**An Introduction to Mathematics Capital in Mathematics Education**

**Frances E. Anderson[[1]](#footnote-2)**

University of Nebraska at Omaha, USA

francesanderson@unomaha.edu

Seminal research in social, cultural, financial, and science capital defines capital by explaining that capital positively influences a person’s outcomes in the context in which it is being described (Archer et al., 2014; Archer et al., 2015; Bourdieu 1977, 1998; Coleman 1988). One factor with limited representation in research is the concept of mathematics capital (Williams & Choudry, 2016). Recent educational research has sought to level the playing field for all students, creating justice for our comprehensive population (Safir & Dugan. 2021). Mathematics education research has successfully identified factors that influence student success in mathematics without identifying *mathematics capital* as an underlying factor of a student’s outcome in mathematics (NCTM, 2014). Capital experts report that capital exists as an overarching power in any definable context (Bourdieu, 1977; Coleman 1988). Mathematics education is an established, well-defined context, suggesting that *mathematics capital* is an operationalizable phenomenon.

Bourdieu explains that researchers must consider whether they are subjects within their research field. If the researchers are a part of the subjects, the research will not remain without influence (Bourdieu, 1990). Operationalizing *mathematics capital* offers the opportunity to reimagine the mathematics education field holistically. This view will provide a clearer vision of mathematics education, and individual student needs; any stakeholder in the field of mathematics education, be it mathematics learners, teachers, researchers, or other will know that mathematics outcomes lack the integral descriptor, *mathematics capital*, and this descriptor influences mathematics success**.**

**Social Capital and Coleman**

Searching for misunderstood facets of our social world, we discovered an undervalued and interconnected variable: social capital (Bourdieu, 1986). Refined by Coleman, social capital began to describe the human social potential and is inherent connectedness to financial and human capital, impacting a person’s potentiality and opportunities in their lifetime (1988). As a society, the phrase, “It’s not what you know but who you know” is well-known and socially acceptable. When something so powerful and interconnected controls our relational sphere and potential life outcomes, it is reasonable to wonder if this same interconnectedness is hidden in other spaces, impacting outcomes.

Similarly, social capital can be measured by the number of potential exchanges within the relationships of the actors in a community, how many communities each actor is connected to, and the diversity of actors’ connected communities. Communities must be built so that the parties are closely intertwined, offering each actor opportunities to draw from the network independently. Social capital withdrawals are only possible if the giver chooses to release to the receiver, which is why social capital is vastly underutilized in comparison to the other forms of capital (Bourdieu, 1977, 1986; Coleman 1988, 1990; Hoenig, 2003; Putnam, 1995). Social capital has been studied in educational contexts, in the home, and the workplace (Furstenberg & Hughes, 1995; Driskell et al., 2012; Archer et al., 2015; Teachman et al., 1996). In essence, social capital is the concept that “it takes a village” to raise a child, having a village to rely on, and choosing to rely on the village (Hanifan, 1916).

Coleman (1988) introduces capital as a web-like structure where he finds all forms of capital are intertwined and passed down through families. Human capital cannot make its way to children if the home’s social capital is nonexistent. Parents' relationship with their children is the determining factor of whether their human capital is passed down. In line with the funds of knowledge concepts from Esteban-Guitart and Moll (2014) who state that a person’s capacity to value and identity with specific things is oftentimes in close relationship to how their parents value and identified it. Thus, this interdependent nature of constructs is not secular to capital, but instead crosses over in a multidisciplinary fashion.

Bourdieu agrees with capital’s interdependency by finding economic capital as the root of all forms of capital and that “the convertibility of the different types of capital is the basis of the strategies aimed at ensuring the reproduction of capital” (1986, p. 25). Capital presents as a web of intertwined opportunities, fighting to protect those in it and holding firm to keep others out, whether this is intentionally, or unintentionally, is still negotiable (Nolan, 2012).

**Social and Ancillary Capital**

Extensive capital research has been done in educational contexts (Teachman et al., 1996; Turnball et al., 2019). Thus, social capital and its impact on education remain highly prevalent in research today while being described as early as 1916. Hanifan (1916) explains that when the school, families, and the community work together to build relationships, student outcomes improve. Specifically, the products are better attendance, and more family and student engagement. Paralleling these products are successful improvements within the community. Researchers conclude with certainty that their work resulted in positive outcomes.

Dewey (1899) describes the ideal home for a student and how this yields optimal educational results. “When children are invited into household tasks, the children have more opportunities to gain knowledge” (1899, p. 17). He continues by discussing the differences between youth and how these differences arm each child uniquely. These differences are highly predictive of the student’s success and skill development which foreshadows the description of cultural and social capital.

