Outcomes

walkSTEM has established a strong relationship with the SMU Simmons School of Education, as well as the greater SMU community. Professors Wilhelm and Walkington of the Research in Mathematics Education Group

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at SMU Simmons co-authored the attached study regarding the impact of walkSTEM during its launch year. Highlights include:

- Research and math education professors applied and received an internal grant to support a yearlong study of walkSTEM in 2017; their research was presented in April 2018 at a national educational research conference in New York City
- walkSTEM@SMU was created at the request of the community outreach office at SMU; walkSTEM@SMU will be made available to over 1,000 middle school students who visit the campus for field trips every year.
- Koshi Dhingra, Director of talkSTEM, was invited to speak to groups of teachers about walkSTEM initiatives at SMU.
- Conversations about joint funding at the national level are ongoing.

Finding mathematics in art, architecture, and landscape in urban areas: The walkSTEM movement

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Objectives

Students' interest in learning mathematics can decline as they reach adolescence (Fredericks & Eccles, 2002; Frenzel, Goetz, Pekrun, & Watt, 2010), as the mathematics they are learning in school typically becomes less concrete and immediately relatable to everyday activity. Mathematics educators face a challenging question: How can we engage students and to allow them to see that mathematics is a rich and dynamic subject that is useful for describing and understanding the world?

Urban areas are dense with architectural and artistic attractions, as well as planned natural areas. Such community sites can be an avenue for children and families to explore how mathematical concepts occur in the world around them. Students who are residents of urban areas often have familiarity with the major landmarks, environments, and areas in the downtown. This familiarity can be used as a resource to support their learning of mathematics (Civil, 2007). Indeed, students come into school with key resources or *funds of knowledge* (FOK), from their homes and communities that have been historically-accumulated and culturally-developed (Moll, Amanti, Neff, & Gonzalez, 1992).

In the present paper, we describe a research study conducted on the *walkSTEM* initiative. In this initiative, children and their families can sign up for free "math walks" in the Dallas Arts district on weekends. Walks are led by trained docents who engage families in discussions around how mathematics appears in the world. We conducted surveys with families who participated in the walks, as well as with docents who led walks.

Theoretical Framework

The FOK perspective accentuates that students often engage in situated quantitative reasoning in out-of-school contexts (Civil, 2007), and these resources can be brought into the classroom to support student engagement and learning. Utilizing FOK shows students that their communities are valued and that the things they do in their everyday life are relevant to school learning. Researchers have examined how the "everyday math" that students use in their homes, communities, and day-to-day activities. Research has explored the creation of instructional school units around children's experience playing games (Civil, 1994), with different types of money, and with home-based knowledge of gardening and construction (Civil, 2007). Interviews with families have revealed that they use mathematical practices while cooking, sewing, engaging in construction, and scheduling (Gonzalez, Andrade, Civil, and Moll, 2006).

While using community-based resources to draw upon funds of knowledge and enhance interest has promise, research has documented the incredible difficulty of students making connections between math and the real world (Inoue, 2005; Lave & Wenger, 1991; Masingila et al., 1996; Saxe, 1988). Research is needed on programs like walkSTEM that can serve as models for other communities, and for other programs that seek to connect math to everyday life. Our first research question is: *What do families learn from participating in an urban math walk experience?*

Math educators also need to understand how connections are made between math and the community. Turner et al. (2012; 2016) conducted studies in which pre-service teachers engaged in "community walks" where they visited students' neighborhoods, and wrote activities connected to students' home and community lives. They found that teachers tend to make connections to students' lives at a variety of depths – some teachers used general, overarching assumptions about an age group (e.g., liking swings), while others used knowledge about student preferences that was not necessarily quantitative. The strongest connections included mathematization of family practices and mathematical activities that children actually engaged in (e.g., scoring points in basketball; Turner et al., 2016).

