and delivery of content as might be replaced by online instruction. I have also documented the variety of network actors that support the testing industry, from academics who work for testing companies to the federal government's role in motivating testing megacontracts and pushing for the experimental studies in math education research that validates testing's place in education. These examinations have also revealed that educational business undermines, in part, the human capital interest to develop independent thinking and problem solving. This example of conflict leads into my final chapter, where I present other conflicting pairs of interests in the network that I have presented in chapters 3 through 6. Ultimately, these conflicts, including the one I presented in this chapter, lead to my conclusion that national math education fails to increase the knowledge and use of mathematics by people living in the US.

Chapter 7: The Failure of National Math Education

The preceding four chapters have presented my findings of the representative social network surrounding national math education that I constructed in chapter 2. These findings have indicated that math education in the national interest primarily serves the interests of businesses and not the public. In this concluding chapter, I first review these findings in order to begin my critique of them. This critique will commence with my arguments regarding how the trends in national math education undermine each other. I next present a less powerful trend in national math education, namely math education for democracy, as expressed by the network's individuals and organizations. Both of these considerations reveal that national math education fails to deliver two aspects of mathematical thinking: problem-solving and quantitative literacy. As well, I argue national math education's context will result in less knowledgeable teachers in the classroom. Accordingly, I argue national math education fails to increase the knowledge and use of mathematics by people living in the US. Finally, I offer alternatives to national math education and ask fellow math enthusiasts to call mathematics down from its false pedestal of superiority, a notion embedded within the corporate interests that ultimately mitigate the learning of math.

The Winning Trends of National Math Education

In an attempt to summarize my findings, I first re-articulate the trends as I outlined them in the preceding chapters and then present them again by considering how math education will look should these trends in national math education continue. My reading of this network involved searching for the ideas about math education that were most often expressed. The most stated purpose for national math education is to prepare the nation's workforce, what I denoted in chapter 3 as the development of human capital. Academics and their organizations, such as the National Council of Teachers of Mathematics (NCTM) agree that math education should develop human capital, expressing their commitments to it in words and actions. Therefore, I argued that the development of human capital is the primary interest in national math education.

The network's two primary academic interests, math pedagogy and teacher education, align closely with the development of human capital. In chapter 4 I argued how both the progressivist math education researchers and the traditionalist mathematicians situate their respective perspectives within the goal to create a strong workforce and US economy. I also examined in what ways these perspectives actually support the development of human capital. The progressivists contribute greater numbers to the workforce as well as the skills of problem-solving, collaboration and independent learning that are considered essential for the workers of today's knowledge economy. The traditionalists contribute a means by which to sort the professionals and producers in the economy, as well as a moral education emphasizing productivity.

In chapter 5 I discussed the other academic interest, namely those working on teacher education and development who believe that US math teachers do not know math. There I argued how the promotion of such a myth contributes to the goal of developing human capital. It motivates the re-education of math teachers and policy changes affecting teacher performance and jobs, including increasing the ability for bosses to fire teachers.

Finally, in chapter 6 I presented the auxiliary business interest that answers the call to use math education for developing human capital. As it turns out, educational business is also now entangled with the information and communications technology (ICT) industry. We might expect educational businesses to be the best suited for such development, because they would use the corporate creed of efficiency towards the production of the goal. However, as I argued, educational business does not fully utilize all the ways that math education can develop human capital. Specifically, educational business fails to deliver the content that will develop problem-solving, independent learning and collaboration, the progressivist elements of national math education.

I have reviewed my findings in order to motivate this chapter's critique of them. Perhaps a more illuminating view of these findings is to describe the teaching and learning of math in the US, should these trends continue. For the remainder of this section, I will outline each of the following circumstances: the prioritizing of math, the use of digital instruction, digital testing in math education and, impacted by all of this, the future of the math teaching profession.

Because math education appears to be so important for corporations, it is prioritized in the education of US youth. To be sure, math provides a foundation for the study of other subjects, such as engineering and computer science. I argue that the potential for profits in these areas is why math is prioritized. Prioritizing math could take place in the absence of such profits, because engineering and/or computer science may be particularly useful for the advancement of social organization.

However, as it stands in the interest of profits, this prioritizing manifests itself in the early grades via the replacement of music, art and other “specials” with instead math. As I presented in chapter 5, “math specialists” are a new breed of employee that are gaining significant attention in the national math education social network. Some of them aid the generalist elementary school teacher in her teaching of math, but many do and more will teach a special math class. This comes at the same time that special art or special music teachers are being cut from the budgets of elementary schools.

The prioritizing of teaching math will also be made manifest by the fact that math teachers will be paid more than teachers of other content areas. As I mentioned in chapter 5, Math for America pays math teachers money above their salaries. Although the organization argues that this is necessary to attract people with mathematical talent to teaching, I argued that Math for America indicates human capital's commitments to math education above other content areas. This type of differentiated pay will occur in the public system if the policy attacks against teacher unions, as I mentioned in chapter 6, are successful.

The process of math education, what teachers and students will do together, is also going to change. The influence of the ICT industry, and their emerging connections to educational business, will make personal computers the center of math instruction. Because the national curriculum now presents a rigid sequence of learning, these instructional materials will likely emphasize mastery of math facts and procedures. The teacher will monitor the students' progress on such mastery with tools that record and analyze every action the student takes.

Also online, standardized testing in math will be given for students in grades 3 to 11, and at least 3 times a year. Students will likely become more anxious over these exams, because the stakes are high, but not because their scores have a direct result to their lives. Instead, their results have a direct result on their teacher's life. The usefulness of standardized testing will be to determine the "value" a teacher "adds" to his students. In other words, the amount of human capital he has developed that year. Some teachers will be fired for poor performance; others possibly given bonuses.

