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Culture Counts: Culture, Language & Mathematics in the U.S.

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Culture Counts: Culture, Language & Mathematics in the U.S.

Title of Thesis

LINFIELD COLLEGE
CHRP-IRB Chair
(503) 883-2708

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DATE: **Jan 2, 2012**
TO: Arielle Ramberg

FROM: **Kay Livesay**
Committee for Human Research Participation (CHRP)
Institutional Review Board (IRB)
IORG0002606

RE: **CHRP/IRB 201112-08**
Title of research: Culture Counts: Culture, Language & Mathematics in the U.S.

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If you have any questions or concerns, please contact me at (503) 883-2708.

Thank you,

Kay Livesay
Associate Professor of Psychology
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Abstract

This study explores the interaction between culture, language, and mathematics through the experiences of multicultural individuals in the United States as they learn mathematics in English as a second language. Regarding mathematics as a fundamental a-cultural truth hides the role that cultures have played in its construction. This study critically examines this perspective through the contradicting experiences of multicultural individuals shared in qualitative interviews. I focus on the power relations implicit in not only the Standard English of the classroom, but also the standard forms of mathematics that students must learn to succeed, and the effects that this power has on student comprehension and on students as subjects. The students described their mathematics experiences largely in the form of struggles that extended into conflicts with their own identities as they confronted their differences and conformed to the dominant form of mathematics that they learned at school in Standard English. Educators must acknowledge the effects of the standardization of math in the classroom when educating students and, in turn, avoid devaluing students like those in my study who struggle without knowing why.

Introduction

Carmen, a Latina student who grew up speaking only Spanish at home, discussed her experiences learning math in English to me with recurring themes of trauma and struggle. During standardized testing in sixth grade, she had difficulty with the context of the word problems, but her teacher did not consider possible reasons behind her confusion and belittled her instead. Carmen described to me, “The teacher, because she saw how much I was excelling in other things, could not understand why I could not get the word problems...she had me redo it again and again. She’s like ‘Why. Don’t. You. *Get it*?’ And I was like ‘I don’t know.’” For Carmen and other multicultural students in this study, math education in the United States required learning the language and context of the classroom, and the effects of this assimilation on their comprehension and personal identities were left unacknowledged. This study seeks to explain the source of the students’ struggles through analyses of the language choice and the way of doing mathematics in their respective educational settings, while also exploring the institutional frameworks that contribute to these conflicts.

Mathematics is generally regarded as a fundamental a-cultural truth, denying the role that humans have played in math’s construction and hiding the variations in understandings of mathematics in different cultures. Past studies show that, beneath math’s façade of objectivity and cultural invariability, language and culture can influence students’ mathematical comprehension. Lakoff and Núñez (2000) credit the popular belief that math is purely objective and a-cultural, in part, to the institutionalization of mathematics in Western culture, which helped to create and now reinforces this perspective. In this way, what is viewed as “fact” and “truth” to Westerners, may be perpetuated by the “standard forms” of mathematics discussed by Verran (1987) that regulate what forms of math are taught in school. While math’s universality or “real” existence is beyond the scope of analysis of this study, I explore the experiences of multicultural individuals like Carmen that arise, often in conflict, within the United States' "culture of mathematics", by which I refer to the linguistic and cultural contexts that dominate within educational institutions. In other words, I analyze the power relations implicit in not only the standard English used in classrooms, but also the standard forms of mathematics that students must learn to succeed, and the effects that this power has on student comprehension and on students as subjects.

Following this approach, this study investigates what the process of learning mathematics in English in the U.S. requires of individuals of various cultural and/or language groups and how their cultural identities relate to their experiences in mathematics. To approach this question, I conducted qualitative interviews with a convenience sample of multicultural college-age students both within and outside of the subculture of mathematics (i.e. mathematicians and non-mathematicians); these students all had learned math in a second language at some point during their lives. The interviews reveal how the students had to adapt to a different worldview during their adjustment to the standard language in order to succeed in mathematics in school, often abandoning the language and approaches that they had learned at home in their first language since childhood.

Similar to the standardization of language often enforced in the school systems, the standardization of mathematics results in the valuing of certain dominant types of mathematical knowledge, and thus creates power relationships in educational institutions that promote this standard and thereby make students subjects by forcing them to recognize themselves in relation to the dominant culture(s) of the classroom. Combining Verran's notion of "standard forms" of mathematics with other anthropological theories of knowledge, Bourdieu's discussion of standardization, and Foucault's discussion of power, knowledge, and subjectivation, I account for the conflicts that the interviewees experienced in math education, which are not usually acknowledged due to math's standardization; while revealing the hidden struggles, I also explain why these experiences are not identified and the effects that they have on students. The standardization of mathematics assigns value to different languages and cultures through mathematics education and promotes the belief that mathematics is a-cultural, denying students' real and often deeply personal struggles in their attempts to comprehend the dominant form of mathematics in educational institutions in the United States.

Literature Review

Since students in this study learn mathematics in languages and cultural contexts different from their own, past studies in sociolinguistics and the anthropology of learning, knowledge, and science provide insight into the way that students navigate linguistic situations and classroom environments. Other studies from various disciplines have focused on mathematics specifically, relating it to institutions, language and identity, and debating its reality as a concrete entity. Overall, the literature surrounding mathematics and the complexities of language and culture establish a framework for further analyzing the way students experience mathematics. For the purpose of this study, I draw on previous research to shed light on the many dimensions of mathematics as a form of knowledge interacting with language and culture; I also build on comparisons of math to language standardization, an approach thus far absent in the U.S. that I use to determine the effects of math's standardization on multicultural students.

First, math can be viewed as a form of knowledge. Antweiler (1998) defines complex knowledge as concepts, belief systems, and knowledge systems that "are made up of interlinked concepts and their constituent elements" (p. 475). In general, knowledge of this type is divided unevenly in society since there are specialists in knowledge systems, and one's knowledge may vary depending on the context and across time (Antweiler, 1998, p. 475). This perspective demonstrates the complexities of knowledge systems like mathematics, including their hierarchical structures, and allows for an examination of the amount of knowledge an individual may possess in different contexts. Given that science "dominates large geographical parts of the world and many sectors of the economy [today]" (Antweiler, 1998, p. 482) and the fact that most scientific fields depend on math, we must now consider scientific knowledge in particular.

Over the years, anthropologists have studied knowledge in the form of science with different approaches: Malinowski "stressed the universality of science," while Fleck "argued that all knowledge—including scientific knowledge—was socially constructed" (Gonzalez, Nader, & Ou, 1995, p. 867). The constructivist approach focused on "the importance of social and historical context in the formulation and development of scientific fact" (Gonzalez et al., 1995, p. 867). Bourdieu (1991b) views science as a social entity, remarking that "Even in the 'pure' universe where the 'purest' science is produced and reproduced, that science is in some respects a social field like all others—with its relations of force, its powers, its struggles and profits, its generic mechanisms such as those that regulate the selection of newcomers or the competition between various producers" (p. 5). Thus, science can be examined in terms of the social relationships, struggles, and power structures involved, which provides a framework for looking at the social aspects of mathematics as a scientific field. Regardless of the approach taken, knowledge—and in particular, science—has captured the interest of anthropologists, especially in Western cultures where knowledge systems like mathematics are institutionalized.

Knowledge's relationship with language adds another dimension to its importance since students in this study acquire knowledge and language skills simultaneously. In order to analyze the role that language plays in mathematics experiences, I also consider the relationship between language and knowledge systems. Crick (1982) emphasizes the connection between language and knowledge, arguing that "knowledge is best articulated in language" (p. 288). Furthermore, he discusses the idea of "Communicative competence [which] involves far more than knowledge of language; it involves a knowledge of social rules, apperceptions of concepts, [and] understanding what is not and need not be said" (Crick, 1982, p. 289). This suggests that knowledge, as expressed through language, is affected by and demonstrated through the communicative competence of an individual, which includes skills as well as cultural know-how. We may also consider one's mathematical knowledge—and more specifically one's competence in mathematics—as expressed through language. The relationship between language and culture in general provides further insight into the interplay between knowledge and language.

