Math Help Centers: Factors that Impact Student Perceptions and Attendance

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Mathematics help centers have become common fixtures in post-secondary education, where undergraduate students can go for more assistance on typically first and second-year courses. However, there is scant research on them. In this study, we report on existing literature concerning Math Centers. Then, we use data collected at one university in the southwestern United States from 1088 students over six academic semesters and grounded theory analysis techniques to study and draw initial conclusions. For example, of the 14% of students who did not attend, 45% stated that they did not feel they needed any help. Roughly half of the 67% of students that went to the math center more than once a month felt as if the tutors were responsive to their needs and willing to help. We claim that more work needs to be done, specifically inter-institutionally, on math centers in order to corroborate many of our results.

Keywords: tutoring, university mathematics, support services, math center

Mathematics help centers, also known as mathematics learning centers, mathematics support centers, mathematics tutoring centers, or simply "math centers" (the term that will be used in this paper) typically aim to provide support to undergraduate students in their mathematics courses. Math centers often focus on the mathematics courses students take during their freshman and sophomore years of study. At most of these facilities, students typically receive tutoring services from peer tutors (Rickard & Mills, 2018) who are often advanced undergraduates or, in some cases, graduate students. This tutoring is usually provided on a drop-in basis.

Math centers have become common fixtures in postsecondary education. This is evidenced in a recent study of calculus conducted by the Mathematical Association of America, where over 70% of the course coordinators surveyed reported that their institutions had a math center (Johnson & Hanson, 2015). There has also been an increased focus on math centers as noted by a recent handbook for math center directors (Coulombe, O'Neill & Shuckers, 2016). The handbook, which had contributors from 31 institutions ranging from two-year community colleges to liberal arts institutions to large research universities, demonstrated that a variety of institutions have given math centers a permanent position in their academic-support service structure. The increase in math centers is not just a U.S. phenomenon; efforts to implement math centers are found in the United Kingdom as well (Gill, Mac an Bhaird, & Ní Fhloinn, 2010; Matthews, Croft, Lawson, & Waller, 2013).

With a rise in the numbers of math centers and increased attention on them, there has also been an increase in educational research related to math centers. This can be noted by the new working group in RUME (i.e., the *Research Opportunities for RUME Researchers in the Context of Mathematics Resource Centers* working group) dedicated to this line of research. We aim to add to this small, but growing, research on math centers.

Research on Math Centers

While there is a sizable body of research on tutoring at the collegiate level across subject areas, Cooper (2010) has suggested that tutoring at math centers with drop-in attendance differs significantly from traditional tutoring and has called for more research on the impact of this kind of tutoring. Some educational researchers (e.g., Matthews, Croft, Lawson &Waller, 2013; Rickard & Mills, 2018) have answered this call. In the most recently published study related to this line of inquiry, Rickard and Mills (2018) reported that attending math center tutoring had more of an impact on lower-achieving students' grades than the grades of other students for their first calculus course, even when other variables were considered. Their model predicted that students' final course grades increase by one percent with every three visits to the math center.

Rickard and Mills' findings are in line with those of Cohen, Kulik and Kulik (1982). In their meta-analysis that considered tutoring for a variety of content areas, they found a positive correlation between students' attendance in tutoring programs and their course outcomes. For the more than 60 studies they considered, Cohen and colleagues reported that students who received tutoring consistently outperform students who did not. In addition, they reported that tutors also benefitted from the interactions with the students. Moreover, the noted benefit of attending tutoring centers was reported as being more pronounced with mathematics tutoring than other content areas.

While many of the math centers provide drop-in tutoring, it should be noted that math centers may also offer other services to students. Some services include access to print or digital resources, guidance on use of digital devices and platforms used in mathematics courses, and review sessions prior to mid-semester and final examinations (Coulombe, O'Neill & Shuckers, 2016). In one of the few studies that considered a mathematics support service other than tutoring, White, O'Connor, and Hamilton (2011) investigated the reasons students in a statistics class gave for attending peer-led review sessions. The authors reported that there was increased attendance when the students had positive attitudes of the review sessions. The results of this study also support the theory of planned behaviors, saying the intention to perform a behavior (e.g., attend a review session) is related to the rate of carrying out that behavior (e.g., actually attending the review session).