These changes make the work of teaching math look very different. For one, math teachers are less responsible than ever for the delivery of content. In the world of math education research, there is a concern over a teachers' over-reliance on teaching from the textbook.[377] However, using online instruction could make teachers even more disconnected from planning instruction around the ideas of mathematics. Teachers will monitor the students' progress, and perhaps act as the primary motivator for students to stay focused and productive. In this sense, the math teacher's role as the inculcator of morals, specifically hard work and perseverance, is made stronger. And, given the new structures of their jobs and the material consequences student performance will have on teacher's lives, math teachers will indeed find the ways to teach this moral.

This second presentation of the trends in national math education, as a look at the future of math teaching and learning in US schools, indicates how the development of human capital and the interests of educational businesses, along with the ICT industry,

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[377] See, for example, Deborah Ball and Sharon Feiman-Nemser, "Using Texbooks and Teachers' Guides: A Dilemma for Beginning Teachers and Teacher Educators," *Curriculum Inquiry 18,* No. 4 (Winter, 1988): 401-423.

manifest themselves in the act of teaching math. For some, this picture might sound satisfying, but for me I have several concerns regarding the direction in which we are heading. I will present these concerns in the remaining sections of this chapter. I begin by considering the ways that the most prominent themes in national math education are actually a failure.

Conflicts and Tensions Among the Trends in National Math Education

Janine Wedel is the anthropologist whose new perspective on contemporary governance inspired my approach for analyzing national math education, as I discussed in chapter 2. She also posits that the interest in a policy domain's social network often conflict with each and in many cases, undermine the one or the other of a network actor's particular goals. Here I offer examples of these with regard to the social network surrounding national math education. I intend to indicate that these conflicts fail to result in national math education's stated goal: to increase the knowing and use of mathematics by people living in the US.

In this section, I offer three examples of how the interests I outlined in chapters 3 through 6 contain contradictions resulting in failure of execution. The first of these, the failure of educational business to fully satisfy the development of human capital, I elaborated upon in chapter 6 but will attend to again here. The second is the progressivist's “equity principle” that pays reference to some notion of social justice yet perpetuates a system of injustice. The last centers on the conflicting interests among those who agree that US math teachers do not know math, the subject I addressed in chapter 5.

Finally, I argue how these contradictions actually make math education in the US worse.

As I discussed in chapter 6, the products that educational businesses like Pearson provide resonate more the traditional perspective on math education than the progressive. The traditional interest and the educational business interest, which is now also backed by the ICT industry, provide the power that has shifted national math education to a clearly traditional program. The “coherent curriculum” I described in chapter 3 is but one example of this trend. However, as I also argued in chapter 4, the progressive perspective contributes an important aspect to developing human capital. Creating a productive workforce is the primary interest in national math education, and this is achieved in part with the progressivist focus on problem-solving, independent learning and collaboration. These aspects are not supported by the services provided by the education industry.

For me, this was a motivating dilemma in math education with which I hoped my analysis would grapple. In my first chapter, I introduced a few scenarios that could help to understand what is going on with this dilemma and here I will attend to them again, this time in more detail. First, as I've suggested, the influence of the ICT industry on national math education is clear. Their backing of educational business may create a force formidable to the general interest to develop human capital. The testing industry and its related materials are now moving online, something that is very lucrative for ICT corporations. Not only does it require the consumption of products for use in schools, it also inculcates in students a life attached to technology, as Joel Spring argues.[378] So the educational business' promotion of the traditional perspective is enhanced by its backing

[378] Joel Spring, *Power, Wealth, Cyberspace and the Digital Mind.* New York: Routledge, in press.

from the powerful ICT.

To be sure, the ICT industry requires a large number of computer programmers for their work. These computer programmers require a strong mathematical education, with special attention to algebra and logic. This is assumed to be the reason why the ICT industry is interested in a strong US math education. However, given the outsourcing of computer programming jobs, I argue that the true motivation for the ICT industry comes from the increased use of ICT products in school, and the opportunity to use schools as a place where students become further addicted to digital products.

Ironically, there is reason for ICT to consider the opposing perspective on math education: the progressive position. The progressivist position has continually argued for the increased inclusion of statistics and probability into the curriculum. Many ICT companies use such knowledge for their work, including Google. The Internet search engine and advertising outlet uses very sophisticated probabilistic models to perform the functions that have garnered its immense success.[379] Contained here is another contradiction between the interests behind national math education.

Yet another possibility exists regarding the tension between developing human capital and educational business' emphasizing traditional math education, although this one resolves the tension somewhat. Michael Apple considers the corporate interest in educating people in mathematics as "rhetorical."[380] He suggests that math is very useful to these corporations, and they must remain in control of this knowledge and not actually

[379] James Gleick, "How Google Dominates Us," *New York Review of Books* 58, No. 13 (August 18, 2011), 24-27.

[380] Michael W. Apple, "Do the Standards Go Far Enough? Power, Policy and Practice in Mathematics Education," *Journal for Research in Mathematics Education* 23, No. 5 (1992), 412-431

educate everyone in it. However, national math education is occurring, with several corporate sponsors, so I find his analysis not to be the case. Instead, it could be that their commitments to educating all with the progressive elements of math education is what is merely rhetorical. The traditional elements, those that sort students into producers and professionals, and that inculcate in students a moral of hard work, are indeed executed by the corporate interest to develop human capital. In other words, there is no contradiction between developing human capital and the educational business' traditional math education. Using math education to develop human capital actually uses the hidden curriculum of traditional math education and not the stated connections between the progressive perspective and the knowledge economy. Whether the tension exists or not, what remains clear is that the progressive aspects to math education are not coming to play. Thus, the progressivist interest in national math education is undermined.