Intentional development of skill, access to financial power and flexibility, access to machinery, or strong connections with a community or communities creates advantages (Bourdieu, 1977, 1986; Coleman, 1988, 1990). In literature, these advantages are now referred to as capital (e.g., human, social, physical). And yet, advantages have been alluded to in the way of skill development, financial power, machinery, or community since 1776 and possibly before. Smith (1776) alludes to what is now known as human capital via an array of positions that labor men have by contrasting their ability to perform each skill based on their prior experience with the noted skill. His discussion of nails notes that one untrained man could make two to three hundred nails of poor quality in a day. Smith notes, “I have seen several boys, under twenty years of age, who had never exercised any other trade but that of making nails, and who, when they exerted themselves, could make, each of them, upwards of two thousand three hundred nails in a day” (p. 4).

Coleman, in 1988, explained that social capital was no longer theoretical but instead conceptual. Although still used in a “theoretical enterprise,” social capital has been operationalized and validated as a measure of function and opportunity that exists within social spheres. Coleman’s work continues to reframe and expand social capital under the umbrella of education. This reach is not unreasonable, instead quite fitting when mirrored with Dewey’s work in 1899, where social capital, although not operationally defined, was first introduced and theorized as described above. With an overarching goal to present a new perspective for consideration in mathematics education research, it becomes relevant to consider describing mathematics capital similarly to social, cultural, and human capital.

**Research Question**

The research question proposed for this work is: Is there an underlying, operationalizable phenomenon, *mathematics capital*, that has otherwise not been described, offsetting individual student outcomes in mathematics education? Is it possible to design a structure such that the beginnings of such a term, mathematics capital, can be imagined?

**Conceptual Framework**

Through a Bourdieusian lens, it can be argued that researchers can consider mathematics education as a field within which *mathematics capital* can be termed (Bourdieu, 1977, 1986, 1990; Bourdieu & Wacquant, 1992). Within such a lens, subjective and objective are retired, and instead, finite concepts are defined: *capital*, *field*, *habitus*, and *doxa*. An abbreviated explanation of each follows.

*Capital* is an overarching power that exists within a described field. This power influences the way people find success in the field. *Field* is any closed circuit that can be captured and described. Within this description, we can make clear what are considered gains and what are considered losses. Further, we know people’s lives are impacted within the described field. *Habitus* is what is understood as acceptable actions within the field. Said differently, habitus could be considered acceptable status quo. *Doxa* is the acceptable actions that are found in the unconscious mind, as it reigns over all people both willingly and unwillingly (Bourdieu, 1977). Capital can also inform people about acceptable habitus, which again only more positively influences persons within the field. When capital is described in the field, it is delineated from the word capital and instead is captured as a short sentence, two words where the precursor describes the field. For example, if one wanted to discuss the capital that exists within social structures, the phrase “social capital” would be used. Likewise, if one wanted to describe how capital exists in the world in how it relates specifically to the exchange of money and the strength of wealth, “financial capital” would be used.

**Contemporizing Bourdieu**

Bourdieu refines capital when he attaches to the arts, highlighting his reasoning founded in the positive social attainment that an affinity for the arts offers (1984). As the Science, Technology, Engineering, and Mathematics (STEM) world continues to impact social outcomes in many areas, it seems reasonable to extend Bourdieu’s original concepts of capital attached to the arts that inform social advantage to mathematics attainment. The reason for this is that mathematics outcomes can substantially impact people’s futures. This was first extended by Archer and colleagues when they termed *science capital* (2015). Thus, *mathematics capital* is adopted as the overarching power that exists within mathematics education, where mathematics capital informs outcomes of people either reproducing advantage or disadvantage.

All components of mathematics education are presumed intertwined, and all forms of capital are intertwined (Bourdieu, 1984; Martin, 2009). It is theorized that this perspective will add to the literature by contemporizing Bourdieu and connecting what is said in current mathematics education research along with the results of the achieved success as a result of positive outcomes in mathematics education. One example is that currently, people who work in the STEM field (thus having been successful in math) typically earn substantially more income than their counterparts (Fayer et al., 2017). A theoretical and contemporary bridge connects capital, field, habitus, and doxa to a Bourdieusian perspective, to mathematics education today for mathematics capital to be operationally defined (Bourdieu, 1977, 1984, 1986, 1990).

**Mathematics Education Research**

Mathematics is a constant subject of conversation, as it has been for so many years. Nevertheless, this conversation is valid. A student’s outcomes in mathematics are directly related to their performance in many academic areas (Pong, 1998; Rose & Betts, 2001). Not only is mathematics a predictor of student performance in other areas, but lack of mathematics success also holds people back in STEM. One may question relevance again, but this author continues by highlighting income discrepancies between STEM occupations and non-STEM occupations by nearly half that of the first (Fayer et al., 2017; Rose & Betts, 2001) which means that mathematics success can impact how much money a person makes over a lifetime.

