MEASURING HIGH SCHOOL STUDENTS' FUNDS OF KNOWLEDGE FOR LEARNING MATHEMATICS

MEDICIÓN DE LOS FONDOS DE CONOCIMIENTO DE LOS ESTUDIANTES DE SECUNDARIA AL APRENDER MATEMÁTICAS

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Mathematics experienced by students can be derived from the contextually situated "real world" experiences of the educator, which is typically White and middle class and not a reflection of the demographics of many classrooms in the United States. Activities where students find connections to their lives and interests have shown promise in enhancing student performance and experiences in mathematics classrooms. In this study, mathematics funds of knowledge are assessed in a novel survey instrument, reinforcing the salience of relating math experiences to students' lives and acknowledging skills and knowledge originating from experiences outside of the math classroom.

Keywords: Culturally Relevant Pedagogy, Equity and Diversity, High School Education

Many believe that there is no culture in mathematics. This would mean that arithmetic is the same no matter who a person is or where a person is physically in the world. However, the "real" in "real world" problems being solved is different for each student. Developers pull from their personal world but may not consider the perspective of their audiences. As such, many math word problems tend to be written from a white, middle class perspective (e.g., see Gerofsky, 2009; Frankenstein, 2009).

Expectations and decision-making of teachers are grounded in their cultural systems that may not align with those of their students. As teacher cultural expression is displayed and enacted through classroom practices, the lack of acknowledgement of those expressions and how they affect students can be problematic. The knowledge and awareness of how one's beliefs, experiences, values, and expectations are linked to their cultural identity is a major tenet of culturally responsive teaching (Griner & Stewart, 2013).

The racial gap between teachers and students in the United States continues to widen as the rate of diversity in teachers is declining more slowly than the rate of enrollment of students of color (NCES, 2017). According to NCES, White teachers make up 80% of teachers while over half of US students are Black, Latinx, Asian, Pacific Islander, Native American/Alaska Native or other races/ethnicities. This disparity in teacher-student ethnic demographics, structural barriers in advanced mathematics courses (U.S. Department of Education, 2018), lower expectations for African-American students (Gershenson & Papageorge, 2016), and racist policies for students being recommended for gifted courses (Ford, 1998), perpetuates the idea that there is no place for Students of Color in these classrooms.

Because of the opportunity gap that exists for students of color, math performance and preparation for college pathways in STEM for these students have become a matter of high interest and importance to teachers, schools and leaders in education policy and reform (Contreras, 2011; Gullatt, 2003; Noble, 2013; Marzocchi, 2016; Balfanz, 2006; Kotok, 2017). In this paper, we describe a research study conducted with high school students who were predominantly Latinx and African-American and were poised to become first-generation college students. Using a survey instrument we developed, we assessed students' everyday funds of knowledge for learning mathematics. The purpose of developing this assessment was to drive further instruction and enrichment in mathematics for these students. Here we report on the properties of the survey instrument, in the

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hopes that it could be used by teachers and researchers to assess their students' funds of knowledge and enact culturally responsive teaching.

Theoretical Framework

Culturally Responsive Teaching

According to Ladson-Billings (1995), Culturally Responsive Teaching (CRT) includes (a) students having the opportunity for collective success, (b) students developing or maintaining cultural competence, and (c) students developing a critical consciousness through which they challenge the status quo of the current social order. These things are not typically found in everyday lesson plans and many teachers require assistance to include these characteristics of CRT into their pedagogy. CRT involves teachers maintaining a high level of "cultural competence" in their pedagogy (Lindsey, 2009). These teachers are able to gather from the cultural experiences brought into their classroom via their students in their learning environment. CRT not only requires acknowledgement of student culture, but also the use of student culture as a learning tool in the classroom. The culture of the classroom transcends ethnic backgrounds, but also includes sexual orientation, disabilities, religion and language (Rogers, 2016), among other identifications and groups. Culture also includes the community inside and outside of school.

Funds of Knowledge

Funds of Knowledge (FoK) are the everyday knowledge bases from which students experience and learn within their homes and communities (Gonzalez, et al., 2005). Posited from the works of Velez-Ibanez and Greenberg (1992), the concept of FoK conveyed the notion of the existence of skills, talents, aptitudes, and inter-cultural exchange within Mexican-American homes. Moll et all. (1990b) focused on FoK originating solely from the household, but updated this opinion later (2005) crediting that FoK must incorporate information accumulated outside of the household in varied settings and activities. Moje et al. (2004) found that students' FoK derived from a combination of the home, peers and other networks. Andrews and Yee (2006) concurred that FoK stems from students' lived lives including their personal interests and influences. These personal interests serve as a source of knowledge not only useful for the wellbeing of the household, but of the student as well. Barton and Tan (2009) actually describe FoK as deriving from students' interests and talents.

