Defining the Varied Structures of Tutoring Centers: Laying a Foundation for Future Research

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The creators and leaders of mathematics tutoring centers at universities make many choices about the organizational structure of their centers. Some of those choices include the location of the center, the education level of the tutors, the method of tutor training, the number of hours tutoring is available, and the way tutoring is provided (i.e. drop in or scheduled). Our group's long-term goal is to provide research-based evidence to help faculty and administrators choose effective structures for centers. This paper documents similarities and differences between centers to provide a descriptive foundation for future hypothesis generation and testing.

Keywords: tutoring centers, organizational structure, definition of constructs

While most would recognize that mathematics tutoring centers (henceforth called math centers or centers) are units associated with post-secondary institutions whose purposes are to aid students studying mathematics, little is actually known about their general characteristics. Whetten, Felin, and King (2009) insist that organizational research should begin with context sensitivity that acknowledges and accounts for the relevant conditions of the entities to be studied. For that reason, we began this study with a series of questions: What are the structural similarities and differences of math centers? What are useful ways to define organizational structures of math centers?

Our group's long-term goal is to generate and test hypotheses about the effectiveness of competing organizational structures. The three stages of this research are:

1. Describe the organizational structures of various tutoring centers.
2. Compare qualitative and quantitative measures of success from various centers and develop testable hypotheses about the choices that impacted the success of these centers.
3. Design research methods to specifically test hypotheses generated in stage two.

This paper addresses the first stage. We draw on our experiences as tutor center leaders to identify, define, and document significant organizational structures of various tutoring centers.

Theoretical Perspective

Research on organizational identity suggests that identity is a construct formed from comparisons. Gioa, Patvardhan, Hamilton, and Corley (2013) suggest that some of the first stages of organizational identity formation process should involve considering contrasts and converging on a consensual identity. Albert and Whetten (1985) put forth that "organizational identity is formed by a process of ordered inter-organizational comparisons and reflections upon them over time" (p. 273). While theories such as these are more common in management fields, for educational researchers this might be reminiscent of variation theory, which suggests a concept is understood when its critical features are acknowledged, and the means to deem features as critical is discerned only through experienced variation (Runesson, 2006). To determine the organizational identity that is associated with math centers we look at the central, stable features of math centers that make them distinctive (Gioa, Patvardhan, Hamilton, & Corley, 2013). We looked outside of mathematics education for theoretical guidance on how to study organizational structures because this is not a common topic in research in undergraduate mathematics education. We narrowed in on the idea of defining identity by making comparisons between organizations for the first stage of the research.

Literature Review

Empirical investigation of mathematics tutoring and tutoring centers at the undergraduate level is still in the beginning stages. *Characteristics of Successful Programs in College Calculus* reported that undergraduate tutoring is commonplace: 97% of the 105 institutions surveyed had a tutoring center for students to receive help for calculus, and 89% of the institutions offered tutoring by undergraduate students (Bressoud, Mesa, & Rasmussen, 2015). Several quantitative studies indicate that visiting mathematics tutoring centers is correlated with higher final grades (Byerley & Rickard, 2018; Rickard & Mills, 2018; Xu, Hartman, Uribe & Menke, 2014). Each of these studies focused on a single institution, and the metrics for success are limited to final grades, rather than other indicators of success such as persistence through a STEM major. Matthews, Croft, Lawson, and Waller (2013) reviewed the literature concerning tutoring center effectiveness and found a wide diversity in the metrics that determine success, such as grades, retention rates, frequency of repeated visitors, and student reports of confidence and motivation. They recommend further investigation into “what constitutes effective delivery of mathematics support” (p. 23). Due to the small number of studies on tutoring centers we feel confident that no studies have compared centers with contrasting organizational structures to make hypotheses about structures of effective centers.

To explain the success of tutoring, a number of studies have examined the intricacies of tutor-student interactions. Research indicates effective tutoring commonly includes active inquiry and self-explanations on the part of the student (Chi, 1996; Lepper and Wolverton, 2002; Topping, 2005; Van Lehn, 2011), and appropriate questioning and responsive scaffolding on the part of the tutor (Graesser et al., 2011; Roscoe & Chi, 2007; Topping, 1996). While these findings are helpful in guiding productive tutoring, they were not conducted in a mathematics tutoring context, nor do they offer significant insight into the structural organization of a tutoring center. Solomon, Croft, & Lawson (2010) is one of the few studies to describe the impact of a physical space on the climate of a math center.