 To date, researchers have considered math achievement and outcomes based on specific areas, considering items individually. Researchers have been focused on groups of people; how one area or characteristic might contribute to overall mathematics success (Boaler et al., 2016; Bulková et al., 2020; Jorgensen & Larkin, 2017; Jorgensen, 2018; Martin, 2013; Navarro, 2012; Singh, 2002; Xu et al., 2021). This work does not stand in contrast with previous work. Instead, this work is to creatively connect all previous work in mathematics education aiming to find out why each person is individually successful in mathematics.

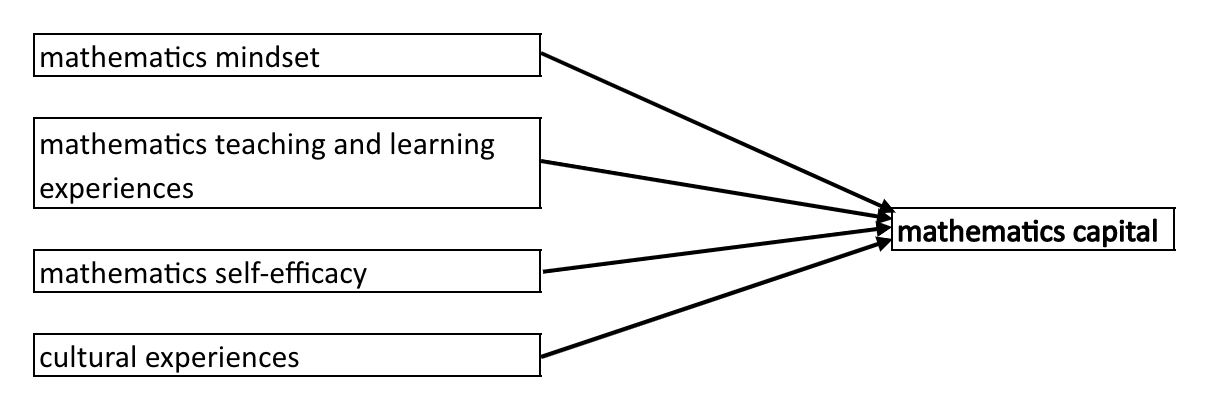
Mathematics research often focuses on subgroups to analyze mathematics achievement. In this research, each person is considered individually as a player in the field, such that each person’s outcome remains unattached to any subgroup. This perspective offers the nuance to consider a holistic perspective on a person’s mathematics achievement; this is fluid and changing due to different people's mindsets, experiences, self-efficacy, and culture. This influences their mathematics capital and, thus, their outcomes in mathematics education.

**Mathematics Capital–Contemporizing Bourdieu’s Work–A Four-Part Model**

Bourdieu’s 1984 work, Distinction, describes how preferences, specifically taste (in art selection and more) can work to impact a person’s social mobility. Bourdieu categorizes and defines a person’s ability to exist in “higher” cultures based on an analysis of their taste. This is the first example of considering how people are treated individually to determine how the person fairs long term. Archer et al. (2014) introduce *science capital* showing that science capital is a relevant extension of capital, embodying cultural, social, and symbolic capital as science capital impacts a person’s financial outcomes. A year later, Archer et al. (2015) refined and adapted Bourdieu’s work, to describe and quantify the term *science capital*. Within this, researchers use a three-part model, for means to consider each person individually and measure their levels of science capital to quantifiably verify whether this impacts their science achievement. These authors conclude by stating that science capital should not be conditioned; it should simply be understood so that the social structure in which science outcomes are so vastly divided can be better understood (Archer et al., 2015). For this paper, Bourdieu and Archer et al. interact to develop the four-part model to begin to describe *mathematics capital*. *Mathematics capital’s* four-part model includes the layer of mathematics mindset that is unique to mathematics education literature and developed by Jo Boaler (2015). The conceptualized four-part model is based on *mathematics mindset,* *mathematics teaching and learning experiences, mathematics self-efficacy,* and *cultural experiences* where each part of the model impacts a person’s mathematics capital.

**Figure 1**

*The Conceptualized Model*



***Mathematics Mindset***

Jo Boaler studies high school mathematics while comparing the outcomes of males to females. Within this, she highlights the authoritative approach to mathematics teaching and learning in their setting, explaining that it impedes the high-achieving females from learning and that it did not for the males. This author closes by differentiating between mathematics and school mathematics, stating that the beauty within mathematics is often eliminated as it is introduced in schools (Boaler, 1997).