Although it has been shown that Latinx households demonstrate strength in the complexities associated with sharing recourses and social networks within their community (Velez-Ibanez, 1988), educators have historically not used these FoK as a resource inside the classroom. Taking educators out of the classroom and into the homes and communities of their students has been highlighted in the works of Gonzalez, Moll, and Amanti (2005). In this study, teachers became researchers seeking and discovering the household knowledge of students developing rich relationships which set the stage for transactions of knowledge between teacher and student targeting student interest. FoK were found to focus on activities and tactical knowledge deriving out of culture (i.e., social, economic, political) essential to household functioning and progression. The involvement of student background into daily lessons and teacher pedagogy requires teachers to take an authentic inventory of their students and those students' cultural experiences to truly direct their pedagogy with a culturally responsive lens.

FoK emphasizes the salience of both academic and personal background knowledge of students. A culturally responsive educator focuses and utilizes this accumulated lived experience and knowledge to build upon it, increasing student learning. The FoK used to navigate social contexts are affirmed in culturally responsive lessons when properly addressed and utilized. As educators facilitate culturally responsive opportunities for students to broaden their FoK including their world views shaped by cultural, historical and political events, students' sociopolitical and critical consciousness are influenced to critique the inequities in their own educational and societal establishments.

Funds of Knowledge for Mathematics

Funds of Knowledge in mathematics and connections between home and community involvement has been the subject of considerable research (Civil, 2007; Gonzalez, Andrade, Civil & Moll, 2001; Civil & Andrade, 2002; Nasir, 2002; Nasir, et al., 2008). The work of Civil (2007) on mathematical FoK focused on everyday life activities and how they connect to mathematics. Civil's work highlighted success in using FoK in the development of mathematics learning objectives through an educator's authentic desire to learn about their students' community, and to understand and leverage the community's resources and the knowledge originating from students' households. As opposed to making cultural generalizations about the community, teachers took invested interest in learning about their students' home and community lived experiences. Certain dilemmas are addressed in Civil's work, such as the tension between authentic problem-solving opportunities that relate to home and community experiences and dealing with socio-mathematical norms in the classroom where students are conditioned that mathematics "work" involves worksheets inside the classroom.

Work on FoK in mathematics has also been connected to research on personalizing instruction. Personalizing students' mathematics learning by drawing upon their FoK can affect student interest and performance in mathematics, as demonstrated in Walkington and Bernacki (2015). In their article, Walkington and Bernacki had students pose mathematical problems based upon their out-of-school interests in areas like sports or video games, harnessing their FoK to develop more meaningful connections to mathematical concepts. Walkington and Hayata (2017) also describe a series of teaching experiments where students posed, solved, and shared algebra problems related to their out-of-school interests.

Algebraic story problems can be presented to students as a method of contextualizing life experience to confront inequalities. In Turner, et. al., (2016), using students' FoK, an educator gave students opportunities to discuss mathematical situations where injustices they have experienced in their lives that could be represented as inequalities. Prompting students within the context of injustices with inequalities, students gained deeper understanding of constructing these types of equations and contrasting them against others.

While there is a large body of work that support the use of FoK within an educational context, there are also critiques of this practice. Zipin (2009) notes the absence of what he calls "dark" or negative pedagogies including abuse of others and substances, mental health issues and alcoholism. Here, the idea is presented that educators wish to only focus on "light" or positive FoK as opposed to the whole lived experience of students, light and dark, which may seem troubling for educators to consider in the classroom (Zipin, 2009). Although dark FoK may challenge traditional approaches by educators, it provides a rich and authentic source of knowledge from which students could draw. In addition, knowledge as metaphorical capital has been criticized for being incomparable to financial capital and has been framed as an inappropriate connection to the negative economic and political dominance of capitalism (Hinton, 2015). Oughton (2010) also points out the theory of funds of knowledge literature has morphed from deriving from household knowledge into various sources of knowledge which may be influenced by what the researcher has determined to be FOK. However, the power of individual, parental and educator agency as potential propelling forces behind the acquisition of knowledge and increases of performance in students is highlighted in by Rodriguez (2013).

Research Purpose

Very few prior studies have focused on quantifying FoK. In one such study (Rios-Aguilar, 2010), 212 K-12 Latinx students took the Latino/Hispanic Household Survey where connections to FOK were made to both academic and non-academic outcomes focused in reading and literacy. Rios-Aguilar (2010) found that activities and experiences in Latinx households contributed to both academic and non-academic outcomes for these students.