Many studies related to attendance often focus on data associated with sign-in information that many math centers collect. These data are often gathered from students' academic files or students' self-reports. Bannier (2007) used correlational analyses to examine which students attended math centers based on a variety of variables, such as the student's age, prior college experience, confidence level in mathematics, perceived importance of mathematics, current course enrollment, and enrollment history. She found that academic experience (i.e., years in college) and life experience (i.e., years since high school graduation) both positively correlated with math center attendance, while confidence in mathematics had a negative correlation with attendance. Bannier concluded that young, inexperienced students might be the least likely population to visit a math center. This finding is in line with Hodges and White's (2001) study with high-risk students in a university setting. Their design featured four groups of students, one control group and three treatment groups (one of which involved explicit encouragement for students to attend tutoring). None of treatments produced any increase in tutoring attendance. In a third study, Rogers (2010) came to a similar conclusion and reported that underprepared students were less likely to seek out tutoring than other students.

Mac an Bhaird, Morgan, and O'Shea (2009) and Halcrow and Iiams (2011) reached similar conclusions as the studies previously mentioned. Mac an Bhaird and colleagues (2009) reported

that attending a math center had a positive effect on students' grades, and this was particularly beneficial for students whose mathematical backgrounds were weaker. Halcrow and Iiams (2011) found that lower ability students were less likely to attend a math center, and that there was a correlation between the time spent in a math center and course grades. They also reported that once students overcame their fears of interacting with tutors, they generally found them to be helpful. According to the authors, students felt that tutoring helped contribute to their mathematical success. These studies add on to the growing number of studies regarding math centers that have taken place in Ireland (Dowling & Nolan, 2006; Gill & O'Donoghue, 2007; Mac an Bhaird & O'Shea, 2009; Ní Fhloinn, 2010). Most of these studies have considered either the contributions of math centers or ways to evaluate the services offered by math centers.

Research Questions

The benefits of attending a math center are somewhat documented, particularly that those who would benefit most from attending a math center are often the least likely to make use of it. However, little is known regarding students' perceptions of and reasons for attending a math center. For that reason, the following open research questions guided the current study: *What do students expect from a math center? What are their perceptions of a math center? What impacts students' attendance at a math center?*

Context

This study was conducted at a large, public, research university in southwestern United States. The university has a math center that serves students in freshman- and sophomore-level mathematics classes. The math center primarily offers drop-in mathematics tutoring. Undergraduate tutors offer just over half of the tutoring, and mathematics graduate students working as graduate assistants for the mathematics department offer the rest. The math center also offers other support services, such as access to print resources, guidance on use of digital devices and platforms used in mathematics courses, and review sessions before exams.

Students who attend the math center are in a wide range of courses including a) the general mathematics course typically taken by arts and humanities majors; b) algebra through calculus courses typically taken by business, life science, and social science majors; and c) algebra through multivariable calculus courses typically taken by science, technology, engineering, and mathematics majors. Each fall semester approximately 5000 students are enrolled in courses that are served by the math center. Of all individual students eligible to attend the math center, well over 40% typically visit the center at least once during the fall semester.

The research team consisted of four individuals with a variety of backgrounds. They included the math center director, who has served in this position for five years; a mathematics professor with RUME interests, who helped create the survey; the first-year mathematics director with RUME interests, who started in her position in fall 2017; and a Ph.D. mathematics education graduate student, who has served as a tutor in the math center.

Data Collection

A voluntary, online survey was used to collect data for this study. All instructors for courses served by the university's math center were asked to share the link for this survey with their students. For the last three semesters of data collection, the math center director also sent the survey link out directly to all students in courses served by the math center. In addition, signs were posted in and around the math center with information regarding the survey link.

Data from student responses are obviously self-reported. Students participating in the survey were not asked to share any identifying information to encourage honest participation from the students. A total of 1,088 students participated in the survey. Of the participants, 63% were freshman; 24% were sophomores; 8% were juniors; and 5% were seniors, while the rest did not respond. The participants' attendance is given in Table 1 below.