Language is a cultural product and, as such, can be used to understand a culture. Sapir (1929) emphasizes the importance of language as "a guide to 'social reality' [that]… conditions all our thinking about social problems and processes." (p. 209). This implies that people cannot think outside of their languages and thus an individual's understanding of the world cannot be viewed separately from their language. Describing different cultures as living in "distinct worlds" (Sapir, 1929, p. 209) because of their languages, Sapir argues that language constructs reality, meaning that people of different cultures experience the world differently. From this perspective, words and concepts within a language have power to lead to certain interpretations that may differ by culture (Sapir, 1929, p. 210). Since language is used to express knowledge as Crick discusses, understanding that language constructs and reflects reality means that the knowledge expressed through language—such as that in mathematics—may be associated with different realities. Overall, Sapir stresses the importance of "language as the *symbolic guide to culture*" (Sapir, 1929, p. 210; emphasis in original), which may make language particularly significant in considering the experiences of members of a culture.

The connection between language and identity adds to the importance of language in the consideration of mathematics experiences in different languages. Language is related to being since it "imparts a certain way of seeing, feeling, and even, perhaps behaving" (Gade, 2003, p. 430**).** Thus, in addition to its social constructedness as suggested by Fleck (Gonzalez et al., 1995), knowledge's association with being implies it also influences one's identity. As a result, competence in language, which can be used to exchange knowledge, plays an important role in constructing identity. Since language plays such a large role in constructing an individual's reality according to Sapir (1929) and relates to being according to Gade (2003), this creates a framework for looking at knowledge together with language.

We may now consider mathematics more specifically. First, let's consider mathematics as a cultural product, which makes it variable. Anthropologist Wagner (1986) focuses on the symbolic content that models the world as we perceive it and argues that "Mathematics, 'Queen of the Sciences,' is entirely a work of the [human] imagination, and thus one of the humanities" (p. 12). Though math as a field has an "aura of factuality" (Geertz, 1973, p. 90)—not unlike other symbolic, cultural systems that Geertz discusses—that suggests it has an existence separate from humanity, many have argued that mathematics is actually a human invention designed to model and thus simplify the complexities we experience. Psycholinguists Lakoff and Núñez (2000) state that "Regularities in the universe exist independent of us. *Laws* are mathematical statements made up by human beings in an attempt to characterize those *regularities* experienced in the physical universe" (p. 344; emphasis in original). This suggests that the concrete ideas of math enable humans to explain the world as they experience it. Lakoff and Núñez credit the source of mathematical concepts in Western culture to empirical observations, rather than suggesting they exist independent of humanity awaiting discovery; the distinction of "*regularities*" recognizes the human ability and desire to use patterns to order the universe as they experience it. This suggests that mathematics' status as a fundamental truth is an illusion, which has important implications for how mathematics should be studied.

Other scholars argue that the correlation between mathematics and the real world is too strong to be based purely on observation. As Livio (2009) states, math "appears to be almost too effective in describing and explaining not only the cosmos at large, but even some of the most human enterprises" (p. 1). He describes how mathematical discovery happens in both "passive" and "active" ways (Livio, 2009, p. 4); passive discoveries are made when research in pure mathematics (as opposed to applied math) is later found to have applications in the world, while active discoveries originate from observations used to create precise laws. The passive discoveries reveal the most about the puzzling correlation between math and the real world since even abstract math with no initial applications or roots in observational experience has been eventually found to model the world in surprising ways. From this perspective, math must have a concrete reality since the accuracy in mathematics can come without modeling from the real world and is often too perfect to just have arisen from patterns imagined in the human mind. However, Livio (2009) also mentions cognitive scientists' comparisons between language and mathematics that imply a certain level of constructedness: "in this 'cognitive' scenario, after eons during which humans stared at two hands, two eyes, and two breasts, an abstract definition of the number 2 has emerged, much in the same way that the word 'bird' has come to represent many two-winged animals that can fly" (p. 12). This example demonstrates the embodied origins and socially constructed nature of mathematics, but does not necessarily answer the question of whether mathematics overall is observed or created. Again, as noted above, while the answer to such a question is beyond the scope of this study, the question itself has important implications for the cultural constructedness of math learning

Examining whether math concretely exists in the universe is not the primary goal of this study; however, the question of whether humans are observing math or creating it still implies a human role in the understanding of mathematics. In turn, this means that those studying any aspect of math as a field cannot ignore the role of mathematicians and thus the relationship math has with culture. The studies that describe mathematics as a social construction (to any degree) imply that math is not entirely a-cultural, creating the possibility of conflict for those of different cultural backgrounds. Acknowledging that math—or at least the interpretations of the same mathematical reality—varies culturally explains why individuals have different understandings or apply different meanings to mathematics; then, we have a basis for exploring the interactions students of various cultural backgrounds have with math in the classroom. In fact, past studies have explained how the beliefs about mathematics' reality influence the way that math is discussed in Western culture.

The rhetoric of Western mathematics—that is, the way people talk about mathematics in Western culture—reproduces the belief in math's existence separate from humanity and disregards the cultural aspects of math that influence how people understand and learn math in institutionalized settings. Mathematics in its institutionalized form in the West can quickly become abstract and disembodied to the point where the charisma of the rhetoric leads us to accept it as fundamentally true. Lakoff and Núñez (2000) describe this effect as the "Romance of

Mathematics." Through the Romance, math is seen as an objective truth of the universe that is disembodied but real; mathematicians, then, are objective scientists that have witnessed these truths in nature and recorded them (Lakoff & Núñez, 2000, p. 339). Thus, the abstractions made in formalized mathematics have separated the discipline from the embodied, cultural experiences that inspired mathematics in the first place. Furthermore, for a lot of mathematicians, the "Romance of Mathematics is part of their worldview, their very identity" (Lakoff & Núñez, 2000, p. 339)—so much so that mathematics *is* their reality, despite its lack of a concrete existence. This leads to the question that Ingersoll (1987) poses of "how to study a culture that attempts to think itself out of existence" (p. 3). Since the Romance emerges through the institutionalization of mathematics, masking the effects of language and culture on student comprehension, it is examined critically in this study as it is expressed in the interviewees' responses.

Studies have suggested that language is a key element of culture's influence on mathematics experiences. In her discussion of doing mathematics in different cultures, Verran (1987) mentions linguistic structure as a factor in mathematical learning, with a "theory of knowledge [that] points to social practices like linguistic methods, as the origin of categories in knowledge" (p. 17). Insisting on relativism, Verran studied the logic of Yoruban mathematics in Nigeria. She found that language revealed cultural logic and she determined that students work in different symbolic domains, influencing the way they approach and understand mathematical concepts. In her discussion of "standardized forms" (Verran, 1987, p. 9) of mathematics, parallels exist with standardized forms of languages. From a sociolinguistic perspective, the goal of the latter is "to remove variation and establish only one system to serve as a uniform one for a group" (Romaine, 2000, p. 88). These standard versions do not occur naturally, but have artificial origins. While describing the way that people succeed at math daily using different methods than those learned in the classroom, Verran (1987) refers to “the ‘officially sanctioned’ way of doing numbers that is enshrined in mathematical curriculum documents,” concluding that the “standard forms are politics” (p. 9). This suggests that, as with language, there is a standard version of math that students must learn when they begin school. The choice to standardize mathematics is largely a political decision, which has repercussions for those whose symbolic domains or languages do not coincide with those of the classroom.

Since so much of knowledge is cultural, those outside of the dominant culture of education can suffer as they are required to culturally and/or linguistically adapt in order to master new material. In a study of multilingual classes in Papua New Guinea and Australia, Lean, Clements, and Del Campo (1990) determined that language choice in the classroom influenced student comprehension. They posed word problems in English to 2493 students age five to fifteen, citing linguistic competence as the source of mathematical understanding or misunderstanding. The Australian students whose first language was English understood better than the Papua New Guinean students for whom English was their second, third or fourth language—even though English was used in the classrooms for both groups. This study of students in multilingual classes illustrates the importance of language in mathematics education since those whose first language matches the language of the classroom are at an advantage compared to those who speak the classroom language as a second or third language.