So then, mathematics teaching has centered around a set of checklists and not on individualized understanding or connection to mathematics, as many subjects are taught, as described by Boaler (1997), creating a noticeable divide between the act of learning and what we define as mathematics in K-12. Brown (2010) continues to establish that mathematics is one of the only subjects that has not adapted to cultural changes; instead, the standards and content today is very much the same as what it was many years ago. He finds value in the fluidity of ideas taught as it establishes relevance to current events.

***Mathematics Teaching and Learning Experiences***

In 2014 the National Council of Teachers of Mathematics (NCTM) released a publication to specify recommendations for mathematics teaching and learning with six guiding principles for school mathematics and eight recommended mathematical practices for mathematics teachers. This guide explicitly details recommended teacher and student actions within the eight practices and research analyzed and executed mathematical tasks (NCTM, 2014). This publication followed NCTM’s 2000 book, where NCTM leads with six other, slightly different guiding principles. However, NCTM focuses here on the content and five process standards, what a mathematics learner should do while doing mathematics, to describe details of high-quality mathematics education (NCTM, 2000). Jo Boaler works reverently to research mathematics mindset and the impact that mindset has on mathematics (2015a). Boaler’s research extends to understanding how the brain works, specifically how synapses fire while working with mathematics, as evidence that all students can learn mathematics. Modifying the learning environment offers more opportunities for all students and publishes many examples of this work in action (Boaler, 2015b, 2019).

*Mathematics teaching and learning experiences*, embodied by cultural and economic capital (Bourdieu, 1986), will be defined as, but are not limited to: (a) a person’s school-aged experiences in mathematics learning via courses took toward graduation; (b) a person’s experiences in STEM courses that specifically teach mathematics content; (c) a person’s workplace experiences, while in school, where their position requires learning of mathematics or continued use of mathematics; (d) a child’s experiences with mathematics prior to attending formal schooling, in the home, in daycare or in informal preschool; (e) an adult’s experiences after leaving formal education; (f) a person’s workplace experiences, after leaving formal education, where their position requires learning of mathematics or continued use of mathematics; and (g) a person’s time devoted to strengthening mathematics skills in the way of homework practice, tutor, parental support.

***Mathematics Self-Efficacy***

Self-efficacy (i.e., a person’s belief or perception of their ability to complete specific tasks) through a Bourdieusian lens, connects the concentric spheres of social influence in Bourdieu’s theory of social capital (Bandura, 1977, 2002; Bourdieu, 1986). The synthesis of these two theories places the individual as the center most sphere. Within the primary sphere exists the person and their interactions with the various components that form Bandura’s theories of self-efficacy and one’s own sense of self (1997). The learners’ experiences form through practice and observation, mastery and vicarious experiences, and with formal instruction in school. Within social interactions, learners access resources available to them to support their learning.

*Mathematics self-efficacy,* embodied within Bandura’s theory of self-efficacy and Bourdieu’s theory of social capital, will be defined as, but is not limited to: (a) a person’s belief in themselves as mathematics learners, in and out of mathematics classes; (b) a person’s agency as it relates to mathematics and (c) a person’s identity in mathematics.

***Cultural Experiences***

Cultural capital can influence a child’s success in education. Sella & Kadosh (2018) question the biological, cognitive, motivational, and external factors for individuals who enter STEM fields using their cultural capital as a descriptor. Other researchers use empirical evidence to show that school transfers can impact social capital, increasing the likelihood that a student will drop out of school early (Teachman et al., 1996). Sella & Kadosh’s views parallel Turnbull et al. (2019) when they show that physics, the whitest, male-dominated STEM field, continues to increase the attrition of women which perpetuates the viewpoint that physics is a white, male-dominated field.

Archer et al., consider the crossover of cultural capital to science. Using Bourdieu’s preliminary thoughts from 2005 where science capital is first termed, these authors investigate:

scientific forms of cultural capital (scientific literacy; science dispositions, symbolic forms of knowledge about the transferability of science qualifications), science-related behaviors and practices (e.g., science media consumption; visiting informal science learning environments, such as science museums), science-related forms of social capital (e.g., parental scientific knowledge; talking to others about science). (Archer et al., 2015, p. 929).

C*ultural experiences*, embodied within cultural capital (Bourdieu, 1986), will be defined as, but are not limited to: (a) a person’s economic background; (b) a person’s voluntary social activities; (c) the value placed on mathematics and on education as a whole in the home; (d) the value placed on mathematics and on education as a whole in the person’s social circle(s); (e) a person’s non-STEM educational experiences; (f) a person’s experience from the viewpoint of their race or ethnicity; (g) the influence of a person’s self-identified cultural group’s value of mathematics; and (h) a person’s chosen role models and how these role models view mathematics.