Here, our purpose was to expand this work and consider specifically what knowledge bases students might have that are relevant to learning mathematics. Our first research questions is: (1) How are different areas of FOK in mathematics related to each other? Our remaining research questions are: How do measures of students' FOK for mathematics (both overall and in individual areas) predict: (2) Student interest in mathematics? (3) Math grades? (4) AP math course-taking? (5) Dual Credit math course-taking? (6) Desire to pursue a career in STEM?

Method

Participants

This study included students participating in an educational program outside of school hours. These students are from various high schools in a large, urban, US Southwestern school district. Students' ages ranged from 14 to 17 years old. All students are low socioeconomic status and most are Black and Latinx. Similar to other US urban school districts, the one the students from this study come from serves over 150,000 students where 87% of the community is economically disadvantaged and 44% are limited in English proficiency. Students in the district were 69.6% Latinx, 22.5% African-American, 5.4% White, 1.4% Asian-American, 0.3% Native American, and 0.7% two or more races.

There were 72 students participating in the study with 49 (68%) female students and 23 (32%) male students. Students' self-reported grades in their prior math class were 24 (33%) with As, 41 (57%) with Bs, 6 (8%) with Cs, and 1 (1%) Ds. Seniors made up 14% (10) of total students while 44% (32) were Juniors, 24% (17) were Sophomores and 18% (13) were Freshman. Students' current high school math class included 10 (14%) in Algebra 1, 22 (30%) in Algebra 2, 3 (4%) in AP Calculus, 4 (6%) in College Algebra, 4 (6%) in AP Statistics, 12 (17%) in Geometry, 1 (1%) in Math Models, 13 (18%) in Precalculus, 1 (1%) in Trigonometry and 2 (3%) students that did not answer. Sixty-five percent of students indicated interest in pursuing STEM major in college and 68% of students were interested in STEM careers.

Students completed the survey on their phones. There were no incentives for the students to complete the survey. All included participants gave assent along with having parental consent.

Measures

This study used the researcher-created Mathematics Funds of Knowledge Survey (MFoKS) to assess students' level of FOK. The MFoKS is used to quantify students' level of Funds of Knowledge in 9 "bins" including: Money, Travel, Sports/Fitness, Social Media, Video Games, Cooking, Health, Art, and Directions. The survey is a 70 item mixed-model of qualitative (9) and quantitative questions (61). Each bin had 3-11 items. The survey includes a 5-point Likert scale including 1 for "almost never," 2 for "at least once a year," 3 for "at least once a month," 4 for "at least once a week," and 5 for "almost daily." The survey calculates FoK as a frequency of usage in each of the bin which will generate a score for each bin. Some examples of items from the MFoKS include: "How often do you check how many retweets or shares a post [on social media] has gotten?" and "How often do you pay attention to how many plays, spins or streams a song has?" and "How often do you consider different shipping rates when shopping online?"

The overarching survey that students in the educational program took also included questions about students' interest in mathematics using a scale from Renninger and Schofield (2014) with 24 Likert questions ranging from 1 to 5. Students had an average score of 2.89 in math interest.

Data Analysis

To answer the first research question, a correlation matrix was generated to determine which categories were highly correlated or not correlated. The remaining research questions were answered using regression models. The *lm()* command was used in RStudio. The outcomes were average math interest (rated on a 1-5 scale), grade in their last math course (4=A, 3=B, 2=C, 1=D), AP Track (i.e., a 0/1 variable denoting whether the student was in AP math classes), Dual Credit (i.e., a 0/1 variable denoting whether the student was in Dual Credit classes) and STEM Major interest (i.e., a 0/1 variable denoting whether the student was interested in majoring in STEM). Math interest and last math grade were fit as linear outcomes. The *glm()* command was used for AP Track, Dual Credit, and STEM Major Interest, as these were 0/1 variables - we used the binomial family and logistic regression. Predictors in the models were average 1 – 5 Likert scale ratings of the 9 areas in funds of knowledge. Control variables (not shown in table for brevity) were what math course the student was currently enrolled in and their gender. The Dual Credit model also included an additional control for what year in high school the student was currently enrolled, as dual credit opportunities are usually for older students.

Results

Students rated their FOK for mathematics highest for cooking, with an average rating of 3.56. The lowest FOK rating across student was for Money with an average rating of 2.46.