Table 1: Self-Reported Attendance of Participants to Math Center (Note: not 100% due to rounding)

	Respondents	Percent of Respondents
Never	154	14%
Once or Twice	207	19%
Once a Month	190	17%
Once a Week	352	32%
More	177	16%
No Response	8	1%

The survey consisted of multiple-choice, Likert-scale and free-response items. Individual items will be discussed in the findings section; however, we first outline the manner in which the coding system, which was used for the free response items, was created.

Data Coding

Similar to grounded theory analysis, the research team used general inductive techniques and constant comparison to study and draw initial conclusions on students' perception of and reasons for attending the math center. According to this method, the researcher does not begin with a preconceived structure but allows categories to emerge from the data. The researcher utilizes these categories to make sense of observed activity or phenomena (Thomas, 2006).

Two members of the research team (the first and third authors) individually read through the data individually using theoretical memoing (Glaser, 1998) to record and classify ideas evident in the data set. They then discussed their findings together combing back through the data until categories emerged. As the two discussed the data, new categories were examined as they emerged to determine if they were unique or could be subsumed under, or merged, with other categories. Once it was determined that all coding categories had been developed, they went through and coded a subset (10%) of the data with over 90% agreement. They discussed discrepancies and decided that more clarification on some of the subcategories was needed. The following categories and subcategories, which are presented in Table 2, were used for coding. These were shared with the other two research team members to verify that they were reasonable. Note that responses not related to the math center, such as comments on issues related to courses or instructors (e.g., desire for a high grade, perception of instructor deficiencies) were not coded.

Two members of the research team, the first and second authors, coded all of the responses using a single response to a free-response item as the unit of analysis. When there was a discrepancy, they discussed this between themselves and with the third author, until there was a resolution. For each coding category, the research team recorded the comment as being either positive (i.e., agreement that the math center under study was doing well in this area) or as being negative (i.e., comment related that the math center under study needed improvement in this area). For the current study, the number of positive and negative responses are not addressed; instead, both positive and negative responses were calculated in a total sum since either type of

response indicated that the issue was of sufficient importance for the student to make the comment.

Table 2: Categories Used for Coding

Category	Subcategory	Code
Facilities (should have)	Sufficient space, tables, chairs	F1
	Good environment/atmosphere for studying	F2
	Outlets for digital devices	F3
	Food in or nearby area	F4
	Quiet areas, no noise distractions	F5
Tutors (should be)	Attentive, "on point", not caught up in their own work, not distracted	T1
	Knowledgeable, know material, not sharing incorrect methods	T2
	Able to teach or explain, able to show different ways to do problems	T3
	Able to help with digital devices and platforms (e.g., WebWork)	T4
	Supportive, encouraging, not condescending	T5
	Patient	T6
	Friendly, pleasant, kind, approachable, not rude	T7
	Responsive to needs, willing to help/helpful	T8
	Proactive in seeing if students need help	T9
	Able to communicate in understandable English	T10
	Able to help students learn how to work independently; don't take over	T11
	Good hygiene (e.g., cover mouth when coughing)	T12
	Able to admit not knowing, willing to get help if needed from others	T13
Systems & Procedures (should ensure)	Sufficient number of tutors available, scheduling enough tutors	S1
	Ability to make appointments with tutors	S2
	Access to tutor schedules (for specific tutors)	S3
	Access to support materials, do more than tutoring (general)	S4
	Math center is staffed with course instructors rather than tutors	S5
	Students from a variety of academic majors serve as tutors	S6
	Tutors are easily identifiable	S7
	System is in place to efficiently get a tutor's attention	S8
	Organization of students by class at same table	S9
Access (to the following should be provided)	Solutions from the textbook, with photographing options	A1
	Solutions to homework problems, specifically related to the digital platform being used	A2
	Additional practice problems, not assigned as homework	A3
	Exam review sessions	A4
	Exam answer keys	A5
	Tutoring for all math courses, not just those in the first two years	A6
	Books to check out	A7
	Online tutoring	A8
	Extended evening hours (i.e., stay open late)	H1

Hours (should include)	Extended morning hours (i.e., open early)	H2
	Extended weekend hours	H3
Location (should be)	Specific cite (e.g., central, in dorms, close to math classes)	L1
	Be more than one place; have multiple locations	L2

Findings

In the first non-demographic item, 82% of students responded that they felt like they were encouraged to attend the math center by their instructors. Students were then asked about their math center attendance, which was reported in Table 1 above. Students who never attended the math center (n=154) were given a multiple-choice item that asked why they did not attend and allowed more than one response to this item. The results are in Figure 1: Reasons students did not attend the math center below.