**Discussion**

Immanent regularities suggest constants across all subjects that should be considered as we develop, criticize, and synthesize ideas. The goal of this research is to learn more, yet to learn it in a way that provides consistent, predictable understandings to either continue a discovered path of opportunity or to make corrections where paths of impossibility appear. And if there was a constant that existed to predict an individual’s likelihood for success, wouldn’t this be of interest? Furthermore, what if this constant existed in every form of success that a person could have? Not just social and financial, but for this work, what if it were mathematics?

  Capital is a power that holds ultimate reign over every field (Bourdieu, 1977, 1986) where similar patterns emerge as evidence of capital, existing within all *fields*. Truthfully, mathematics does not necessarily exist self-contained (Lakoff & Núñez, 2000), but mathematics success and ideas are described and can be measured in a self-contained way in formal education, as it has been done. In that, consistency of nuanced containment exists such that mathematics capital is convertible, similar to the other forms of capital (Bourdieu, 1986).

  If mathematics education is a *field*, then within this field, mathematics capital must be describable (Bourdieu, 1977, 1986). Acting exactly as social capital, higher amounts of social capital positively impact one’s ability to be successful in the social realm. It can be considered that higher levels of mathematics capital can positively impact a person’s mathematics education/outcomes. Social capital informs a person's outcomes or successes in social spheres. Then, if we have adequately measured mathematics capital, mathematics capital should be directly related to mathematics success.

Coleman argues with sociologists who attempted to individually describe the economic, intellectual, and social organization as necessary to revise and reconsider a new framework that includes social capital.  Struggling to tangible define social capital, Coleman instead describes social capital by its function. The function of social capital is not exclusive, instead inclusive and has a pair of common elements. These two elements are (a) aspects of social structures and (b) aspects of the actions of the actors within the social network (1988). Coleman continues by stating that “social capital is productive, making possible the achievement of certain ends that in its absence would not be possible” (Coleman, 1988, p. S98).

A continuous stream of information, including parenting strategies, floods families who actively engage in schools’ social networks. Pong (1998) recognizes that this stream creates a positive compounding effect for the students as parents gain knowledge and resources. College-educated parents continue to offer many different advantages to their children. For example, college-educated parents understand the collegiate experience as they experienced it, versus their counterparts do not, as they did not experience college. Godwin et al. (2015) conclude by noting the importance of further research on first-generation college students and the array of differences and experiences between first-generation college students and students who are not.

Social learning theory identifies learning through two pathways: direct experience and observing the behavior of others, where three regulatory processes, stimulus control and reinforcement control, influence a person’s choices. Bandura finds the nuances in action predictability as cognitive factors that always impact a person’s observations and feelings, which are influenced by past experiences. These nuances significantly impact a person’s learning (Bandura, 1977).

We learn from those around us, in what they do, say, and in their actions, founded by Bandura (1977) where either a person directly experiences something or observes a behavior; the brain works to process actions/words/reactions of others and to notice the environment. Learning by the example of others and with others offers us the ability to learn more with less. Mathematics researchers agree with this constructivist approach to learning by many researchers concluding that math learners must do the math themselves to understand mathematics as opposed to being told how to perform mathematics problems (Boaler & Greeno, 2000).

Writing from Williams & Choudry (2016) supports Archer et al. by clarifying the differences between Marx and Bourdieu where Bourdieu’s focus remains primarily with capital attached to a subject (e.g., social, cultural). Williams and Choudry establish a difference between the ability to apply mathematics learned in school as an adult to having been successful in mathematics to move the person through new, higher-level fields and employment positions (e.g., getting into an ivy league school requires high scores on the SAT but that student doesn’t necessarily need to remember the mathematics learned after the test has been taken).

**Conclusion and Implications**

If someone is both arithmetically competent and a master of extensive mathematical knowledge, then does this make them have a math mind? Stated another way, does mathematical competence combined with mathematical expertise mean that a person has natural mathematical ability, or could it instead be the simple result of extensive time spent with mathematics? Sella & Kadosh’s (2018) findings lead to more questions on investigating whether cognitive differences exist between math experts and non-experts. Specifically, these researchers notice that the brain fires in the same way as math experts and non-experts.

And yet, the comments like, “I’m not a math person” still stampede our culture and classrooms (Hachey, 2009; Kimball & Smith, 2014; Willingham, 2009). Research shows that those who carry on in mathematics are not always the young children identified early on as mathematically gifted. Instead, students who persevere through high-level mathematics courses, and continue in a career in STEM, are self-regulated learners carrying a specific set of epistemic beliefs and these are those who sustain in mathematics. This author specifically identifies and profiles high-achieving mathematics students and yet, the question of context remains at bay for the author, wondering if the student profile would differ depending on the function of the domain in which the profile exists (Muis, 2008).