Other studies have shed light on the role that language choice in the classroom plays on student comprehension by creating distance both culturally and linguistically between the student and the classroom. Since understanding math already requires translation between daily applications of math using natural language and the formal language of mathematics, additional translation to another language negatively affects mathematical comprehension (Nesher &

Katriel, 1986). Devlin (2001) credits some difficulty to the languages themselves, arguing that some languages make mathematics more intuitive than others. For example, to discuss numbers in English may require more linguistic knowledge than in Chinese and thus complicate the process of basic arithmetic. To say 20 in English requires linguistic knowledge that 20 is *twenty* whereas the literal translation of 20 in Chinese is *two-tens*—here, the multiplication of 2 and 10 is built into the word for 20. Devlin explains that this makes it easier for Chinese children to learn numbers and basic arithmetic, which is explicit in the linguistic structure. Furthermore, due to the difficulty of translation between first and second languages alongside translation to mathematical language, bilingual students are more likely to use their first language for basic math with which tasks like arithmetic are performed more naturally (Devlin, 2001). This suggests that they may struggle in the classroom where they are required to do mathematics in a language that does not come to them as automatically as their first language.

Barwell (2003) argues that "language discrimination" may be a factor in situations like these, where students must learn mathematics through the dominant language of larger society: "native speakers of the classroom language have some degree of advantage, as compared with fellow students who are still learning the language of teaching and learning" (p. 38). The conflicts with the language choice of the classroom extend beyond issues of comprehension. To lack knowledge of the linguistic code of the classroom places students at a disadvantage and, as a result, "the school and education system reproduce social inequalities, undermining the purported equality of the school context" (Stathopoulou & Kalabasis, 2007, p. 232). Therefore, native speakers of the classroom language have an advantage over students learning in a second or third language, not only in terms of their success in the classroom, but also in the larger social sphere. The correlations between language and culture involved in mathematics education further complicate the issue.

In addition to the difficulties of learning in a second language, Barwell (2003) refers to connections "between the social practices of mathematics and the patterns of the mathematical discourses of different languages" (p. 38), which can lead to difficulty for some students. He describes instances where researchers have found cultural values to be revealed through different languages, concluding that "there are 'connections' between different languages and the social and linguistic practices of mathematics in those languages. [Hence] Doing mathematics is different in different languages" (Barwell, 2003, p. 38). Thus, the language chosen for the classroom influences student comprehension in math since only native speakers of the classroom language can access some cultural aspects of math.

While Barwell cites the level of language familiarity and cultural practices as sources of conflict in math education, Stathopoulou and Kalabasis (2007) connect mathematics and language choice in the classroom to cultural identity. Their study of Romany students in a Greek school reveals the "role of language as identity-forming…that contributes to cultural conflict for Romany students within a mathematics classroom" (Stathopoulou & Kalabasis, 2007, p. 238). Therefore, the fact that language relates so strongly to cultural identity can cause struggles for students who are not native speakers of the classroom language. Overall, these studies from Barwell, Devlin, and others indicate that mathematics is not as a-cultural as it seems and provide insight into the sources of conflicts that can emerge in mathematics education based on the language choices made in the classroom.

The goal of this study is to explore the interaction between mathematics, language and culture by revealing the experiences of multicultural students in their confrontations with the dominant knowledge system of the classroom and by pushing aside the Romance that perpetuates the belief in math's invariability in the Western culture. Past research indicates that culture and math are intertwined and that language affects mathematical comprehension. Rather than continuing to allow the Romance's pervasiveness to restrict the critical examination of math as a field, this study examines how math experience in the United States may differ from the singular viewpoint of the Romance, which makes math appear as objective and a-cultural. Whether or not mathematics has a concrete reality, it is a social field like any other science, as Bourdieu (1991b) discusses; the fundamentally human aspects of math must be considered in order to determine the power relationships and underlying cultural and linguistic aspects that influence how students experience math in different languages and cultural contexts. Building from Verran's notion of standardized forms of mathematics, I use the discussions of language standardization and of institutionalization to explore the interactions of multicultural students with standard math in the United States.

Theory

Viewing math as a social behavior and a way of being in the world that is influenced by culture, I examine students' personal struggles in math education, the roles they must play, and their acquisition of mathematical knowledge through the concepts of standardization, cultural capital, and role identity. Building on the standardization of language and the notion of dominant knowledge systems in educational institutions, this study uses the anthropology of knowledge, Bourdieu's theories on standard language, and Foucault's theories on power, knowledge and the subject to explain multicultural students' experiences with mathematics in the United States. Using this framework, I explore what power relationships are expressed in formal math education in the United States, how students' identities are affected in their math experiences, and how mathematical competence relates to one's cultural and linguistic background.

In this study, I extend discussions of the power involved in the production and circulation of knowledge systems to mathematics. Generalizing various examples of opposition to power, Foucault links struggles with authority to struggles against a particular form of knowledge, in which "What is questioned is the way in which knowledge circulates and functions, its relations to power. In short, the *regime du savoir*" (Foucault, 1972, p. 781; emphasis in original)**.** In a Foucaultian lens, authority puts forth a certain type of knowledge, and struggles with this specific form of knowledge can be recognized as struggles with the authority that presents it. Bourdieu also deals with the notion of knowledge coming from a certain group in power, describing the "recognition of a certain definition of knowledge" (Bourdieu, 1991b, p. 8) enforced through inculcation and familiarization. Possessing "a weight proportional to the symbolic power of the groups whose specific interests they express" (Bourdieu, 1991b, p. 8) legitimizes this form of knowledge; thus knowledge's association with dominant group(s) legitimizes it in the same way that Foucault describes knowledge as originating from authority.

The anthropology of knowledge provides further insight into the politics behind knowledge. Discussing institutionalized knowledge, Crick (1982) states that "Classifications, symbols accepted in society, are dominant; they represent knowledge because dominant ideas are part of the ideology of those who dominate" (p. 303). Since they express dominant ideas, knowledge systems promoted in school systems represent dominant cultures. Furthermore, in terms of educational institutions, there "are underlying assumptions, or *codes*, that are rarely made explicit but which profoundly affect the purposes and processes of learning. These assumptions frame and shape the orientation of an institution, establishing what is known, [and] how it is to be interpreted and valued" (Martin, Ranson, Nixon, & McKeown, 1996, p. 19; emphasis in original). Thus, each institution has assumptions that influence what knowledge system they promote, and this relates to the ideology of the culture that frames the institution. Drawing on the notion of dominant ideologies expressed in institutionalized knowledge, I analyze the presence of dominant ideologies and dominant culture in math education. The relationship of dominance in institutions also carries over into language choice in the classroom.

According to Gutstein (2007), "language is about power, about who has the authority to designate the language of instruction and the 'official' languages" (p. 244-5). When those with authority have selected a specific language in the classroom above all others, this implies that a dominant group subordinated the other languages. Furthermore, when one language becomes the standard, Bourdieu (1991a) argues:

> [The] state language becomes the theoretical norm against which all linguistic practices are objectively measured. Ignorance is no excuse; this linguistic law has its body of jurists—the grammarians—and its agents of regulation and imposition—the teachers—who are empowered *universally* to subject the linguistic performance of speaking subjects to examination and to the legal sanction of academic qualification (p. 45; emphasis in original).

According to Bourdieu (1991a), acquiescing to the standard means gaining power because individuals have access to the language belonging to and imposed by authority. Thus, individuals choose to conform to the standard language in much the same way that they choose to assimilate to the ideologies of the dominant knowledge system, as Crick (1982) suggests, and power relationships are involved in the act of making this choice. Furthermore, Gutstein (2007) argues that language is "the student's identity and being, and to denigrate one's language is to disparage her culture, personhood, community, ancestors, and ways of making sense of the world" (p. 244-5). Therefore, the standardization of language involves the influence of some authority and devalues a student's background through the language assigned to the classroom. These theories contribute a framework for studying the effects of standard languages in the classroom, while also allowing for a comparison between standard language and standard/dominant knowledge systems, both of which create value and involve ideologies of those in power. In turn, this establishes a basis for studying knowledge systems like mathematics and the way their standardization in institutions impacts students—in particular, we may explain how individuals obtain more power through the knowledge and language skills they acquire.