Methods

We will compare structures that differ between tutoring centers by drawing on our experiences with tutoring centers. All six authors of this paper are actively involved in their university’s math center, attend a national conference for tutor center leaders, participate in weekly or monthly online meetings with other tutor center directors, and lead or attend tutoring center working groups at the RUME conference. Our understanding of tutoring center structures is built on our frequent interaction with our universities’ tutoring centers, notes from conferences and online meetings, and a shared digital resource library.

Multiple center leaders wrote descriptions of various aspects of their centers such as tutor selection, tutor training, center hours, classes tutored, numbers of students served, description of physical space, and description of relationship with the mathematics department. We analyzed these documents to create and refine definitions of organizational structures. Of course, there are other differences between our centers that did not emerge in our conversations and writing. This methodology relies on the expertise of tutor center leaders to choose what they believe are the most important contrasts between centers. We make no claims that the structures we define will turn out to be the most important once more formal study is conducted.

Descriptions of Different Tutoring Center Structures

In the following section, we describe six significant dimensions of undergraduate mathematics tutoring centers: (1) Specialist versus Generalist Math Tutor Models, (2) Strength of Relationship between Center and Math Instructors, (3) Type and Extent of Tutor Training, (4) Types of Tutoring Services, (5) Physical Layout and Location, and (6) Tutoring Capacity.

Specialist versus Generalist Math Tutor Models

A specialist math tutor is assigned to tutor for one course. This tutor helps numerous students with the same course and becomes familiar with the homework problems, student mistakes, homework solutions, the syllabus, and expectations for testing. Ideally the tutor would communicate with at least one instructor of the course to give feedback on students' experiences and to ask for any clarification needed. Sometimes specialized tutors also serve as Learning Assistants in the course (see Goretzen et. al., 2011 for definition of Learning Assistant). Often Learning Assistants attend a course and assist faculty with in class group work and hold mentor groups outside of class. Typically, specialist tutors are not available during all times the center is open and students must attend the center when tutors are available for their course.

A generalist math tutor is someone who tutors for many or all of the courses the center serves that the tutor understands. When students come to the center while it is open they have a reasonable expectation that someone will be there to help them. A generalist tutor should be able to respond to questions about all or most of the courses served by the center. Students typically ask tutors some of the harder questions in the homework and it is difficult even for experienced tutors with advanced degrees to answer questions on the spot in courses they took semesters ago. Compared to specialist tutors generalist tutors will spend more time solving the problem and be more likely to use a textbook or other resources. We are not claiming that tutors needing to use resources to solve the problem is negative. Perhaps seeing tutors model how to solve unknown problems is better for students that seeing tutors who know the assignment and answers intimately. Generalist tutors are less likely to understand the scope of the course or the particular procedures the instructor is assessing, especially for courses like College Algebra the tutors typically took in high school.

Strength of Relationship between Center and Mathematics Instructors

There are a variety of characteristics of tutoring centers we identified as having strong relationships with the mathematics instructors at their university. It is unknown if the effectiveness of a tutoring center is related to the strength of its connection with the mathematics instructors. It might be that having strong connections with student services or centers for teaching and learning are more important predictors of effectiveness.

Course Coordinators Collaborate with Tutor Center Leaders. At some centers the leaders interact frequently with course coordinators. The center leaders might be math faculty who are also course coordinators or instructors. An example of collaboration is a course coordinator that offers extra credit to students for completing a task at the center and the center records this information. Other center directors do not teach math or communicate frequently with the course coordinators or instructors. If a center relied on the mathematics faculty occasionally to provide recommendations for tutors or to provide course syllabi the center could still be categorized as having minimal collaboration with course coordinators.

Instructors of Courses Hold Office Hours in the Center. Some department chairs request that instructors hold office hours in the center. Other centers are only staffed by undergraduates or a mixture of undergraduate and graduate students. We believe that when instructors are tutors in the center there is more potential for dialogue between instructors and other tutors.

Tutors Interact Frequently with Course Instructors. In some of the universities with specialist tutoring models, the tutors attend the courses they tutor for as Learning Assistants who help with group work. Generalist tutors might also interact frequently with course instructors if the instructors also tutor in the center or the tutor center leaders are also course instructors.

Type and Extent of Tutor Training

In our centers, undergraduate tutors are the most likely to receive training and graduate student tutors are the second most likely. In our centers, faculty do not receive tutoring training.