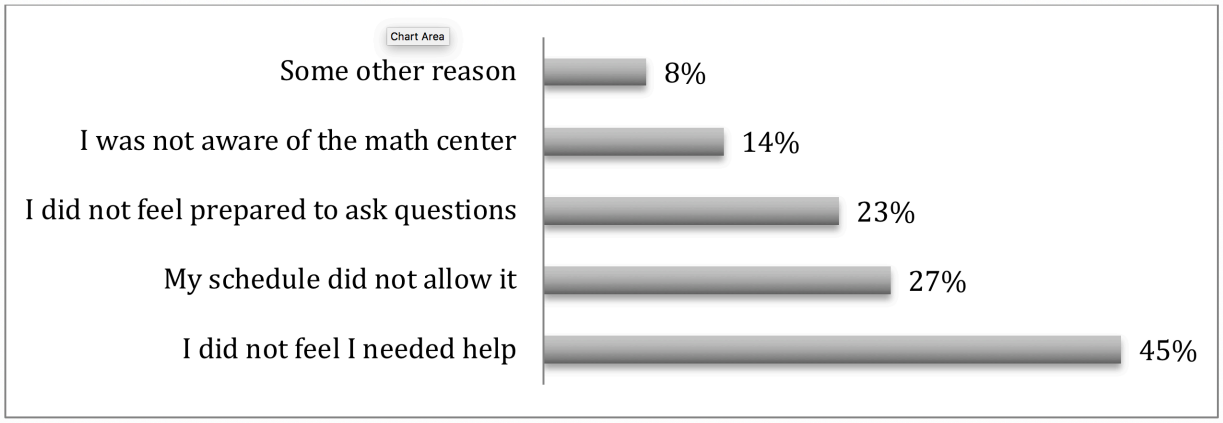

Figure 1: Reasons students did not attend the math center

Students who attended the math center once a month or more (n=530) were given a multiple-choice item that asked why they did attend and allowed more than one response to this item. The results are in Figure 2: Reasons students did attend the math center below. Note that this population was intentionally used to eliminate those students who only attend the math center immediately before (often the same day of) an exam.