In our discussion of power and knowledge acquisition**,** Bourdieu's theory of cultural capital sheds light on the meanings and status associated with knowledge. While mathematics clearly falls under the notion of institutionalized cultural capital since people earn diplomas and other qualifications in school that demonstrate their knowledge, we may also examine mathematical knowledge as cultural capital in its embodied state. Bourdieu describes this form of capital as the learning of culture including the development of the self and the ways of thinking (i.e. habitus) of an individual. The acquisition of embodied cultural capital in the form of habitus is a process of "labor of inculcation and assimilation, [and it] costs time, time which must be invested personally by the investor" (Bourdieu, 1986, p. 48). Status can increase depending on the social value of the knowledge and/or skill, often reliant on its scarcity, and thus one's habitus can either hinder or advance their status depending on the value of the skills it has produced.

Individuals acquire cultural capital through socialization and assimilation. The family provides an individual with cultural capital prior to formal education; thus, individuals from families that possess more capital will be at an advantage (Bourdieu, 1986, p. 49). Cultural capital can also vary depending on the context since, in some situations, an individual may be at an advantage for possessing certain skills, but lack some cultural knowledge in another context. Overall, the notion of knowledge acquisition as an increase in cultural capital and as an enduring component of an individual's habitus inspires questions about its value, its transmission, and the role it plays in defining one's identity and relationships to others.

In his discussion of capital, Bourdieu also describes the scientific field more specifically. Though scientific knowledge is public, it requires mastery and adherence to certain laws in order to participate (Bourdieu, 1991b, p. 6). Bourdieu defines two types of scientific capital that play a role in the struggles of conservation and subversion between individuals and institutions in the scientific field: "*capital of strictly scientific authority*, which rests upon the recognition granted by the peer competitors for the competency attested to by specific successes…[and] *capital of social authority* in matters of science…which rests upon delegation from an institution, most often the educational system" (Bourdieu, 1991b, p. 7; emphasis in original). Thus, within scientific fields, academic qualifications or scientific competence describe individuals.

Thus far, the theories I have presented provide a framework for examining the power relations that influence legitimized knowledge, the dominant cultures represented in institutions, and the way that individuals increase their status through knowledge as scientific and embodied cultural capital. This still leaves an incomplete picture about the effects that power has on the individual and her or his identity. Bourdieu (1991b) determines that the requirements to participate in the scientific field influence the individual:

> [A]dmittance to the field, like entry into the game, presupposes a *metamorphosis* of the newcomer, or better yet, a sort of *metanoia* marked in particular by a bracketing of beliefs and of ordinary modes of thought and language, which is the correlate of a tacit adherence to the stakes and the rules of the game (p. 8; emphasis in original)

Thus, there are guidelines to participating in the field, which in turn changes the individuals, including their beliefs and ways of thinking (i.e. habitus). However, these transformations often involve some level of difficulty since learning is analogous with becoming: "to become a person with a distinctive agency in the world—is never accomplished without struggle. The identity we develop of ourselves, however, and the motivation we have to unfold it are always acquired with and through others" (Martin et al., 1996, p. 16). Therefore, learning or acquiring knowledge plays a crucial part in developing the identity of the individual. Building on the notion of institutions representing dominant culture, this process of becoming through learning can thus be influenced by the assumptions and values of the institutions, and by the acquisition of the appropriate cultural capital. Since learning is becoming, we may consider struggles in mathematics as personal struggles to create an identity in confrontations with institutions' ideologies.

Finally, since knowledge involves power dynamics, we may consider students as subjects. According to Foucault (1972), "power categorizes the individual, marks him by his own individuality, attaches him to his own identity, imposes a law of truth on him which he must recognize and which others have to recognize in him. It is a form of power which makes individuals subjects" (p. 781). This corresponds to the discussion of becoming through learning in which identity is developed "with and through others" (Martin et al., 1996, p. 16) as learners are forced to recognize themselves in relation to the category in which they have been placed. Thus, Foucault (19721) defines a subject as someone who is "subject to someone else by control and dependence; and tied to his own identity by a conscience or self-knowledge" (p. 781). Thus, using a Foucaultian lens, we may view students' struggles with math through their struggles with the dominant system of knowledge and their role as a subject dealing with power that seeks to categorize them.

In the process of self-categorization, Stets and Burke (2000) explain that individuals define themselves in relationship to in-group and out-group and accentuate similarities and differences. Developing a role identity is a reflexive process in which individuals alter themselves to meet expectations, often placing themselves in a social category. Possessing a certain role identity “means acting to fulfill the expectations of the role, coordinating and negotiating interaction with role partners, and manipulating the environment to control the resources for which the role has responsibility” (Stets & Burke, 2000, 226). Lastly, they refer to normative roles, which are “defined along stereotypical, normative lines as held in the culture” (Stets & Burke, 2000, p. 230). Therefore, individuals who undergo subjectivation and confront in-group and out-group differences, like those who find themselves in different cultural or linguistic contexts, may take on the roles expected of them.

Combining these perspectives, math’s standardization in educational institutions, as suggested by Verran (1987), represents a “regime du savoir” or a dominant culture’s ideology, which allows for an analysis of the power relationships and the personal struggles caused by this standardization. Since assimilation to standard languages means gaining access to power (Bourdieu, 1991a), assimilating to the standard math can be examined as a way to gain power, which is achieved through the acquisition of embodied cultural and/or scientific capital. Using Bourdieu’s theory of cultural and scientific capital, this study explores what it means for families to prepare their children with sufficient cultural capital before beginning formal education, and how mathematical knowledge can affect an individual’s status and identity. I use a Foucaultian lens and theories from anthropological studies of knowledge to analyze the social expectations, norms, and values expressed in mathematics in institutionalized settings, especially in their role in the subjectivation of individuals. To explore the students’ interaction power implicit in institutionalized math education, this study also considers if students gain or lose power due to the mathematical standard in education through capital acquisition, the roles that students may find themselves playing, and the effects that the standardization of mathematics has on students.

Methods

For this study, I conducted seven semi-structured qualitative interviews. I focused on the mathematics experiences of young college-age individuals, who I selected since they were close enough to their school years to vividly recall memories and were also legal adults to avoid issues of access. My study began with a convenience sample of individuals age 18-24 with multicultural and/or bilingual backgrounds and became a snowball sample as I gained access to more respondents of similar backgrounds through my first few interviewees. For the purpose of this study, I chose to interview students of diverse backgrounds in order to determine how they related to the "dominant" forms of knowledge and language in their math experiences in the United States, with a particular focus on individuals who had learned mathematics in a second language at some point in their lives. The seven interviewees were all current college students or recent college graduates, and my sample included math majors, math minors, and students who did not major nor minor in math.

I developed open-ended questions about student experiences with mathematics at various stages throughout their lives, such as their transitions from learning at home to at school, primary to secondary school, and high school to college. To inspire a discussion of language and mathematics, I asked interviewees to describe their language transitions and the role language has played in their math education and everyday math usage. Depending on their previous responses, I posed more specific questions relating to their personal experiences since not all questions fit the circumstances of the individual. For instance, I asked the international students to discuss their experiences in their home country and then the transition to learning and using mathematics in English in the United States. I questioned the bilingual students (e.g. Latino/a students) about their transitions from learning mathematics in their first language at home to in

English at school. In general, the interviews lasted an average of 45 minutes and were all conducted in English, which was the second language of all of the interviewees.