I now move to the second example of the tensions among the trends of national math education which again relates to the progressivist perspective on math education. This time, I focus on the contradictions between "equity" and developing human capital. As I reviewed in chapter 4, the progressivist perspective on math education contains a notion of social justice, captured in part by the National Council of Teachers of Mathematics' (NCTM) "equity principle." Most broadly, the commitment seeks to prepare all students with a strong math education because of the association between success in math and job opportunities in later life. This notion, equal opportunity for all, is one type variant among many in the education research world's "social justice." A quote from Nora Ramirez I included in chapter 4 demonstrates accompanying notions of social justice, such as her implication that math education could empower students to not just gain employment but seek social change. This pays tribute to a belief that poverty is the result of economic and political structures, in opposition to the compassionate conservative view I reviewed in chapter 4. I am claiming that, for some network actors like Ramirez, equity means more than equal opportunity for all. It could mean teaching math so that the students have the power to advocate for changes to political and economic sources of oppression.

However, the primary interest in national math education is to develop human capital. This interest supports the perpetuation of such political and economic sources of oppression. Furthermore, the interest is hardly in support of the workers it plans to employ. While the development of human capital is almost always articulated to benefit the individuals who will be employed (and so is often the articulations of "equity" in math education), in reality the development of human capital creates more competition among workers and results in lower wages. There always exists the conflicting interest between employers and employees regarding the price of labor. A national math education that develops talent in the corporate interest results in individuals selling their labor at lower prices.

The third example of tensions in national math education comes from the contents of chapter 5, on the content knowledge deficits myth about US math teachers. I argued that the knowledge is not sufficiently poor relative to teachers in other countries, yet I do recognize the contribution that some of the academics supporting the myth may make regarding the teaching of math. For example, what might be especially helpful for helping math teachers are the refined efforts of work in teacher knowledge, such as actor Deborah Ball's emphasis on the distinction between subject matter knowledge and pedagogical content knowledge. The latter makes the point that simply knowing the math will not always lead to effective teaching.

The interest in teacher knowledge that comes from academics contains the implication that teachers are professionals requiring preparation similar to doctors or lawyers. These academics put forth that future teachers require an education in how to teach effectively, specifically by teaching how content knowledge is enhanced by a particular knowledge used when teaching. This preparation would occur in the present system of university teacher education, in which most of these academics are situated.

However, the interest in teacher content knowledge is also promoted by actors in my representative social network who seek to replace such university based teacher education. The sense from these individuals and organizations is that US math teachers do not know math, and did not learn anything useful in their university based preparation for teaching. All that is required to teach math is math knowledge. The alternative routes to certifying math teachers should primarily assess a teacher's content knowledge. Therefore, the groups agreeing on teacher knowledge have underlying interests that compete with one another. Although the anti-university teacher education interest in the network may not be powerful enough to replace university based education, the two groups counteract each other's efforts and fail to accomplish either's goal. As I argued in chapter 5, the attack on university education also serves to prevent future math teachers from learning about teaching philosophies that counter educating for human capital.

In this section I have presented three examples of the tensions among the major trends I found to exist in national math education. The conflict between educating for human capital and the educational businesses/ICT industry centers on the latter's emphasis of traditional math education. The contradiction may be superficial because developing human capital may actually prefer this emphasis, but at the very least it indicates that the progressivist position is undermined by competing interests in the network. Second, the equity principle, especially including its connotation of social justice and social change, is undermined by the interest to develop human capital. Third, the content knowledge deficits of teachers is a myth supported by two opposing interests: those who want to preserve the university-based teacher education and those who want to replace it.

These tensions also provide examples of national math education's failure to increase the knowledge and use of mathematics by those living in the US. First, the progressive position emphasizes several components of mathematical thinking, such as problem-solving. The traditional triumph in national math education, with its “coherent curriculum” that emphasizes math facts before such higher level thinking will prevent several students from coming to learn this aspect to math. I am not suggesting that traditional math is also not mathematics. It is an important aspect of knowing and using math. However it is only one aspect, and increasing the knowledge and use of mathematics requires attention to all areas of mathematical behavior. Second, ignoring the research involved with pedagogical content knowledge, and furthering replacing teachers with digital media, signifies poorer instruction in mathematics. Thus I have provided a few examples of the ways that national math education fails to teach math effectively.

Math Education for Democracy: The Losing Trend in National Math Education

Another failure in national math education centers on math education's role in the encouragement of democratic practice. Many in my representative network surrounding national math education state that one purpose of national math education is to encourage democratic practice and/or civic society. However, I did not determine these to be a significant interest in the network; far fewer statements were made about math and democracy than were made about math and the economy, workforce, etc. It seemed that promoting US democracy was, at best, a secondary goal for national math education. In this section I will argue that not only is this interest less often stated, national math education works against math education for democracy in very real ways. Primarily, this occurs for the conflict between developing human capital and quantitative literacy, the branch of mathematical thinking most connected to democracy.

Although democracy is a contested term, I am here referring to the simple notion of rule by the people. Janine Wedel's thesis, the motivation for my inquiry into national math education, would be a counterexample for such democratic practice. The “shadow elite” and “new forms of governing” that engage private interests into public-policy making does not suggest that the people governed are making policy, or that the policies made are in the interest of those governed by it. Because national math education satisfies Wedel's perspective on contemporary governance, right off the bat we witness a contradiction between national math education and democracy.

My primary point here, however, is to suggest that some in the network believe math education can facilitate democracy, and that this belief is squandered by more powerful interests. A few examples of network actors might help. The primary goal of the National Science Foundation's (NSF) education division, the Directorate for Education and Human Resources (EHR), is to educate for human capital as demonstrated in my quoting from their mission statement in chapter 3. However, their mission also pays reference to democracy: “The mission of EHR is to achieve excellence in US science, technology, engineering and mathematics (STEM) education at all levels and in all settings (both formal and informal) in order to support the development of ... [workforce] ... and a well-informed citizenry that have access to the ideas and tools of science and engineering.”[381] Such a “well-informed citizenry” requires knowledges, some of them mathematical, to participate in the democratic process.