Content Training. Content training is focused on refreshing and deepening the tutors' knowledge of the content of the classes they are responsible for. Examples of content training that exist at our centers are asking tutors to read the book according to the posted schedule or asking tutors to complete homework problems focused on relevant material.

Pedagogical Training. Pedagogical topics include how to help the student use resources to solve a problem, how to report students in crisis, how to ask good questions, how to motivate students, how to teach study strategies, how to respond to complaints about instructors, etc. Pedagogical training varies between centers because of the variations in the philosophy of tutoring between center leaders.

Mathematical Knowledge for Tutoring. We suspect that effective tutors draw upon more than content knowledge and pedagogical knowledge and have developed additional insight into learning mathematics. We speculate that the construct mathematical knowledge for tutoring is not identical to the construct mathematical knowledge for teaching (Thompson A. and Thompson P., 1996; Hill, Ball, & Schilling, 2008) but has some similarities. There are no known programs to develop mathematical knowledge for tutoring, but tutor center leaders report that they try to help tutors understand this issue sporadically. For example, some center leaders analyze student work with tutors and help them generate hypothesis about student thinking.

Time Spent on Training. Training time includes meetings between tutors and center leaders focused on improving content or pedagogical knowledge. Most centers who provide training do more training in the first semester of the tutor's job. Although tutors might learn from experiences such as attending class to facilitate group work, we do not count this as training.

Types of Tutoring Services

Some centers focus on a particular type of mathematics, such as calculus, and only serve a few courses and are typically housed in smaller locations. Other centers serve upwards of twenty different courses ranging from developmental mathematics to linear algebra and are typically housed in much larger spaces. One advantage of having large centers that serve the majority of courses is that the university can put one person in charge of managing the center. If smaller centers serve restricted clumps of courses, the university might need more people to manage the centers. We wonder if smaller centers develop different cultures than larger centers serving many courses. Additionally, some centers offer drop in tutoring, others offer scheduled one-on-one tutoring, and others offer a combination of services. A potential benefit of drop in tutoring is that some students work together and make study friends at the center. A downside of drop in tutoring is that some students complain of waiting too long for help and not having enough time with a tutor.

Physical Layout and Location

Oklahoma State's center is housed in beautiful rooms with huge windows, ample natural light and expansive views of campus while other tutoring centers have no windows. Some centers do not have enough chairs for students during busy times, and students choose to either sit on the floor or leave the center after evaluating the crowd. The ceiling height and ventilation differs at centers leading some students to complain of stuffiness or smell. In addition to wide variations in the quality of the centers' spaces, there are variations in the center's location on campus and how far the students typically must travel to attend the center. Some centers offer tutoring services in other locations. For example, University of Oklahoma offers tutoring in one of the largest dorms in the evenings before a coordinated exam.

Tutoring Capacity

Our centers have wide variation in the number of tutor hours available per eligible student. We propose multiple metrics to evaluate the availability of tutors. First, we define *tutor hours* to mean the sum of all the hours tutors are employed. One metric is the number of tutor hours per student eligible to use the center. We consider a student eligible to use the center if they are enrolled in a course the center serves at the end of the semester. Another metric is the number of tutor hours per student visit. This metric takes into account the wide variation in the percentage of eligible students who use a center at a particular university. Some universities have multiple options for tutoring and so a particular center needs fewer tutors to satisfy demand. A third metric that is harder to track, but available at some universities, is the number of tutor hours per student hour spent at the center. Although these metrics are relatively easy to compute they do not capture the number of tutors per student at peak hours before tests and before homework is due. A potential solution is to use electronic queueing systems and record the time between when a student asked for help and when the tutor responded to their request.

Structural Organization of Selected Math Centers

Table 1 compares two distinct centers that serve students at large state schools. In Fall 2017 Oklahoma State has an average of 6.9 visits for each eligible student and Ohio State has an average of 1.6 visits per eligible student. There are so many variations between the two centers and student bodies it is difficult to hypothesize why one center is used more frequently. Is the quality of the space, a connection to math, or something else?