So then, consider exploring what early life indicators predict a student’s early life academic success. When this is unpacked, we instead notice not that intelligence, as difficult as it is to measure, is routinely not able to be disentangled from patterns of behavior. In fact, in educational psychology, a child’s ability to regulate themselves can either impede or expedite a child’s ability to learn. Self-regulation plays a critical role in the child’s ability to utilize their working memory (Shing et al., 2010). Even more, executive functions and attentional processes where both a child’s ability to pay attention and their ability to control themselves overlaps so vastly that they are measured together, as an umbrella term, in some studies (Poutanen et al., 2016), where executive functioning is a set of cognitive processes (e.g., inhibition, working memory) and attentional processes are related to a person’s ability to orient themselves.

Previous math success is a predictor of current and future mathematics outcomes, alongside the importance of preparedness in mathematics and mathematics success. So much so that early school success in understanding fractions and whole numbers outweighs and predicts a student’s success in mathematics over the intelligence quotient, socioeconomic status, and parental education (Siegler et al., 2012). Basque and Bouchamma study Canadian eighth graders alongside teachers and administrators to find two very specific things. The first is that by eighth grade, 50% of the variance that exists between students is determined by a student’s mathematical success in fifth grade. This supersedes other predictors like socioeconomic status and parents’ academic achievement. These authors close by stating the importance of early intervention for schools (2016).

Math readiness is a widely used term for students at many grade levels and is found to be the strongest predictor of success in mathematics courses (Li et al., 2013). Quality preparedness for collegiate mathematics remains a focal point of mathematics education research, especially due to the lack of success connected to remedial math courses in college (Xu & Dagar, 2018). Further, even when obstacles like remedial coursework to take college-level mathematics are removed, students who meet all necessary academic requirements and are able to begin in their college mathematics courses are more successful (Atuahene & Russell, 2016).

Lastly, common misconceptions in mathematics could become a topic of conversation as student mistakes made in mathematics rarely change; instead, the same errors are repeated at each level. In research, we find the topic of fractions studied at almost every grade level in K-16 (Clements & Sarama, 2004; Fuchs et. al, 2016; Jordan et al., 2016; Li & Kulm, 2008). What does this mean if prior success is a predictor of future success and even more, all the same mistakes continue to be made from preschool through college?

**References**

Atuahene, F., & Russell, T. (2016). Mathematics readiness of first-year university students. *Journal of Developmental Education, 39*(3), 12-20.

Archer, L., DeWitt, J., & Willis, B.  (2014).  Adolescent boys’ science aspirations:  Masculinity, capital, and power.  *Journal of Research in Science Teaching, 51*(1), 1-30.

Archer, L. Dawson, E., DeWitt, J. Seakins, A. & Wong, B. (2015).  “Science capital”:  A conceptual, methodological, and empirical argument for extending Bourdieusian notions of capital beyond the arts.  *Journal of Research in Science Teaching,* *52*(7), 922-948.

Bandura, A. (1977). *Social learning theory.* Prentice Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. W.H Freeman and Company.

Bandura, A. (2002). Social cognitive theory in cultural content. *Applied Psychology: An International Review, 51*, 269-290.

Basque, M., & Bouchamma, Y. (2016). Predictors of mathematics performance: The impact of prior achievement, socioeconomic status and school practices. *International Studies in Educational Administration, 44*(1), 85-104.

Boaler, J. (1997). Reclaiming school mathematics: The girls fight back. *Gender and Education, 9*(3), 285-305.

Boaler, J. (2015a). *Mathematical mindsets: Unleashing students’ potential through creative math, inspiring messages, and creative teaching*. John Wiley & Sons.

Boaler, J. (2015b). *What’s math got to do with it?: How teachers and parents can transform mathematics learning and inspire success.* Penguin Books.

Boaler, J. (2019). *Unlocking children’s math potential.* Parents League Review.

Boaler, J. Chen, L. Williams, C., & Cordero, M. (2016). Seeing as understanding: The importance of visual mathematics for our brain and learning. *Journal of Applied and Computational Mathematics, 5*(5), 1-6.

Boaler, J. & Greeno, J. (2000). Identity, agency and knowing in mathematics worlds. In J. Boaler (Ed), *Multiple perspectives on mathematics teaching and learning*. Ablex Publishing (pp. 171-200).

Bourdieu, P. (1977). *The social structures of the economy*.  Polity Press.

Bourdieu, P. (1984). *Distinction:  A social critique of the judgment of taste*.Routledge and Kegan Paul, Ltd.