Results

The sample of interviewees for this study included two non-math-major Mexican-American students from Spanish-speaking households, one non-math-major Korean-American student, three Asian exchange students (one math minor, one math major, and one non-math-major), and one non-math-major student who lived outside of the United States and did not speak English until second grade. Pseudonyms have been given to each interviewee. While the cultural and linguistic backgrounds of the individuals I spoke with varied, their experiences had many commonalities. The following section includes summaries of the interviews with specific quotes, which I transcribed from the recordings, that highlight the students' experiences. I focus on each student's background in math, the transitions the student made (and continues to make) between languages and cultural contexts, the struggles she or he endured, and the experiences that the student emphasized during the interview.

Carmen: Mexican-American college graduate, first language Spanish, second language English, non-math-major.

Carmen, who did not speak English until she started school, recalled the methods her mother used to teach her math at home: "my mom would try to teach me with beans how to add. And I remember that specifically. It was like *mas.* It was all in Spanish. That's how I remember learning math, by simple adding and subtracting, and I learned better through, you know—*cómo se dice?*—visually." She explained that the one-on-one lessons with visual representations created by her mother made learning math at home easier for her than at school. While the presentation of the problems already made them hard to understand at school, she also recalled that activities in the books always involved "White Bobby and White Lucy…[and] concepts that I was not familiar with." Throughout elementary school, she continued to go to her parents for help. Carmen's mother, who did not speak English, would note the sign involved (add, subtract, etc.) and make the problems more relatable to her: "from there she'd teach me with beans. She'd teach me counting with my fingers or something easier, something more interactive, or using family members to add. 'If you have your three uncles here,' [she would use] things like that, or food." Carmen reflected on how her skills with math developed as her English skills improved. However, when the math concepts she was learning in class surpassed her parents' education level, she could no longer go home for help and was forced to learn mathematics in English as the teacher was teaching it.

This transition was difficult for her as she explained: "I started getting really frustrated. I remember crying. I remember just being really frustrated because I would go home with like a division problem that I did not understand and I would ask [my parents and]…they don't understand the problem either. I could no longer really focus on doing it in Spanish because I really had to concentrate in class on how to do that division problem as it was being taught to me." As she tried to adapt, she struggled particularly with word problems because, even though the language adjustment was becoming less challenging, she remembered that the problems themselves were not applicable to her life: "they were all word problems relating to lifestyles and events that I didn't grow up with…I always remember if individuals were used they were white and they were always in some situation that I don't think I'd ever find myself in." To this day, word problems are a source of struggle for Carmen, who believes it is due to the cultural differences.

When asked how she does math now, she said that she thinks about certain problems in Spanish and others in English: “If it’s like the symbol…I will think ‘oh this is *por*’, *tres por tres*, nine…It’s weird ‘cause with adding…to say add is *mas*, so I always go *mas* in my head.” For Carmen, the division between performing math in English and Spanish relies on complexity: “If it’s more complex, I’m doing it in English. It’s like a jumbled mix sometimes, starting with basics and as it gets more complex, I am thinking about it in English because it’s the way I’m being taught at school.” In particular, she noted: “I’m just scared I won’t get the answer right if I do it in Spanish.” The process of doing math for Carmen involves thinking in both languages and rethinking it many times, which she said can take a lot of time.

Overall, Carmen stated that during her childhood she had negative experiences with math: “I always feel like I’m being belittled with math. I always feel like I’m not going to do well enough or it’s gonna be a big fancy word problem.” When asked to elaborate, she described a few negative experiences. First, she recalls standardized state testing in sixth grade, when she was faced with a word problem:

> By that time, I was perfecting my English and it was fine but I’m not good at the word problems. It doesn’t ring with me. At the time, I obviously didn’t say ‘this doesn’t make sense with me,’ but as I look back, that’s why. I don’t understand why I would not understand a problem…the teacher, because she saw how much I was excelling in other things, could not understand why I could not get the word problems...she had me redo it again and again. She’s like ‘Why. Don’t. You. *Get it*?’ And I was like ‘I don’t know.’

Afterwards, she recalled her experiences with going over scores in the classroom and the feeling of dread at always having a lower score than the other students; in general, her negative experiences linked back to the word problems that she says “traumatized” her. Considering all of her experiences with math, Carmen concluded: “I know I could’ve gone farther in math. I know

I'm smart. I know I can do well in math. I could probably have taken math classes, but again, for me personally, it's just the word problems that I just don't like to deal with and that always makes me feel like I just suck at math, which I don't think I do."

Sarah: college student, first language Portuguese, second language English, non-math-major.

Sarah's first memories of math took place in Portugal: "my clearest memories are in second grade being so nervous to go to class because we had to have our times tables memorized and not knowing them and being so scared I hadn't memorized them." Her mastery of the times tables in Portuguese was fulfilling for her as she recalled, "I remember being really smart at math and being like 'oh my God, I'm so good.'" Then, halfway through the second grade, she moved to the United States and struggled to realize that mathematics--at least as far as times tables went--referred to the same ideas: "I didn't know them [the times-tables] anymore because it was a new language and so I didn't make the connection that two times two in Portuguese was two times two in English and so I had to relearn them all…and [I remember] just being so confused and how the introduction of English into my life, 'cause I didn't know it until I moved here, was so confusing to me because I didn't understand that two languages could mean the same thing. It was like a different world that I was entering."

These experiences caused Sarah distress as she remembered "being humiliated because I just felt like I didn't know anything and even though I had learned everything in Portuguese and had been really good in my English class, I was like the weird immigrant child that like couldn't speak English." This struggle manifested itself in a lot of tears that she said "freaked out" her dad until, after years of failing tests, she began to excel in seventh grade. Sarah cited her desire to fit in as the primary reason for adapting to mathematics in English: "when I moved from Portugal to the U.S., I decided that I didn't identify anymore with Portuguese because I was the weird immigrant child and I didn't want to be that. So in everything I did, I didn't identify with that anymore…that probably does really affect a lot of things in my life and math is one of them…I probably do feel really comfortable in English 'cause I always strive to be '*American*' or that's what I did for a long time when I was little—[to] not [seem] weird anymore."

Sarah described her experiences with word problems as "a constant struggle," believing that it is because English is her second language. Despite the struggles that still exist for her today when it comes to mathematics Sarah has positive feelings about mathematics: "I love it. I think it's so cool and maybe it's because when I first moved here I struggled with it so much that the fact that I like overcame that and like was able to access that part of my mind, that means a lot to me in terms of personal success."

Carlos: Mexican-American college student, first language Spanish, second language English, non-math-major

Carlos' transition from home to school was eased by the fact that, growing up in California, his teachers were Spanish-speaking and bridged the language gap in his early years. In the end, he was fluent in English and Spanish. Throughout his childhood, he spent alternating school years in the United States and Mexico. He learned the basics of mathematics in Mexico and then took math exclusively in English after fifth grade. When doing math, he stated that he generally thinks in Spanish first: "I'll catch myself counting in Spanish instead of English, even if no one else speaks Spanish, but I can count a lot faster for some reason in Spanish…if I see something, I'll be like 'oh that's *a dos'* and in my head it's kinda like [I] switch it to English and then say it out. I don't even think about it, but I just know it." This automatic process is one that he carries out in daily life. In general, Carlos stated that if he knows the type of problem in Spanish, he will do it in Spanish, otherwise he will do it in English. For Carlos, Spanish is generally reserved for so-called “lower end stuff.”

In Mexico, Carlos believes that the school system is a lot more difficult because there is pressure to remember everything and it was easy to get in trouble in class. In addition, he cited differences in teaching styles. While in Mexico students were expected to do the problems quickly and accurately, he remarked that in the U.S. it is more about cooperation and ensuring that everyone understands before moving on.