Academics in the network promote math education's role in democracy as well. For example, network math education researcher Deborah Ball and network mathematician Hyman Bass co-authored an article titled “The Role of Mathematics Instruction in Building a Socially Just and Diverse Democracy.”[382] There, the two argue how particular pedagogic practice in math education can encourage students to practice engaging with others' views and reaching resolution. The article does not focus on the types of math knowledges that empower citizens to make knowledges in their interest, as

381 National Science Foundation, “About EHR,” accessed May 9, 2011, http://www.nsf.gov/ehr/about.jsp

382 Deborah Loewenberg Ball, Imani Masters Goffney, and Hyman Bass, “The Role of Mathematics Instruction in Building a Socially Just and Diverse Democracy,” The Mathematics Educator 15, No. 1 (2005): 2-6.

was perhaps implied by the NSF quotation above.

Network mathematician David Bressoud presents a clearer articulation of the math knowledge that is useful for democratic practice, which is specifically quantitative literacy. In one installment from a column he publishes through the Mathematical Association of America (MAA) discusses mathematics and democracy,[383] Bressoud describes quantitative literacy as "the power and habit of mind to search out quantitative information, critique it, reflect on it, and apply it in [one's] public, personal, and professional life."[384] To give a concrete view, he also offers an example of instruction in quantitative literacy: students are given the goal to learn to read the newspaper "with a critical understanding of how data, graphs, statistical inference, and numerical information are being used or abused, and a recognition of the quantitative information one would need before forming a reasoned reaction to a particular issue raised in such an article."[385]

Quantitative literacy, as Bressoud defines, is one example of mathematical knowledge that is useful for democratic practice. As well, my network's professional organization Mathematical Association of America (MAA) holds on its website a book titled *Mathematics and Democracy: The Case for Quantitative Literacy.*[386] For example, a common phenomenon in today's political world is the use of statistics to shape public opinion. Many times, opinion polls that use leading questions are reported as evidence of

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383 David M. Bressoud, "Launchings: Mathematics and Democracy +10," accessed March 25, 2011, http://www.maa.org/columns/launchings/launchings_01_11.html
384 Ibid.
385 Ibid.
386 Lynn Arthur Steen, ed. *Mathematics and Democracy: The Case for Quantitative Literacy*, (2001), http://www.maa.org/ql/mathanddemocracy.html.

public opinion. When reported, these polls encourage other individuals to agree. An education in quantitative literacy will introduce the proper ways to collect and analyze data, thereby providing the means to critique opinion polls, as well as other statistical justifications for ideas.

Perhaps surprisingly, poor statistical justification is used by several actors in national math education. Here I provide an example of this. As I mentioned in chapter 4, one of the common arguments in national math education is that success in mathematics is associated with better-paying jobs in adult life. This argument centers on the classic misunderstanding of correlation and causation. In statistics, two variables are said to be associated if there is a positive or negative trend between them. A positive trend means that, as one variable increases, the other variable increases. However, many falsely interpret such a trend to indicate that one variable *causes* the other one. In the context of math education and job opportunities, the positive trend could be indicated as follows: for individuals, the greater number of years of successful math education, the greater the amount of money earned per year. Network research and policy institute Achieve, Inc. calls attention to this trend and suggests, as others have, that math education is a civil right: "Numerous studies demonstrate that successful completion of rigorous mathematics, such as Algebra II, in high school is an important gateway to success in college and the work place."[387]

The reporting of this trend fuels the claim that everyone should learn mathematics, thus providing public support for national math education. However, such

[387] Achieve, Inc., "Math and Civil Rights," July 29, 2011, http://www.achieve.org/math-and-civil-rights.

use of the trend indicates faulty reasoning. The association between mathematical studies and economic success does not suggest that mathematical studies causes economic success. Correlation does not imply causality. Thus, we have no concrete evidence that increasing the number of students who study mathematics will land each of them high-earning jobs. Observed associations between two variables only opens the door to consider possibilities, some of which could be causal relations (and these are only provable by controlled experimental studies, if possible). As I suggested in chapter 4, one possibility for the association between successful studies in math and high-earning jobs later in life is the simple fact that performance on mathematical standardized tests are a gatekeeper to professional jobs in the economy. As I indicated there, many professional jobs do not require Algebra, the cornerstone of such gate keeping practices. In other words, if there comes a day when national math education indeed prepares all students to succeed on standardized testing in math, there could be other means for sorting out the professional and producers in the economy. In this case, the positive correlation between economic and mathematical success would no longer exist.

I intend this example of faulty statistical reasoning in national math education to illuminate how quantitative literacy can impact our democratic practice. Such faulty reasoning fuels the concern that national math education focus on the needs of job preparation. This is to the detriment of other purposes for math education like education for democracy. Furthermore, the act of committing such statistical misuse indicates to what extent national math education is unconcerned with quantitative literacy and math education for democracy. This is the most obvious losing trend in national math education.

To be sure, quantitative literacy does come up in the writings of economic institutions as a necessary component of developing human capital. For example, my network's Organization for Economic Cooperation and Development's (OECD) Programme for International Student Assessment (PISA) in math is framed by a related notion, termed “mathematical literacy: An individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen.”[388] However, the OECD's PISA fails to fully embrace the knowledges it describes because it primarily includes such mathematical literacy only within business and consumer contexts. PISA's 2003 math framework contains 25 examples of problems that assess mathematical literacy according to their definition. Of these 25, eight have an economic context, nine have a social context, five have a scientific context and three have no context. In general, problems that require a student to “make well-founded judgments” are problems with business contexts, whereas problems with social or scientific context require students to apply math knowledge without making judgments. There is no problem that requires a student to apply their mathematical knowledge to the unequal distribution of wealth, for instance.