While this research is important, it does not examine how educators go about enacting these approaches, and it occurs within the relatively artificial "school math" realm. In the present study, we operate within a community-based informal learning space where educators guide children and their families to think together about mathematics. Our second research question is: *After leading an urban math walk, what reactions to docents have relating to the experience?*

Methods and Data Sources

The walks involved two trained docents (STEM educators) working together to lead up to 25 participants around various sites in the Dallas Arts District (Figure 1, end of document). The walks lasted 45 minutes, and there were two different versions of the walk for elementary versus middle school. Parents would sign up for one of these versions in advance online. The walks would stop at sites like a Pegasus sculpture composed of geometric shapes, a park with a large jungle gym in the shape of an icosahedron, a tessellation of floor tiles in front of a symphony, and a growth of bamboo around a sculpture center.

Two surveys were designed on Qualtrics. The first was for walk participants, designed to be taken on a cell phone. Participants would be given a link and barcode to access the survey at the end of the walk. This survey included demographic questions and three open-response questions: (1) What did you learn from the walk? (2) Describe how math appears in downtown Dallas. (3) Describe how math appears in your neighborhood. The second survey was distributed to docents via email after they led their first walk. The survey contained demographic items and a variety of open-response items, but in the present summary we focus only on two: (1) What was your favorite aspect of the walk? (2) What was challenging about this walk? Docents were offered $25 gift cards to take the survey.

The participants survey was taken by n=40 parents and children, although not all participants responded to all questions. Twenty-one identified as caregivers, teachers, or community

members over 18 years of age, while 18 identified as K-12 students. For the students, the average age was 11.5 (*SD*=2.6), and there were 11 males and 6 females. For those over 18, one reported being aged 18-24, 13 reported 25-44, and 1 reported 45-64, with 4 males and 11 females.

The docents survey was taken by *n*=18 docents (15 females, 3 males). Thirteen reported typically working with elementary students, 6 with middle school students, 6 with high school students, and 2 with university students. Their average amount of experience as an educator was 11.2 years (*SD*=6.1). Nine docents reported a race/ethnicity of Caucasian non-Hispanic, 2 reported African-American, 2 reported Asian, and 2 reported Other. Five reported Hispanic ethnicity.

Open-ended responses were coded using emergent themes (Glaser & Strauss, 1967) by two coders working collaboratively.

Results

RQ1: *What do families learn from participating in an urban math walk experience?*

We looked at walk participant responses to three open ended questions on the participant survey (Tables 1 and 2, end of document). Responses were subdivided depending on whether the respondent was a child or adult. When asked what they learned from the walk, 6 children discussed geometry concepts and terms they learned about. A 12-year-old female described how "I enjoyed seeing shapes and symmetry in nature and the real world." In addition, 6 children discussed algebraic concepts they learned. A 10-year-old female said she learned "How to find a slope." Six children also expressed the sentiment that math was all around them, and part of their everyday life: "Shapes and math isn't just on a piece of paper. It is all around you." Finally, 5 children mentioned math in architecture, nature, or art: "… Lots about shapes in buildings. Also, how math can affect architecture."

The adults were similar, although fewer discussed concepts they learned from algebra and geometry. Some adults cited the STEM (Science, Technology, Engineering, and Mathematics) connections in the walks. One adult described how: "I enjoyed observing how STEM components were highlighted utilizing the various buildings and other structures throughout the Dallas Arts District. Watching the kids engage their current level of knowledge to solve challenges was exciting."

We also looked at participants' responses to two additional questions "Describe how math appears in downtown Dallas." and "Describe how math appears in your neighborhood" (Table 2). For the downtown Dallas question, responses were similar for adults and children. Both groups were most likely to describe architectural sites. A female caregiver described how "Everywhere! In the walkways, the buildings, the signage-- you can't miss it once your eyes are opened!" A 12-year-old female described how "It appears in shapes of the buildings and the slopes, ratios are also used." Connections to nature were the next most often-cited answer, given by 4 children and 7 adults. A 12-year old male describes how "It appears in many things. From the structures and buildings, the circumference of plant stems, and the area of structures." Three children and 2 adults also expressed how math was found in art like statues: "Statues with

shapes. Area on tile. Fractal geometry in magnolias leaves. Linear equations on bamboo sticks." Finally, 4 children and 5 adults again expressed that math is everywhere.