Bourdieu, P.  (1986). The Forms of Capital. *Handbook of Theory and Research for the Sociology of Education,* 241-258.

Bourdieu, P. (1990). *In other words: Essays toward a reflexive sociology*. Polity Press*.*

Bourdieu, P. (1998). *Acts of resistance: Against the new myths of our time*. Polity Press.

Bourdieu, P. (2005). *The social structures of the economy.* Polity Press.

Bourdieu, P. & Wacquant, L. (1992).  *An Invitation to Reflexive Sociology.* University of Chicago Press.

Brown, Tony.  (2010).  Truth and the renewal of knowledge:  The case of mathematics education. *Educational Studies in Mathematics, 75*(1), 329-343.

Bulková K., Medová J., & Čeretková S. (2020). Identification of crucial steps and skills in high-achievers’ solving complex mathematical problem within mathematical contest. *Journal on Efficiency and Responsibility in Education and Science, 13*(2), 67-78.

Clements, D., & Sarama, J. (2004). Learning trajectories in mathematics education. *Mathematical Thinking and Learning, 6*(2), 81-89.

Coleman, James. (1988). Social capital in the creation of human capital.  *American Journal of Sociology, 94,* S95-S120.

Coleman, James. (1990). *Foundations of social theory*.  The Belknap Press.

Dewey, J. (1899). *The school and society.* University of Chicago Press.

Driskell, S., Dufur, M., Parcel, T., & Troutman, K.  (2012).  Does capital at home matter more than capital at school?  Social capital effects on academic achievement.  *Research in Social Stratification and Mobility, 31*, 1-21.

Esteban-Guitart, M., and Moll, L. (2014). Funds of identity: A new concept based on the funds of knowledge approach. *Culture & Psychology*, 20(1), 31–48.

Fayer, S., Lacey, A., & Watson, A. (2017). *STEM occupations: Past, present, and future.* U.S. Bureau of Labor Statistics. <https://www.bls.gov/spotlight/2017/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future/pdf/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future.pdf>

Leinwand, S. (2009). *Accessible mathematics: 10 instructional shifts that raise student achievement.* Heinemann.

Fuchs, L. S., Schumacher, R. F., Long, J., Namkung, J., Malone, A. S., Wang, A., Hamlett, C., Jordan, N., Siegler, R., & Changas, P. (2016). Effects of intervention to improve at-risk fourth graders’ understanding, calculations, and word problems with fractions. *The Elementary School Journal, 116*(4), 625-651.

Furstenberg, F. F., & Hughes, M. E.  (1995). Social capital and successful development among at-risk youth. *Journal of Marriage and Family*, *57*(3), 580-592.

Godwin, A. Potvin, G. Hazari, Z., Lock, R. (2015).  Identity, critical agency, and engineering majors:  An affective model for predicting engineering as a career choice.*School of Engineering Education Faculty Publications.*  Paper 12.

Hachey, A. (2009). I hate math: What we want young children NOT to learn. *Texas Child Care,* 2-7.

Hanifan, L.J. (1916). The rural school community center. The annals of the American academy of political and social science. *New Possibilities in Education,* *67*, 130-138.

Hoenig, C. (2003). Leadership capital: Strategies for managing your organization’s intangible assets. *CIO.* <https://www.cio.com/article/2440069/leadership-capital---strategies-for-managing-your-organization-s-intangible-as.html>

Jorgensen, R. (2018). Building the mathematical capital of marginalised learners of mathematics. *ZDM Mathematics Education, 50,* 987–998. <https://doi.org/10.1007/s11858-018-0966-9>

Jorgensen, R., & Larkin, J. (2017). Analysing the relationships between students and mathematics: A tale of two paradigms. *Mathematics Education Research Journal, 23,* 113-130. DOI 10.1007/s13394-016-0183-1

Kimball, M., & Smith, N. (2013, October 28). The myth of “I’m Bad at Math”. *The Atlantic.* <https://www.theatlantic.com/education/archive/2013/10/the-myth-of-im-bad-at-math/280914/>

Lakoff, G., & Núñez, R. (2000). *Where mathematics comes from: How the embodied mind brings mathematics into being.* Basic Books.

Li, Y., & Kulm, G. (2008). Knowledge and confidence of pre-service mathematics teachers: The case of fraction division. *ZDM, 40*(5), 833-843.

Li, K., Zelenka, R., Buonaguidi, L., Beckman, R., Casillas, A., Crouse, J., Allen, J., Hanson, M., Acton, T., & Robbins, S. (2013). Readiness, behavior, and foundational mathematics course success. *Journal of Developmental Education, 37*(1), 14-36.