Returning to network mathematician David Bressoud, he argues that quantitative literacy is dependent on context: “The mathematics [of quantitative literacy] can be very

388 Organization for Economic Cooperation and Development, “The PISA 2001 Assessment Framework -- Mathematics, Reading, Science and Problem Solving Knowledge and Skills,” (2003), http://www.pisa.oecd.org/dataoecd/46/14/33694881.pdf.

simple. It is the ability to work in context that makes this a demanding discipline, and, for quantitative literacy, context is everything."[389] This concern over context has led some to argue that quantitative literacy be taught in all content areas; quantitative literacy knowledge and skills may not be transferable from one domain to another. In light of this notion, the OECD fails to address quantitative literacy across all contexts. By emphasizing only the quantitative literacy in business and consumer contexts, the OECD only includes quantitative literacy within market economic contexts. Such knowledge will fail to transfer to the quantitative literacy required to be a functional member of democratic practices, according to what mathematicians have to say.

While the OECD and other institutions in my representative network suggest quantitative literacy, at least within business contexts, it is very clear that national math education is less concerned with this branch of mathematical knowledge. Take for example the de-emphasis in elementary grades that statistics has endured with the new national math standards, the *Common Core State Standards for Mathematics*,[390] as compared to earlier iterations of national standards like the National Council of Teachers of Mathematics' (NCTM) *Curriculum and Evaluation Standards for Mathematics*.[391]

I argue the case for quantitative literacy, and thereby math education's role in democracy, loses because it competes with the primary purpose of math education: to develop human capital. As I argued in chapter 3, developing human capital is the interest of corporations who seek to get as much out of employees for as little as it can put in. An

389 Bressoud, "Quantitative Literacy."
390 Common Core State Standards Initiative. *Common Core State Standards for Mathematics*. accessed July 31, 2011, http://www.corestandards.org/assets/CCSSI_Math%20Standards.pdf.
391 National Council of Teachers of Mathematics (NCTM). *Curriculum and Evaluation Standards for School Mathematics*. (Reston: VA, National Council of Teachers of Mathematics, 1989).

education in quantitative literacy would lead to future workers who might be critical of the balance between their job expectations and the pay they receive. These future adults might also be able to critique on a larger scale the increased stratification of wealth distribution, or the political and economic conditions that contribute to it. Although quantitative literacy within business contexts is useful, these skills and knowledges can be taught to the select few *only after* they have been sorted out from the rest via success in Algebra. Indeed, the new national standards, and their sequential curriculum, do just that.

In this section I have considered the network actors who put forth an alternate purpose for national math education, namely its role in promoting democratic practice. As indicated by the framing of my analysis, such claims are immediately refuted given the fact that the conversations regarding national math education have little to do with the public interest, and much to do with the private. The greatest contribution math education has for democratic practice is quantitative literacy. Most interesting, the forces behind national math education thrive on the public's poor knowledge of quantitative literacy, as in the case with the “math education and civil rights” idea. National math education will not teach quantitative literacy because it conflicts with the primary goal to develop human capital. Because quantitative literacy is a significant type of use of mathematics, this phenomenon is another example of how national math education fails to deliver on its promise to increase the knowledge and use of mathematics by people in the US.

The Limitations of National Math Education

Thus far in this chapter, I have indicated at least two areas of mathematical thinking that are not adequately addressed by national math education. These are mathematical problem-solving and quantitative literacy. I have suggested that contesting interests, namely the development of human capital and the educational businesses and ICT industry, prevent these areas from gaining significant ground in the emerging national math education. I have also indicated how the context of national math education changes the landscape for teacher work. In this section I argue each of these as contributing to the failure of national math education.

National math education purports to increase the knowledge and use of mathematics by people living in the US. However, mathematical knowledge of only one variety will be increased by it, namely the math facts and procedures associated with traditional math education. The traditional triumph in national math education is driven by the following formidable influences: educational businesses' quest to keep costs low, the ICT industry, and human capital's need for efficient sorting of workers and productive dispositions for all workers. This has resulted in a national math education that emphasizes math facts and procedures, as indicated by the "coherent curriculum" I reviewed in chapter 3 and Pearson's testing megacontracts in chapter 6.

Math facts and procedures are one type of mathematical behavior. For example, knowing computational procedures for figuring a percentage (say, for a waiter's tip) is a mathematical behavior. For many, this behavior becomes automatic yet, when one who is doing it and asked to consider whether they are doing something mathematical, we expect the typical response to be affirmative. In other words, I do not fault the inclusion of traditional math in the curriculum because it somehow is not mathematics. A math education would rightly include the knowledge of math facts and procedures.

However, limiting math education to these elements does not expose students to other mathematical behaviors. As I suggested earlier, students who fail to master traditional math facts will not gain exposure to quantitative reasoning, mathematical justification or problem-solving. The rigid structure of traditional math education considers math facts and procedures as the only entry point to math. It fails to consider that perhaps some people can be attracted to math in the first place by its other behavioral aspects. Traditional math education occurs alongside a public that has math-phobia and innumeracy.[392] Its limited point of entry may cause many to give up on mathematics.

Besides limiting the type of content that math education provides, national math education also restricts students to particular math teachers. As I discussed in chapter 5, there is much concern in national math education over having teachers know lots of math. The irony in national math education, however, is that much of teacher work is outsourced to educational business. This includes the decisions regarding what to teach, how to teach it, and how to decide that students are learning it. The future teachers of national math education will not decide what math to teach because they will all follow the same national standards. They will rely on digital lessons for the instructional component of teaching. And, they will be bound by the standardized assessments that now occur at least three times per year, likely any additional tests will either mimic these or be provided by educational businesses.

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[392] As documented by John Allen Paulos, *Innumeracy: Mathematical Illiteracy and its Consequences*, (New York: Hill and Wang, 2001).