Laura: Korean-American college student, first language Korean, second language English, non-math-major

Laura believes that her parents stressed mathematics in her youth because it was one of the few subjects they knew they could teach her. She was taught using Korean textbooks until the third or fourth grade since her “mom would always talk about how she felt the American math system just didn’t push us enough and we weren’t going as fast as we should be.” As a result, Laura began learning long division at a much younger age than American students. She did not recall struggling with the Korean math books as there were frequently diagrams illustrating the situations in word problems and she had her parents to explain problems that she did not understand. Though Korean was her first language, Laura was fluent in English by kindergarten: “[Mom] was really scared that I wouldn’t fit in in school and be considered stupid if I didn’t know how to speak English. And so she started putting me in private tutorings to learn to read and write and speak English.” The transition to mathematics in English was not that difficult for Laura, who believes it is because the problems are more straightforward at a young age and "at that point it was still just numbers," and she made the complete transition to solely using English books when she began to learn algebra. Today, Laura is more comfortable with numbers in English rather than Korean, which she thinks is due to the fact that most Korean people know English numbers well enough that using Korean numbers is unnecessary.

Mary: Chinese exchange student, first language Chinese, second language English, came to the United States at the beginning of college, math minor.

Educated in what she referred to as the "very traditional Chinese system," where mathematics, physics, and chemistry were heavily emphasized, Mary originally thought that mathematics would be her major because she was good at it, but later changed her mind. She explained the rigor of Chinese mathematics, which requires working in study centers or having private tutors because "the math from the textbook is too easy, it's not enough for you to be competitive. You have to have extra knowledge of math." Her math lessons began at home with her father, who is a professor. He would pose a question for her daily—a "one-day challenge"—that she would have to solve. Most of these problems were related to real-world situations, counting animals, or figuring out how to cross a river with certain restrictions, which made them easier for her to imagine. Despite her ease at solving math problems without a calculator, Mary stated that: "I cannot do math for a career or something like that because I feel like a lot of Chinese students [who] are good at math, it's not because they're smart, or they're really talented with math, it's more like we were *trained* well and…gives us a lot of pressure in math and [to] study [hard]…[and if] you do that every day, how could you not do that well?" Trained to remember everything, she struggled with the fact that in the United States, she was no longer required to remember everything and pushed to do so; this made mathematics more difficult for her in English since it required her to use her textbook as a crutch and since she was lost without the guidance of someone pushing her to do the problems. She cites the cause as a different standard in mathematics, believing that Chinese, Japanese, and Korean students are expected to learn and retain many more results than American students, which they can apply to problems without referencing a textbook.

When Mary does math problems, it comes to her so automatically that she does not think of the problem in a language. To her, "it's more like number [or] the math, Chinese, [and] English. Three languages for me." At first, when it came to college Calculus courses in English, Mary would translate to Chinese to understand the problem and then complete it. She found this process took too long and told herself that if she was going to continue math in college, she would have to switch to English entirely. Then came the realization that she had other options outside of mathematics, which had been emphasized in China. When it comes to her Chinese peers, Mary mentioned that the competitiveness continued despite taking courses in the United States. She stated that other students think that "because we're from China and we're educated well in math, so we absolutely should be #1 in the classroom…but I don't think that's the case, that you should think that way because somehow we got pressure[d]." Discussing an instance when a "nerdy Chinese" physics major friend of hers shared his grades with her, Mary mentioned not wanting to be a part of that pressure because "That is not something you can show off because people will think you're so nerdy."

Harry: Chinese exchange student, first language Chinese, second language English, came to the U.S. at the beginning of college, math major.

Harry said that he had no idea what mathematics really was for the longest time, after just doing problems in China without trying to understand the concepts. When he came to the United States and took math courses in college, he struggled with the transition to English: “For me, the biggest problem is language. I couldn’t understand what textbooks [said]. I didn’t know how to describe what I thought by [using] English. So for example, [I know] what integers [mean] but I didn’t know how to say it.” He argued that despite the minor differences in languages, mathematics is universal because all forms of it “describe exactly the same thing but just from different perspectives.” In the beginning, he would translate between English and Chinese, but now he uses English directly. In fact, he prefers to do mathematics in English because he stated that English is more efficient to describe some concepts, where one word can describe something that would require many words in Chinese.

Rita: Chinese exchange student, first language Chinese, second language English, came to the United States at the beginning of college, non-math-major

As a finance major, Rita was required to take two mathematics courses in English. She stated the importance of mathematics in China and emphasized the difficulty of the courses: “even if you’re very smart you cannot get [a] very good math score in China.” Furthermore, she does not think that solving the sort of problems posed in China is very applicable to everyday life. In the United States, most of her difficulty with math has come from lacking the knowledge of English mathematical vocabulary. However, once she understands the problem, she can solve the problems easily. Given the difficulty of problems in China, she ironically has trouble with the fact that answers on American exams come easier: “I always think ‘this problem is very hard.’ Even it’s very easy, I think ‘no, it can’t be that easy.’” Having discussed studying mathematics with her Chinese roommate, Rita mentioned what they feel to be the difference between American and Chinese mathematics students, especially math majors: “American students choose math because they really love math and they’re really good at it, but Chinese people choose it because it’s easy for them…[and useful] to apply to graduate school, ’cause it’s good for them to apply to a job. A lot of Chinese students are good at math, but they are not really loving math.” Due to the difficulty she had with math in China, Rita stated that she “suffered” but now mathematics is just a part of her life and much easier in the United States.

In general, the students I interviewed for this study learned mathematics in their first language and then were forced to adapt to different teaching styles, methods, and language skills at school. Particularly when it came to solving word problems, many interviewees described this transition as a struggle and a long-term source of distress. Some individuals expressed satisfaction when they mastered mathematics after a period of time, but for the most part, they still switch languages when doing math depending on the context; some even switched unconsciously during the interview when reflecting on their experiences, despite my lack of knowledge of their first language. For many, the ability to do mathematics held great importance, either contributing to their disorientation in an already confusing educational and linguistic adjustment or adding to their satisfaction at the mastery of the language. In several instances, interviewees stated that mathematical ability or inability was related to cultural background and referenced a certain view of mathematically challenged or talented individuals. After reflection, the interviewees were able to pinpoint the source of their struggles, which were frequently related to their cultural backgrounds or language skills that did not match the context of the classroom.

Analysis

The theories of Bourdieu, Foucault, Stets and Burke, and others shed light on the varying experiences of the multicultural individuals in this study. The interviewees all described their interactions with standard math and language in school, both of which are products of power and had major effects on each student's mathematical comprehension. The purpose of this study is to determine the reactions of the students when confronting the standardization of math and language, explore how students gain status or access to power through assimilation to these standards, and examine how students' identities are shaped through this process. I use Bourdieu's framework of standard languages and Foucault's theory of knowledge and power to analyze the effects of standardized mathematics on students of different backgrounds. Meanwhile, Bourdieu's theory of cultural capital provides insight into the complexity of being prepared for the context of the classroom and for acquiring mathematical knowledge in this new context. Then I utilize Bourdieu's (1991b) "metamorphosis" combined with Foucault's (1972) notion of subjectivation, and Stets and Burke's (2000) concept of role identity to consider the personal struggles of the students.

For the most part, the interviewees spoke of their mathematics experiences in terms of struggles that were both linguistically and culturally based. Word problems were a source of frustration for many. First, the individuals had to adapt to the standard language of the classroom, which meant translating from their first language to Standard English. Then, in addition to the language challenge they posed, the word problems were difficult due to their context. Both Latino students cited context as a reason for their trouble with word problems since Carmen had trouble relating to "White Bobby and White Lucy" and Carlos got caught up on understanding what was going on in the word problem. For these students, mathematics involves a communicative competence in mathematical standard; they must know not only the language of learning (English, in this case) and the mathematical jargon, but also the rules surrounding the standard form of Western mathematics and the social knowledge of objects and scenarios in the word problems. Lacking the cultural capital to understand context resulted in struggles for the students. Carmen and Carlos' remarks reinforce Barwell's (2003) findings that culture is present in mathematics in different languages since the problems that students faced were situated in the context of wider society and not targeted towards Latino/a students. These conflicts with the context of problems also match Foucault's (1972) notion of a "regime du savoir", which describes knowledge as representing dominant ideas of the dominant culture in power. The word problems can be seen as representing the knowledge in power, which is not aligned with the cultures of Carmen and Carlos. As a result, doing standard mathematics in the classroom required a comparison between the students and the context of the problem. The transitional experience during their first lessons in mathematics in a second language forced these students to confront their differences, which were made apparent in the learning process and inhibited their comprehension until they developed more cultural fluency in the form of cultural capital.