Martin, N. (2009). Social capital, academic achievement, and postgraduation plans at an elite, private university. *Sociological Perspectives, 52*(2), 185-210.

Martin, D. (2013). Race, racial projects, and mathematics education. *Journal for Research in Mathematics Education, 44*(1), 316-333.

Muis, K. (2008). Epistemic profiles and self-regulated learning: Examining relations in the context of mathematics problem solving. *Contemporary Educational Psychology, 33*(2), 177-208.

National Council of Teachers of Mathematics. (2014). *Principles to action.* National Council of Teachers of Mathematics.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* National Council of Teachers of Mathematics.

National Council of Teachers of Mathematics. (2018). *Catalyzing change in high school mathematics: Initiating critical conversations.* National Council of Teachers of Mathematics.

Navarro, J., Aguilar, M., Marchena, E., Ruiz, G., Menacho, I., & and Van Luit, J. (2012). Longitudinal study of low and high achievers in early mathematics. *British Journal of Educational Psychology, 82*, 28–41.

Nolan, K.  (2012).  Dispositions in the field: Viewing mathematics teacher education through the lens of Bourdieu’s social field theory. *Educational Studies in Mathematics,* *80*(1),201–215. <https://doi.org/10.1007/s10649-011-9355-9>

Pong, S.  (1998).  The school compositional effect of single parenthood on 10th-grade achievement.  *Sociology of education, 71*(1), 23-42.

Poutanen, M., Berg, S., Kangas, T., Peltomaa, K., Lahti‐Nuuttila, P., & Hokkanen, L. (2016). Before and after entering school: The development of attention and executive functions from 6 to 8 years in Finnish children. *Scandinavian Journal of Psychology, 57*(1), 1-11.

Putnam, R.  (1995). Bowling Alone: America's Declining Social Capital.  *Journal of Democracy,*65-78.

Rose, H., & Betts, J. R. (2001). *Math matters: The links between high school curriculum, college graduation, and earnings.* Public Policy Institute of California.

Safir, S., & Dugan, J. (2021). *Street data.* Corwin.

Sella, F. & Kadosh, R. C. (2018). What expertise can tell about mathematical learning and cognition. *Mind, Brain, and Education, 12*(4), 186-192.

Siegler, R., Duncan, G., Davis-Kean, P., Duckworth, K., Claessens, A., Engel, M., Susperreguy, M., & Chen, M. (2012). Early predictors of high school mathematics achievement. *Psychological Science, 23*(7), 691-697.

Singh, K., Granville, M., & Dika, S. (2002). Mathematics and science achievement: Effects on motivation, interest, and academic engagement*. The Journal of Educational Research, 95*(6), 323-332.

Shing, Y., Lindenberger, U., Diamond, A., Li, S., & Davidson, M. (2010). Memory maintenance and inhibitory control differentiate from early childhood to adolescence. *Developmental Neuropsychology, 35*, 679–697.

Smith, A. (1723-1790). *An inquiry into the nature and causes of the wealth of nations.* Modern Library.

Smith, M. & Stein, M. (2018). *5 Practices for orchestrating productive mathematics discussion*. National Council of Teachers of Mathematics.

Su, F. (2020). *Mathematics for human flourishing.* Yale University Press.

Teachman, J., Paasch, K., & Carver, K. (1996). Social capital and dropping out of school early. *Journal of Marriage and Family*,*58*(3), 773-783.

Turnbull, S.M., Locke, K., Vanholsbeeck, F., & O’Neale, D.J.R. (2019). Bourdieu, networks, and movements: Using the concepts of habitus, field and capital to understand a network analysis of gender differences in undergraduate physics. *PLoS ONE, 14*(9): e0222357. <https://doi.org/10.1371/journal.pone.0222357>

Williams, J., & Choudry, S. (2016). Mathematics capital in the educational field: Bourdieu and beyond. *Research in Mathematics Education, 18*(1), 3-21.

Willingham, D. (2010). Ask the cognitive scientist: Is it true that some people just can’t do math? *American Educator,* 14-39.

Xu, D., & Dadgar, M. (2018). How effective are community college remedial math courses for students with the lowest math skills? *Community College Review, 46*(1), 62-81.

Xu, D., Solanki, S. & Fink, J. (2021). College acceleration for all? Mapping racial gaps in advanced placement and dual enrollment participation. *American Educational Research Journal, 58*(5), 954–992.

1. Author Note. Frances E. Anderson <https://orcid.org/0000-0001-5086-1632>. Correspondence for this article should be directed to Frances E. Anderson, Department of Teacher Education, 6005 University Drive North, Omaha, NE 68182, USA. [↑](#footnote-ref-2)