I am not naive to the claim that math teachers already behave similarly, with their reliance on math textbooks' rigid structure, pre-canned assessments and lessons for instruction. This may be true for some teachers, but it is not true for all teachers because the services of educational businesses have not yet been tied to a teachers' working status. As I presented in chapter 6, national math education seeks to tie a teacher's pay and/or employment to her students' performance on standardized testing. Therefore, math teachers will be compelled to use all educational business' services I described in the preceding paragraph.

The contradiction here is the fact that this type of math teacher does not require sophisticated knowledge of math. All that is required are the specific knowledges related to what is to be taught. Teachers will not be encouraged, or even allowed, to deviate from what is expected of them. Math teachers are expected merely to encourage students to work hard, in whatever way they can do so. The work of teaching math becomes incredibly uncreative, even sad. Not only does the circumstance not require teachers with knowledge, it might discourage some that do from entering the math teaching profession. In plain terms, the rigid structure of national math education will prevent competent, interested and knowledgeable teachers from entering the math classroom. This fails to increase the knowledge and use of mathematics by people living in the US, the supposed goal of national math education.

In summary, I have reviewed the limitations in national math education that will not encourage the knowledge and use of math. These are the non-inclusion of mathematical behaviors like problem-solving and quantitative literacy, and the failure of increasing the number of competent, interested and knowledgeable math teachers.

Sketching an Alternative

After analyzing national math education and its poor attempt at disseminating mathematical knowledge for people living in the US, I feel compelled to offer possibilities for its alternatives. I draw from two areas of thought on math education that, I believe, address the weakness in content I outlined in the previous section (its lack of problem-solving, mathematical reasoning and quantitative literacy). For its other weakness, ensuring strong math teaching, I also review considerations as to the importance of teacher autonomy. Together, I intend these reviews to offer suggestions for three arenas: policy regarding math education in the US (at the local, state and national level), aspects to teaching math that could be considered by math teachers working in public schools and thus bound to the new policies of national math education, and aspects to teaching math that could be considered by math teachers working in alternative schools, such as those rooted in the anarchist tradition.

I begin by juxtaposing two areas of thought in math education: Marxist math education and artistic math education. Each of these arguments addresses the weaknesses in national math education. On its own, each also lacks something. Marxist math education provides the quantitative literacy needed for democracy, but fails to provide the possibility of exposure to a full range of mathematical behavior. Artistic math education emphasizes the creativity involved in mathematical reasoning and problem-solving, but fails to provide the quantitative literacy for democracy. In what follows, I review the exemplar writings in each area, beginning with Eric Gutstein's representation of Marxist math education.

Gutstein's Marxism is evident by his reliance on critical pedagogy, the theory of teaching popularized by Paulo Freire, and his belief that math education can be liberatory. That knowledge of math can empower students to change economic oppressions comprises the essence of his Marxist math education. In a way, Gutstein's work is a radical form of quantitative literacy. The primary purpose of his teaching math is to offer students a strong means by which to critique their world and advocate changing it. Accordingly, his work suggests that the learning of math be centered on lessons where mathematics is applied to issues of political or economic oppression. For example, one event in Gutstein's classroom is the mathematical discussion of the term "minority."[393] Students employ basic mathematical computation and the more advanced concepts of percentage and ratio to justify that this term is a poor descriptor.

Gutstein's approach provides clear examples of the type of quantitative literacy education leading to democracy. However, by motivating the learning of math through its application, Marxist math education fails to contribute some of the other aspects to mathematical behavior. One particular mathematician, Paul Lockhart, has captured the essence of what I find missing in Marxist math education. In *A Mathematician's Lament: How School Cheats Us Out of Our Most Fascinating and Imaginative Art Form* ,[394] Lockhart argues for math education in which students are exposed the creative work of

393 Eric Gutstein, *Reading and Writing the World With Mathematics: Toward a Pedagogy of Social Justice*, (New York: Routledge, 2006), 46-48.

394 Paul Lockhart, *A Mathematician's Lament: How School Cheats Us Out of Our Most Fascinating and Imaginative Art Form*, (New York: Bellevue Literary Press, 2009).

mathematicians, as opposed to a rigid curriculum like that of the *Common Core State Standards for Mathematics*.

Lockhart wants math education to emphasize the mathematical behaviors of problem-solving and mathematical reasoning. He emphasizes these aspects as the essence of mathematics, exalting them to the status of the "purest of the arts ... [Math] allows more freedom of expression than poetry, art, or music."[395] He makes this claim of purity because mathematics is purely imaginary, having no formal reliance on "physical properties of the universe."

An example of Lockhart's may help understand for those with little background in the art of mathematics. He narrates the process of the mathematical reasoning related to the area of a triangle as follows:

> I might imagine a triangle inside a rectangular box. I wonder how much of the box the triangle takes up -- two-thirds maybe? The important thing to understand is that I'm not talking about this *drawing* of a triangle in a box. Nor am I talking about some metal triangle forming part of a girder system for a bridge. There's no ulterior practical purpose here. I'm just *playing*. That's what math is -- wondering, playing, amusing yourself with your imagination.[396]

Lockhart continues by describing this example's serendipitous moment, when he decides to draw a line such as the dotted one in Figure 7-1.[397] The moment leads to the reasoning that the triangle takes up half the area of the rectangle.

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395 Ibid., 23.
396 Ibid., 24.
397 Ibid., 26.