The interviewees, while varying in their circumstances, had in common the difficulty of their transition between mathematics in different languages, the preparation provided by their families for school, and at some point, conformity to mathematics in English. During their confrontations with the standard language and standardized mathematics of the classroom, all of the students were forced to assimilate. The notion proposed by Bourdieu (1986) of normalizing as an outcome of standardization is evident in the responses of the students. It was necessary for them to learn the cultural and language skills of the dominant culture in order to succeed. Bourdieu (1991b) describes how individuals change in relation to the scientific field, which is mathematics in this case. Students in this study were newcomers in a different linguistic and cultural context, which required that they adapt—both in terms of the underlying codes of the institutions and the standard forms of language and math in the classroom—just as Bourdieu (1991b) predicted adherence to different “modes of thought” (p. 8) and new rules.

Overall, assimilation happened in reaction to a few circumstances—first, when the education level of the student surpassed the education level of their parents, such as in the case of Carmen. In this case, Carmen could no longer go home for help in Spanish, so she was forced to learn more English and began to do mathematics exclusively in English. Secondly, students separated concepts by language based on their complexity. Some continue to do math in their first languages in certain contexts, while processing mathematics in different languages to produce an answer. We can consider how language choice in the classroom contributed to the idea of value. Gutstein’s (2007) view of language choice in the classroom as having the power to devalue a student’s background indicates that allowing one language and thus one culture to dominate in the classroom can negatively impact the student and make them feel devalued.

The way Carlos and Carmen discuss the division in languages in the way they do mathematics reveals their opinions about the value of their native languages. From Carmen’s statement of fearing getting the wrong answer using Spanish and both Carmen and Carlos’ remarks that they use Spanish for lower-level mathematics, we may infer that a certain value is placed on Spanish through these experiences. The fact that both students use Spanish for certain things that they learned at home—and in Carmen’s case for concepts taught by her parents—clearly creates a separation from English, which became the primary means of instruction in school for learning certain concepts outside of the home. However, the clear division makes Spanish only appropriate in mathematics for the basics and English ideal for complex ideas. By restricting the teaching of more complex mathematical concepts to English, students associate English use with complexity. Arguably, this puts more value on English usage, whereas Spanish is regarded as inferior since Carmen worries that using Spanish will mean getting the wrong answer. As Martin, Ranson, Nixon and McKeown (1996) mentioned as an outcome of institutionalization, the languages are placed on a continuum of value, with the Standard English and standardized math more highly valued, demonstrating the dominant culture deciding what is valued in educational institutions. Furthermore, the continuum of value, which represents the ideology of the dominant group, also coincides with Bourdieu's (1991a) theory of power as motivation for students to acquiesce to the standard language.

We can understand the power that students gain through assimilation by examining their conformity to the standard through the notion of cultural capital. Student transitional experiences relate to Bourdieu's notions of linguistic and embodied cultural capital, as well as what I refer to as the cultural capital of their mathematical knowledge in their first language. The interviewees experienced mathematics differently based on their cultural and educational backgrounds. First, let's consider linguistic capital. Since previous studies have argued that knowledge is articulated through language, it makes sense for students to have difficulty understanding knowledge in a different language. As Barwell (2003) suggested, this puts native speakers at an advantage and inhibits comprehension for non-native speakers. Laura, who had intensive lessons in English before she began learning math in English, had more linguistic capital at her disposal for this transition. For the other interviewees who had to translate between their native language and English when they began learning mathematics in English, language skills were a form of capital that they acquired through effort over time, which also increased their math skills (especially for word problems). Mathematical knowledge was then another form of cultural capital with linguistic capital at its basis.

The students' mathematical learning through their families and their transition to learning math in English can also be analyzed with Bourdieu's (1986) theory of cultural capital. Students like Carmen and Sarah who had no knowledge of English before being immersed in mathematics in English lacked linguistic capital and thus struggled with math in English for some time, despite already having mathematical capital from lessons in their native language. Laura and Carlos were taught mathematics in Korean and Spanish respectively at home, but were also intensively taught English, easing their transitions into mathematics in English; in other words, they had enough linguistic capital to make acquiring the cultural capital of mathematical knowledge easier.

The capital of mathematical knowledge that I am proposing is not unlike Bourdieu's scientific capital. Carmen mentioned standardized testing and the pressures of her teacher, which can be viewed as required tasks to recognize her competency in mathematics. Whether they be homework assignments, class tests, or state tests, the ability to complete these tasks result in the recognition of competency by others, which increases what Bourdieu calls "*capital of strictly scientific authority*" (Bourdieu, 1991b, p. 7; emphasis in original). Passing classes and moving from high school to college relate to the second form of scientific capital—that of "*social authority*" (Bourdieu, 1991b, p. 7; emphasis in original)—since they require specific qualifications. In the cases of the interviewees, meeting these qualifications to acquire the capital required cultural and linguistic adjustment.

The students switching between different school systems cited the differences in learning ideologies, which can also be taken into account as a form of capital that a student brings to math education in a second language. Sarah mentioned the strict structure of her Portuguese school, Carlos described the focus on speed and accuracy at school in Mexico as opposed to the idea of cooperation in the U.S., and the Chinese exchange students all referred to the rigor of the Chinese education system, which included competition and extreme pressure on memorization and producing accurate results. In all of these instances, the students' experiences in different school systems were experiences with different frames or orientations, resulting from different dominant ideologies. Education enforces the dominant culture's ideologies, which in turn influence the ways in which students tend to learn and approach mathematics and thus adds to their struggles or their success. In a new context, the differences in ideologies were made apparent and the results were mixed. For instance, Harry finally began to appreciate mathematics in the U.S. when he no longer had to do problems without trying to understand the concepts. Meanwhile, Rita expected more difficult problems in the U.S, which led to her overcomplicating problems, and Mary found it difficult to do math in the United States when she no longer had to memorize everything. Regardless of the outcome, these examples indicate how the change in educational institutions was coupled with changes in the "*codes*" (Martin et al., 1996, p. 19) of the dominant culture that decide what is to be valued in the institutionalized setting, whether it be rigorous academics like those in China or a focus on cooperative work in the U.S. as Carlos mentioned in contrast to schools in Mexico.

Next, we may consider how the prior educational experience of the students either at home or in another institution prepared them in terms of embodied cultural capital. Mary, Harry, and Rita—the Chinese exchange students—struggled with the language initially, but came to the United States with extensive cultural capital in the form of mathematics; thus, despite their language difficulties, they continued to excel. All three Chinese exchange students mentioned the rigor of the Chinese education system. Furthermore, for Mary, mathematics comes so automatically that she sees math as another language entirely separate from English and Chinese. The responses of Rita and Mary indicate that their mathematical ability comes in part from their cultural background in the Chinese education system. For students like Mary who view numbers and mathematics in general as a different language, linguistic capital is not even necessary to solve some problems accurately, making the acquisition of cultural capital of mathematics easier. Regardless of the background of the interviewees, each were prepared in different ways with varying amounts of cultural capital by their families and by other institutions to begin to acquire mathematical knowledge in English through the standard mathematics taught in school. As previously mentioned, this process was not always easy and, although each individual did manage to acquire cultural capital of some form and therefore gain access to power, it involved a period of struggle for each interviewee.

The struggles of the students with the new cultural and linguistic context sometimes ended with assimilation for practical reasons (e.g. when continuous translation became too time-consuming, etc); however, for many of the interviewees, assimilation occurred in reaction to a feeling of otherness. Learning mathematics in English made these students acknowledge their differences from the context of learning and they had to self-reflect in order to learn. For Carlos, Carmen, and Sarah, being successful in the standard form of Western mathematics meant acquiring more English language skills, adapting to learning mathematics in English, and overcoming struggles with context. When Carmen was questioned by her teacher and then began to ask herself why she could not understand math, she came to the conclusion that it was because of her cultural differences. Sarah also mentioned feeling like an outsider; she associated her math abilities with foreignness and strove to understand math in English to be more American. The transition to English made her feel like an “other,” causing her much distress. The experiences of these students navigating this transition involved tears, “trauma,” and disorientation as they searched for meaning in mathematics in their second language, but always led to assimilation.