We are in the process of describing approximately 14 centers using definitions offered here and then looking for patterns in measures of effectiveness that might be related to structural choices. We plan to use Table 1 to define the organizational structures of each center. Some aspects of the table were suggested by the literature. For example, usage is one commonly reported measure of effectiveness of a center (Matthews et. al., 2013). The strength of correlation between the number of visits to a center and the student's grade is another measure of effectiveness (Rickard & Mills, 2018). By comparing data from many centers we hope to create hypothesis about shared components of the most effective centers. After creating hypotheses we can do targeted data collection and surveys designed to evaluate the most important features of successful centers

Table 1. Characteristics of Tutoring Centers at Two Universities

	Oklahoma State	**Ohio State**
Tutoring Services		
Generalist or Specialist	Generalist	Tutors begin as specialists then become generalists
Drop in or Scheduled	Drop in	Drop in
Number of Courses Served	12 Math	19 Math (8 Stats)
Physical Space		
Location	Fifth Floor of Library	Basement and first floor of building near math dept.
Windows	Large and Plentiful	Few
Square Footage	8000	7000
Number of Chairs	266	360
Ventilation	No Complaints	Temp Regulation Issues
Computers available	130	13 but starting this year all freshman receive ipads
Relationship With Instructors		
Course Coordinators Collaborate with Center.	Yes	Minimal
Instructors Tutor in Center.	Yes	No
Tutors Interact with Faculty.	Yes	No
Tutor Training		
Content Training (UG)	5 hours per semester	3 hours per semester
Pedagogy Training (UG)	3 hours per semester	10 in first semester as tutor
Content Training (G)	0 hours	0 hours
Pedagogy Training(G)	0 hours	.25 hours

Table 2 compares measures of Tutoring Capacity at multiple centers. These measures can be used to describe capacity and will be used in the future to investigate relationships between tutoring capacity and the effectiveness of a center. We suspect that once the ratio of tutor hours per student visit becomes too small that complaints about availability of tutors will become common on the evaluation surveys. Colorado State, which has a ratio of 0.19 tutor hours per student visit, finds that approximately one third of students complain about tutor availability on their evaluation surveys. In our discussions we realized that some of the numbers are not easy to compare across universities. For example, at Colorado State a separate campus organization provides evening and weekend tutoring so it would not make sense to open the center much more than 36 hours a week. Further, Colorado State has a relatively high number of student visits per eligible student but all instructors' office hours are held at the center. At other institutions the students who seek help from instructors would not be counted as visiting the center. Multiple dimensions must be considered simultaneously and it is not possible to say that one center is more effective than another based on one line of the table.

Table 2. Measures of Tutoring Capacity at Various Centers. Data refers to Fall, 2017.

Undergraduate Institution	Students Eligible to Use Center	Location of Center	Total Student Visits	Hours per Week Center Open
Colorado State	1,148	Math Dept	7,330	36 hours
U of Arkansas	6,021	Math Dept	10,175	55 hours
Oklahoma State	4,523	Library	31,411	64 hours
U of Oklahoma	5,515	By math	22,031	33 hours
U of Portland	1,124	Commons	1,139	29 hours
Ohio State U	8,632	Math Dept	14,096	39 hours

Undergraduate Institution	Average visits per eligible student	Tutor hours per eligible student per week	Type of Tutor (Grad, UG, Faculty)	Tutor hours per student visit
Colorado State	6.38	.08	UG, G, F	.19
U of Arkansas	1.69	.03	G, F	.29
Oklahoma State	6.9	.11	UG, G, F	.24
U of Oklahoma	4	.08	UG, G	.30
U of Portland	1.01	.04	UG	.56
Ohio State U	1.632	.06	UG, G	.53

Limitations and Conclusions

We believe our collective experiences are adequate to offer definitions of many tutoring center structures in use in the United States. This paper contributes to the growing work on tutoring centers by offering shared definitions that researchers can adopt in their work. This paper does not list all of the differences in tutoring centers. For example, each center has a different budget and different restrictions on how the money can be used. Further we recognize that the metrics identified vary for many reasons. Some reasons are connected to the organizational structure of the center and some reasons are beyond the control of center leaders. For example, some universities with low numbers of visits per student have many other tutoring options for students. On the other hand, it seems logical that well-advertised and helpful centers might have higher number of visits per eligible students than centers with less effective organizational structures. As we proceed in identifying ways to measure effectiveness and ways to define centers we will have to continue to grapple with these issues. It will take a lot of reflective consideration to identify effective organizational structures without inappropriately concluding that a lower score on a metric is caused by a structural decision made at the center.

The creation and testing of hypothesis about the effectiveness of various structures will happen later and will involve the analysis of data about students visits to the center, the students' grades, and the students' demographic information. Data collection will also include student surveys about their experiences at the center. The survey questions will be designed to test hypothesis coming out of exploratory data analysis. We welcome participation in our project from other tutor center leaders, and offer these definitions as a starting point for those seeking to define their centers' identity. Please feel free to contact the authors to become involved.

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