With respect to our first research question, when examining how students' ratings of the 9 different areas of FOK were related (Table 1), none of the correlations were over 0.6, which suggests that all 9 of the areas of funds of knowledge surveyed may be distinct from one another. It was also found that there were higher correlations between money and travel, health and art, and cooking with travel, sports, health, and art. FOK areas found to have low correlations with each other were money and art, and video games with travel, sports, social media, health, cooking and distance, with the lowest correlation found between video games and travel.

For the second research question, we found that in the regression models (Table 2) math interest was significantly positively predicted by certain areas of FOK. The FOK areas showing significance include money (p = .004), travel, (p < .0001), cooking (p = .019), distance, (p = .034), and, overall mathematics FOK (i.e., a composite average from the 9 areas; p = .005). For the third research question, it was found in the regression models that travel showed significance in positively predicting math grade (p = .04). The fourth research question addressed predicting the AP Track of students, and it was found that travel (e.g., recognizing the use of numbers and distances while using various modes of transportation) showed significance as a negative predictor (p = .023). For the fifth research question, it was found in the regression models that social media showed significance in negatively predicting Dual Credit enrollment (p = 0.035). The sixth research question addressed STEM Career interest which was significantly and positively predicted by travel (p = .008), social media (p = .046), and overall mathematics funds of knowledge (p = .034).

Table 1: Means, standard deviations, and correlation matrix

FOK Variable	M	SD	1	2	3	4	5	6	7	8	9
1. Money	2.46	.726	--								
2. Travel	2.55	1.080	.45	--							
3. Sports	3.16	1.216	.28	.35	--						
4. Social Media	2.92	1.212	.39	.26	.40	--					
5. Video Games	2.86	1.557	.30	.00	.02	.15	--				
6. Health	3.1	1.219	.23	.29	.43	.37	.18	--			
7. Art	3.08	1.215	.11	.22	.38	.39	.33	.50	--		

8. Cooking	3.56	1.260	.28	.54	.58	.46	.04	.56	.47	--	
9. Distance	3.38	1.367	.35	.39	.38	.39	.14	.42	.32	.34	--

Table 2: Regression Results

	Math Interest	Last Math Grade	AP Track	Dual Credit	STEM Career
Overall Math FOK	.37(.13)**	.05(.10)	-.25(.36)	-.10(-.37)	.81(.39)*
Money	.40(.14)**	.02(.11)	-.61(.40)	-.10(.40)	.67(.43)
Travel	.49(.08)***	.16(.07)*	-.64(.24)*	-.37(.30)	1.03(.39)**
Sports	.15(.09)	.01(.07)	-.21(.24)	-.20(.24)	.40(.24)
Social Media	.08(.09)	-.09(.07)	-.04(.23)	-.59(.28)*	.51(.25)*
Video Games	.07(.07)**	.01(.05)	-.16(.19)	.17(.19)	.23(.19)
Health	.14(.90)	-.02(.07)	-.04(.23)	-.19(.25)	.16(.24)
Art	.15(.09)	.07(.07)	.12(.24)	.12(.25)	.35(.24)
Cooking	.19(.08)*	.10(.06)	-.20(.24)	-.17(.23)	.19(.22)
Distances	.21(.08)*	.07(.06)	-.11(.22)	.28(.24)	.31(.21)

Discussion and Conclusion

In the present study, we developed a quantitative measure of students' FOK for learning mathematics, and discussed the results of administering this measure to a sample of high school students. Our measure covered 9 facets of everyday funds of knowledge, which correlational results suggest were distinct areas – with some facets of FOK being more highly related to each other than others. Our next step will be to conduct a factor analysis and calculate internal consistency values for the survey instrument. We also found that students' FOK for mathematics were predictors of mathematics outcomes that we would care about for students – particularly interest in learning mathematics and their interest in careers in STEM related fields. This suggests potential directions for future work – leveraging students FOK in the classroom could enhance students' interest in learning mathematics, as could asking students to increasingly apply a mathematical lens to their everyday activity. Cultivating students' mathematics FOK could also influence career interest in STEM fields, an area underrepresented by Latinx and African-Americans (Funk & Parker, 2018). A well-designed survey instrument could help teachers assess their students' FOK to be used in targeting instruction; this paper represents the first step towards creating such an instrument.

The purpose of the MFoKS is to collect and quantify students' levels of FoK focused in mathematics for daily living. When teachers and administrators have access to student math FOK, they are able to utilize student interests in personalized lesson plans and identify strengths of their students for participation and opportunities. Students' FoK data counters the narrative about deficits students have with experience with mathematics and numbers outside of the classroom. Lastly, the MFoKS can provide administrators and community leaders with the blueprints for establishing programs to build math FoK in the community.

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