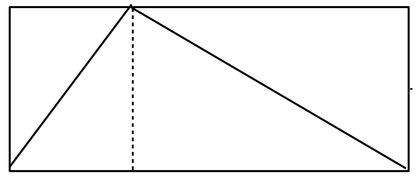

Figure 7-1

He concludes: “This is what a piece of mathematics looks and feels like. That little narrative is an example of the mathematician's art: asking simple and elegant questions about our imaginary creations, and crafting satisfying and beautiful explanations. There is really nothing else quite like this realm of pure idea; it's fascinating, it's fun, and it's free!”[398]

Lockhart describes what might be termed artistic mathematics, and this is lacking in Marxist math education's singular goal of quantitative literacy. Lockhart suggests that the point of this mathematics education is primarily for fun: “The only thing I am interested in using mathematics for is to have a good time and to help others do the same. And for the life of me I can't imagine a more worthwhile goal.”[399] I argue a connection between Lockhart's artistic math education and what some call education for social justice, democracy or freedom from oppression. This connection occurs via the writings of Herbert Marcuse and Maxine Greene. It begins with Marcuse's reflection on the emancipatory aspect to art: “The autonomy of art reflects the unfreedom of individuals in the unfree society.”[400] As Lockhart suggests, artistic mathematics is perhaps the most autonomous of all arts. These mathematical behaviors are playful, imaginative and creative endeavor. Using this view of artistic expression's role in emancipation from

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398 Ibid., 26-27.
399 Ibid., 106.
400 Herbert Marcuse, *The Aesthetic Dimension: Toward a Critique of Marxist Aesthetics*, (Boston: Beacon, 1978), 72.

political and economic oppression, some consider the inclusion of arts education in such a social justice education. Artistic math education represents another imaginative space, similar to writing fiction, for students to "release their imaginations," in the spirit of Maxine Greene.[401]

Therefore, I suggest that math education should include artistic mathematics, as Lockhart describes. I have personally experienced the joy he describes in artistic mathematics, primarily when I was a pure math major in college (and not when I was a K-12 math student in public school). The closest I ever came to teaching artistic mathematics for K-12 students was when I advised the math team at a public high school in New Jersey. There, I opened the team to all students and managed to have participation from a wide range of the student population, including students from all "levels" of math as well as students from among the school's diverse population. For materials, we primarily drew upon the math contests written by the Mathematical Association of America (MAA) and another group called Math League, comprised of two former high school teachers. Both sources offer problems that require students to be creative, requiring them to reason about imaginary worlds and solve problems that they had not encountered in their math instruction. I witnessed several of these students share in the joy that Lockhart describes. We may not have won many competitions, but a variety of students' mathematical artistry blossomed.

I bring this example up to illuminate one weakness in Lockhart's thinking. My math team's members were not coerced to participate. Lockhart seems to think that

401 Maxine Greene, *Releasing the Imagination*, (San Francisco: Jossey-Bass, 1995).

everyone will share his appreciation for artistic mathematics or agree that it is the purest, most creative of all art forms. He also comes close to asserting that artistic mathematics is the primary and superior mathematical behavior. I argue that basic math facts and procedures are mathematical, that applied mathematics (and quantitative literacy) are mathematical, and that artistic mathematics is mathematical. Accordingly, all have a place in this thing we call math education. Students should be exposed to these varieties of mathematical behavior, and encouraged to select the ones that they would enjoy most. I have known several students who have as joyous a moment when learning and performing math facts and procedures, and the same can be said for those who find mathematical application and/or quantitative literacy satisfying.

The goal of math education is to increase the knowledge and use of mathematics, and an effective means to achieve goals in education come from non-coercive practices. Alfie Kohn regularly suggests that a student should be motivated only with the intrinsic desire to learn.[402] Another, Seymour Sarason, suggests that the extrinsic motivation of school grades causes the motivation to learn to steadily decrease as the number of years in school increases.[403] For one, students should be intrinsically motivated to study mathematics, and after reasonable exposure to the variety of mathematical behaviors, encouraged to choose for themselves their area of focus, if at all. Math class could become a happy place, contrary to its current anxiety inducing form.

Such non-coercion should exist for teachers as well. Math teacher autonomy

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402 e.g. Alfie Kohn, *The Schools Our Children Deserve: Moving Beyond Traditional Classroom and 'Tougher Standards,'* (New York: Houghton Mifflin, 1999), 97-98.

403 Seymour Sarason, *The Skeptical Visionary: A Seymour Saraon Education* Reader, Temple University Press, 2003, 167.

allows teachers to develop instruction suited for their students. It requires passion for math and appreciation of all its behavioral forms, be it math facts and procedures, applied math or artistic math. These characteristics are not always the product of someone who is already a math enthusiast, but one who is willing to explore and learn. In other words, an interest in ideas and willingness to learn and communicate them should be the only requirement for becoming a math teacher. Such intellectualism is the only proper requirement for teachers when the goal of schooling is to engage with humanity's knowledge.

These alternatives I sketch apply to both teachers working within national math education's forces and those outside. The type of math education I describe would find a happy home in schools rooted in the anarchist tradition, such as the Albany Free School. There, students come to know ideas through their own natural curiosity.[404] However, for those working in public schools, there are formidable obstacles due to the forces of national math education, such as the fact that their job status will likely be tied to their effectiveness in delivering mandated, traditional and coercive curriculum. I suggest that this reality be balanced by each and every effort, no matter how small, that affords students' exposure to other mathematical behaviors and educates them in the political structures that are determining their math education's focus. Activism can also occur outside the classroom, with acts that disseminate these realities and push against their vitality.

Absent from this sketch is the goal of education that prepares its students for work

[404] See Chris Mercogliano, *Making It Up as We Go Along: The Story of the Albany Free School*, (Portsmouth, NH: Heinemann, 1998).

and jobs later in life. I agree with educators who believe schools should simultaneously prepare students for engaging in democracy to affect change as well as give them the skills necessary to gain employment and earn a middle class life. This alternative sketch leaves out the latter element because to include such would de-emphasize a primary argument in this dissertation: that math education should not be a means to sort people into economic categories. In other words, I reject the "math is a new civil right" idea because there is little reason for Algebra to be a gatekeeper to economic success. Instead, whether or not schools sort students into producers and professionals, producers and professionals should not result in differing economic categories. Finally, I understand that this appeal may be frustrating to parents who want their children to be prepared for today's jobs. My sketch indicates a vision to work towards, and intermediate educational visions should include preparation for jobs in addition to preparation for changing the world.