For the questions about math in their neighborhood, the most common response among children (7/15) and adults (5/11) was to describe how math occurs in houses. A 15-year old male describes how math is in "basic construction of my house" while a female caregiver stated "The designs of the street, the perimeters and areas of the homes." Respondents also mentioned the sidewalk or street in their neighborhood, as well as the signage, gardens and yards, parks and playgrounds, and their local school building: "We would need to know the area of a yard for new grass, or the perimeter for a new fence."

RQ2: After leading an urban math walk, what reactions to docents have relating to the experience?

Table 3 shows docents' responses to questions asking them what was their favorite and most challenging aspect of the walk. All 18 docents said that interacting with families was their favorite part of the walk. In addition, 9 mentioned the enthusiasm they saw from participants, while 8 discussed how participants contributed their own mathematical ideas. One docent described how their favorite was "Being able to explain how art and math go hand in hand in some of the amazing infrastructures and art pieces in the arts district. The students faces light up when they discover this." Another described how "I loved seeing the kids engaged and looking for more things to measure/observe at each stop than just the ones we showed them." A third docent said "My favorite aspect of the walk was being able to interact with the kids, especially at the *REALLY Big Number* stop. The kids were really engaged and spent several blocks discussing other objects or shapes we could count."

When asked what was challenging about the walk, most docents (13/16) mentioned issues with being limited to just 45 minutes. One docent described how "My walk was about 55 minutes instead of the recommended 40-45 minutes. I think this was due to the discussions the walkers engaged me in, increased traffic around lunch time." Another described how "The walk was very interactive and children were engaged which made is difficult to keep track of time so we couldn't do the last stop." Three docents also mentioned issues with age-appropriateness for children: "We were leading a middle school walk; however, a majority of the students who came on the walk were elementary." Finally, two docents mentioned wanted more time to practice with their partner, while 2 cited issues with participants being unable to hear them.

Significance

Here we explored a novel approach to connecting mathematics to the community, and to engaging families together in mathematical reasoning. We describe an informal learning experience where docents lead free math walks in an urban area. Our results suggest that both children and adult walkers benefitted from this experience, and that docents also enjoyed interacting with families around mathematics in an informal setting. WalkSTEM is not intended to be a static math walk specific to downtown Dallas; rather it is conceptualized as a grassroots movement where people design and create and lead their own math walks for their schools, neighborhoods, and communities. Indeed, several of our docents have been expanding

walkSTEM in this way. By communicating this research, we hope to add to the proliferation of community-based mathematical experiences for families.