The personal struggles of the interviewees in this study relate to Foucault’s (1972) notion of subjectivation. Carmen and Sarah’s realizations that they were the “other” are examples of this process. The knowledge in power categorized them in a cultural context different from the one in the classroom. They were forced to recognize their identities as other people, such as Carman’s teacher, recognized their differences. As subjects, these students experienced deeply personal struggles related to their identities. In reaction to this struggle, Sarah expressed her desire to feel more American. As Stets and Burke (2000) suggest, Sarah categorized herself as foreign due to her differences from her peers since she perceived herself as “the weird immigrant child.” Rather than continue as an outsider, she took on a different role. Through her quest for mathematical comprehension in English and her acquisition of standard American mathematics, Sarah re-categorized herself by accentuating new similarities in capital in language and math. During this process, she took on the role of an American student.

Stets and Burke’s (2000) theory of role identity also sheds light on the experiences of the Chinese exchange students. Mary credits Chinese students’ skill in math to the pressure in the school system; describing the intense competition in mathematics, she asked: If “you do that every day, how could you not do that well?” Rita also mentions that math is a popular choice for Chinese students not out of love for the subject, but because it is easy for them after intensive training in mathematics. In their responses, it is clear that the Chinese students experience extreme pressure—not only from their families, teachers, and peers in China, but also from other Chinese students and peers at their host college in the United States. This pressure turned the interviewees into competitive math students, whether or not they actually like or feel that they are good at math. In this reflexive process, the students acknowledged their categorization and took on the role expected of them as excellent math students. As they referenced expectations people had of them, the Chinese exchange students reflected upon their roles as "defined along stereotypical, normative lines as held in the culture" (Stets & Burke, 2000, p. 230), In this way, the roles the students took on matched the expectations people had of them.

For the multicultural students I interviewed, learning mathematics in English as a second language was influenced by their cultural capital prior to the transition and their interactions with the standard form of math. Linguistic capital and the habitus or way of thinking—particularly mathematical thinking as in the case of the Chinese exchange students—of the individuals affected the ease of their transition to learning math in a second language. When encountering the standard forms of math and English in the classroom, the students were forced to assimilate in order to understand the English and the context of the math they were learning. Students underwent the processes of metamorphosis and subjectivation, and in all cases, they adopted the dominant language and knowledge system of the standard form of mathematics, giving them access to power. However, this assimilation process came from a feeling of otherness and resulted in a devaluing of the student's cultural background. The main result of the personal struggles the students underwent was the re-categorization of themselves in relationship to the knowledge in power as expressed in the language and by the cultural context. Thus, in the math experiences of the students I interviewed, we can trace the relationship between knowledge and power as it decides the standard and institutionalized forms taught in school, requires students to assimilate in order to succeed and acquire cultural capital to gain status, and involves a certain degree of “becoming” (Martin et al., 1996) as they take on roles expected of them in the dominant culture’s ideology.

Conclusion

This study contributes to the discourse on math education in different languages and cultural contexts by incorporating the idea of standard mathematics into settings in the United States. While educational institutions often acknowledge the effects of standard languages on students, discussions of math education in the United States do not include the notion of standard forms of math. The dominant culture that designates the standard languages of the classroom and the ideology of the institutions is the same authority that promotes a standard form of math, leading to difficulties with cultural context and language. Since the Romance of Mathematics is so pervasive in Western culture, educational institutions incorporate its ideology and therefore this rhetoric makes its way into the classrooms where the struggles of multicultural individuals like the students in this study are left unacknowledged. Under the Romance, math is objective and a-cultural, which contributes to otherwise avoidable conflicts.

The combination of Foucault, Bourdieu, Stets & Burke’s theory of role identity, and theories from the anthropology of knowledge successfully provides a complete picture of power as it is present in the standard, influences the individuals, and allows them to reframe themselves to regain power through their acquired capital and/or new role. The theories do not address the universality of mathematics, since they only discuss the standard forms perpetuated by and contributing to the notion of universality, as it is present in the Romance. Whether there are different forms of mathematics is open to further investigation, but this study focuses only on the way that students experience math when their approaches to math and cultural and linguistic backgrounds do not match those of the educational institutions in which they are learning.

Overall, this study reveals the outcomes of math's standardization as students interact with power. Assimilation was a key theme in the interviewees' responses since it allowed them to gain access to power; at the same time, the choice of language and mathematical context in school devalued their various backgrounds by forcing them to take on the dominant culture and language in order to succeed. In the assimilation process, students gained cultural capital of various forms and were able to gain status in their new circumstances. The distinctions in cultural capital demonstrate the many factors involved in the learning process.

The results of this study explain why some individuals may struggle with learning math in English as a second language by taking into account different factors and forms of capital that relate to the acquisition of mathematical knowledge. A student's mathematical competence, and ultimately cultural capital of mathematics, depends not only on linguistic capital, but also on other forms of cultural capital. This explains why some students lacking linguistic capital do not struggle as much with mathematics, like the Chinese exchange students who excel at math due to the pressure on them to master mathematics within their culture and who regard math as its own language. Students with a background in the dominant language (i.e. students who have linguistic capital in English in this study) also have a relatively easier transition, in comparison to the students who have some math capital but little or no linguistic capital in English when they begin learning mathematics in English—the latter were the students who described the most struggles. More variety in math and non-math majors would provide further insight into the dynamics of cultural capital in math education. Most of the interviewees were non-math-majors who had less math experience than math majors would; however, the lack of cultural capital in mathematics of my interviewees relative to what I would predict most math majors possess allowed for an exploration of other forms of cultural capital that played a role in mathematical comprehension.

Looking at educational struggles—like those in mathematics—through the notion of cultural capital can uncover reasons behind these struggles. Rather than assuming that all Chinese students are mathematical geniuses, analyzing their knowledge in terms of acquired cultural capital can reveal the influence their educational background in China played in their math skills, as it did for Rita and Laura. This avoids labeling all Chinese students as innately superior in mathematics, providing cultural and linguistic reasons for their apparent mathematical ability. Furthermore, the notion of role identity allows for recognizing role acquisition as a reason for why students appear to meet expectations, whether they actually do or not.

Subjectivation and role identity explain the most important and lasting effects of the power implicit in standard forms of math. The struggles that many students experience due to the difference in context are not recognized under the Romance. These students must compare themselves to aspects of the dominant culture that are present in the classroom and define themselves in relation to it. Much of the "trauma" experienced is due to this feeling of otherness that can only be remedied by acquiring capital and taking on the role of an English-speaking math student of the dominant culture. More interviews from Latino/a students and Asian exchange students—the two groups with the greatest trends in their mathematics experiences in this study—would be beneficial in order to further examine the subjectivation process and the role identities taken on by these students.

Associating these experiences with subjectivation explains why the difficulty that students have with mathematical comprehension is so important to acknowledge, especially when the problems are rooted in cultural and linguistic differences. Subjectivation involves deep personal struggles, which can be disorienting and result in a reframing of the students' idea of a seemingly fundamental truth like mathematics to match the dominant culture. The standard form of math must be considered in terms of the effects it has on students whose backgrounds are not aligned with the dominant culture represented by the standard. These students may feel devalued in this process, due to the ideologies promoted in the educational institutions and the values placed on English instead of their first language, which lead them to assimilate given no other choice. The conflicts with context that Carlos and Carmen experience due to the standardization of mathematics can also be avoided by recognizing the orientation of the educational institutions and the dominant ideologies they represent, and altering teaching methods and word problems to be more culturally appropriate. It is critical that educators cast aside the Romance of Mathematics when teaching students and acknowledge the effects of standardized forms of knowledge so that students like Carmen do not continue to be devalued and to struggle without knowing why.

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