This concludes my sketch of alternatives to the trends in national math education. I have suggested that such alternatives be motivated by exposing students to the variety of mathematical behaviors. This will afford students the chance to develop positive relationships with math, or no relationship at all. What will certainly not occur are the most common relationships to math seen today: the negative “math-phobias,” math anxieties and math-hatred. In the final section, I call on the minority who do have a positive relationship to carefully consider the broad implications of my analysis of national math education.

An Appeal to Fellow Math Enthusiasts

In this final section, I assert my place among fellow math enthusiasts, those who enjoy mathematics in one or all of its forms and ask the community to consider the implications of my analysis of national math education. Specifically, I ask that we consider carefully the source of mathematics' superiority and, thus, the reasons we may enjoy esteem. Following, I recommend to a subset of the community, those with the true interest of increasing the knowledge and use of math, to divorce themselves from the co-opting of said goal by the development of human capital and the world of educational business.

I am a math enthusiast. This means I enjoy mathematical thinking in a variety of ways and am eager to share this joy with others who seem interested. As far as the particulars, I share Lockhart's enthusiasm for artistic mathematics and also have a passion for statistics and quantitative literacy. By pursuing teaching math, rather than research in math, I made the choice to focus on the sharing aspect of my enthusiasm for math. The private work of doing math thus became more a hobby and not a focus. Over some years of teaching math in high school, I found myself up against very significant forces that prevented me from sharing my enthusiasm in meaningful ways. This led me to study educational policy, and in particular, the politics of math education.

As I have stated throughout this dissertation, my primary finding is that math education is used as a means to develop a productive workforce. This is an appropriation of knowledge that I am enthusiastic about and for aims that I consider to perpetuate injustice. As Michael Apple[405] indicates, corporations find math knowledge useful and thus require it be controlled. I have put forth that their interests, coupled with educational businesses, encourage a math education that prevents people from knowing math and instead is used as a method of sorting people into their economic roles in life, as well as inculcating in them a productive disposition. Therefore, corporate power is both the source of math's superiority and the reason why so many have no positive relationship with it.

I urge math enthusiasts to recognize that corporate power prevents so many from appreciating its knowledge. Doing so then requires that we enthusiasts reject corporate power, as well as its claim for math's superior status. I am guessing that my request appeals to math enthusiasts who already hold suspicions about corporate power; but I do suggest that those who are sympathetic to corporate power can at least recognize how it negatively impacts humanity's relationship to math.

What does rejecting corporate power and math's superiority look like? Here are a few examples. It would require enthusiasts who do math to do it for math's sake or for other sakes not associated with corporate profit. This would limit, for example, a mathematician's accepting of funding from a variety of sources, including the National Science Foundation (NSF).[406] For the enthusiasts who share math (like teachers), it would ask them to not accept extra pay from corporate-funded programs like Math for America. Or, they would recognize the importance of exposing students to all of humanity's

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405 Apple, "Do the Standards Go..."

406 As I have suggested elsewhere in this dissertation, NSF, as a government agency, is embedded with corporate interests.

knowledges, thus advocating for the return of arts and music education. Remember, math education is only deemed valuable for its usefulness to corporate profit, be it the development of human capital or as a place for educational business to make money.

On that note, I appeal more specifically to the subset of math enthusiasts who truly want an educational system that can share they knowledge with others. Specifically, I am directing attention to the math education researchers and especially those who are involved in educational policy. As I suggested in chapter 4, this group of individuals is advancing their particular pedagogical perspective by aligning it with the interest to develop human capital. This has been best expressed by the National Council of Teachers of Mathematics (NCTM), the voice of US math education research. My analysis has shown that alignment between progressive education and human capital development has failed. In this case, such alignment has been deceptive for the math education research community.

As I also indicated, many in the math education research community align with the goals of the testing industry. The industry's goals are already negatively impact any progressivist perspectives on math education. Such alliances will not promote the inclusion of artistic math and quantitative literacy into national math education lacks. The community may do best to reject the notion of national math education and instead advocate for teacher autonomy. I am urging the math education research community to divorce themselves from both the corporate interest of developing human capital and the testing industry. Neither alliance has served the community well. I am also urging this community to reconsider their focus on teacher knowledge. As I suggested in chapter 5, the math education community's focus on teacher content knowledge has allowed the human capital interest to target the teaching profession. The math education research community's work in this area provides the political will to make firing teachers easier and job conditions worse. As the voice of this academic community, I am not sure that the NCTM lives up to its name.

Thus concludes my appeal to math enthusiasts generally, and with a specific appeal to those working to improve math education. I have suggested mathematics enjoys superior status for its relevance to corporate power and also how corporate power prevents math from being enjoyed by several people. Therefore, math enthusiasts must reject mathematics' superior status. I also cautioned the math education research community against aligning with corporate interests. Not only has this resulted in policy that betrays the goals of math education, it has betrayed math education's greatest resource, math teachers.

This concludes the final chapter of this dissertation. Here I have summarized the primary findings of my analysis of the social network surrounding national math education. These included the competing interests of developing human capital and educational business, and the academic interests of progressive vs. traditional math pedagogy and teacher content knowledge deficits. I argued that competing trends in national math education indicate significant problems with the emerging policy, such as the exclusion of the particular math behaviors of problem-solving, mathematical reasoning and quantitative literacy. Yet another problem in national math education is the discouragement of math enthusiasts from entering the math teaching profession. In response, I sketched an alternative to national math education, one that emphasizes math for democracy and for personal satisfaction. Therein I also provided examples of how math teachers can resist national math education. Finally, I called to fellow math enthusiasts for the rejection of math's superior status, and to fellow math education enthusiasts for the rejection of corporate interests.

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