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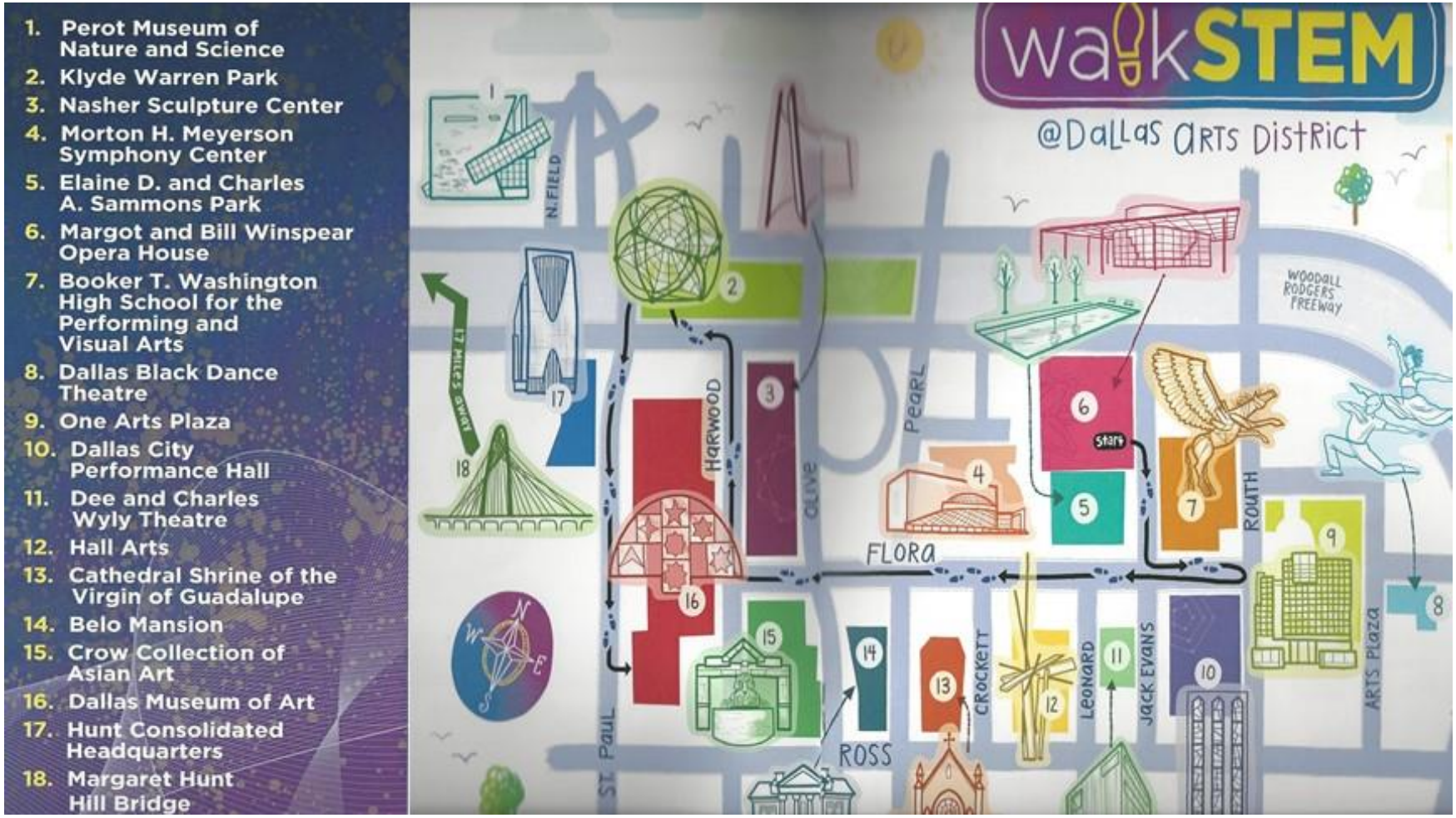

Figure 1. walkSTEM route in Dallas Arts District

Table 1.

*Responses to question "**What did you learn from the walk?"** on participant walk survey*

Children (*n*=18)	**Adults (n=14)**
Geometry concepts and terms (6)	Math is everywhere (7)
Math is everywhere (6)	Architecture/nature/art (4)
Algebraic concepts and terms (6)	STEM integration (4)
Architecture/nature/art (5)	Algebraic concepts and terms (2)
	Geometry concepts and terms (2)

Note. One participant's response can be coded with multiple codes.

Table 2.

Responses to two questions on participant walk survey

Q2. Describe how math appears in downtown Dallas.		**Q3. Describe how math appears in your neighborhood.**	
Children (*n*=16)	**Adults (*n*=13)**	**Children (*n*=15)**	**Adults (*n*=11)**
Architecture (11)	Architecture (11)	Houses (7)	Houses (5)
Nature (4)	Nature (7)	Sidewalk/street (3)	Sidewalk/street (4)
Art (3)	Art (2)	Gardens/yards/leaves (3)	Signs (2)
Math is everywhere (4)	Math is everywhere (5)	School building (2)	Park/playground (2)

Note. One participant's response can be coded with multiple codes.

Table 3.

Responses to two questions on docent survey

Q1. What was your favorite aspect of the walk? (*n*=18)	**Q2. What was challenging about this walk? (*n*=16)**
Interacting with families and children (18)	Time management (13)
Seeing participants excited/enthusiastic/engaged (9)	Age-level appropriate content (3)
Having participants contribute mathematical ideas (8)	Partnering with another docent (2)
	Communicating with participants (2)

Note. One docent's response can be coded with multiple codes.