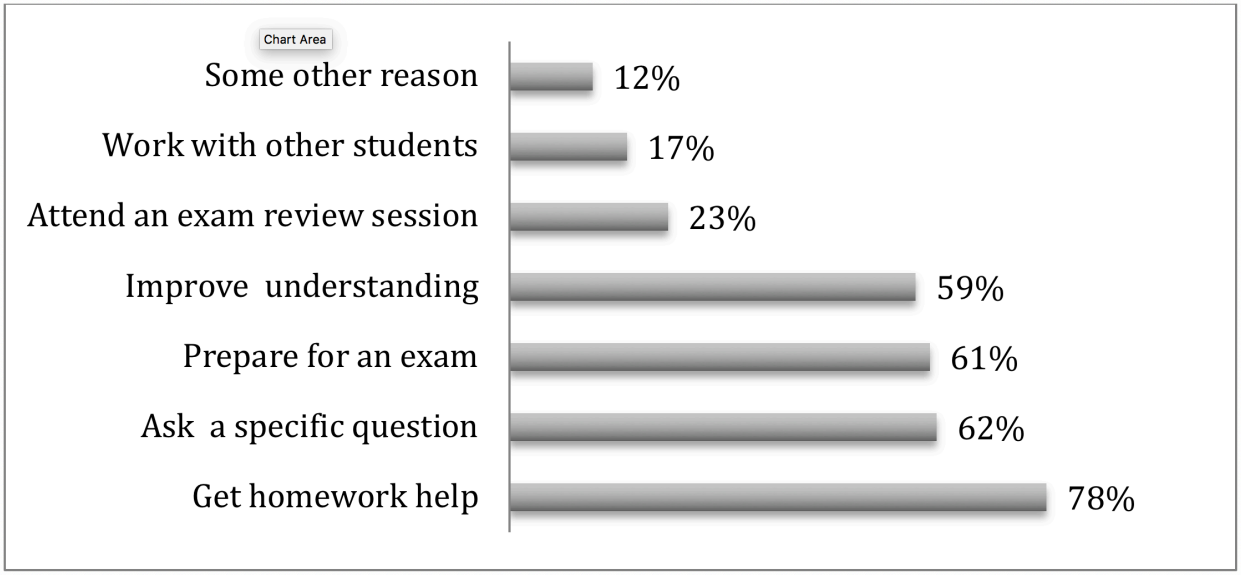

Figure 2: Reasons students did attend the math center

Students who had attended the math center at least once a month were then given four different Likert Scale items related to their impressions of the math center. The results are reported in Table 3.

Table 3: Responses to Likert-Scale Items Related to the Math Center (n=719)

The math center...	Agree to Strongly Agree	Neutral	Disagree to Strongly Disagree	No Response
Was helpful to me	83%	7%	7%	3%
Was dedicated to my success	82%	6%	2%	10%
Improved my math performance	77%	9%	10%	3%
Created a positive learning atmosphere	75%	11%	9%	10%

These same students also responded to four different Likert Scale items related to their impressions of the math center tutors. The results are reported below in Table 4.

Table 4: Responses to Likert-Scale Items Related to Math Center Tutors (n=719)

The math center tutors...	Agree to Strongly Agree	Neutral	Disagree to Strongly Disagree	No Response
Were responsive and patient	78%	8%	6%	9%
Helped me feel at ease	73%	12%	6%	9%
Were knowledgeable	75%	11%	5%	9%
Explain in ways that I understood	72%	13%	6%	9%
Encouraged me to work independently	65%	22%	5%	9%

Those students who had never attended the math center, or only once or twice a semester, were given two opportunities to respond to free-response items that asked for comments on and

recommendations to improve the math center. Students who had attended the math center at least once a month were given the same two items as well as a third item that asked for comments on the math center tutors. Responses from both groups to these free-response items were coded with the subcategories listed in Table 1.

Even though most (52%) of the responses to free-response items were coded as pertaining to the *Tutor* category, there are two other categories that merit mention. The most noted subcategory of the *Systems & Procedures* category was "sufficient number of tutors available, scheduling enough tutors" with 82.6% of the responses recorded in this category mentioning how important this was to them. A number of students commented this was an issue especially right before examinations. The *Facilities* category's most noted subcategory was with regard to providing "sufficient space, tables, chairs" (71.1% of the responses recorded). The responses coded in the *Tutor* category, for subcategories noted in 20 or more responses, are in Table 5.

Table 5: Responses to Related to Tutors Coding Category (n=719)

Tutors are...	Number of Responses Coded
Responsive to needs, willing to help/helpful	346
Knowledgeable, know material, not sharing incorrect methods	147
Able to teach or explain, able to show different approaches to do problems	124
Friendly, pleasant, kind, approachable, not rude	103
Patient, supportive, encouraging, not condescending	84
Able to help students learn how to work independently; don't take over	23
Attentive, "on point", not caught up in their own work, not distracted	22
Able to admit not knowing, willing to get help if needed from others	20

Discussion and Future Work

We will now consider each of the research questions and attempt to answer them using the most apparent findings. The first research question was, "*What do students expect from a math center?"* When looking at the responses across the survey items, the results suggest that respondents focused on the tutoring provided by the math center and the capabilities of the tutors. Students expect the math center to serve as a place where they can: ask specific questions, receive help with homework, and prepare for upcoming exams. Moreover, students had a number of certain expectations of math center tutors. Primarily, students expect the tutors to be responsive to their needs and willing to help them. Students also expected tutors to be both knowledgeable and approachable with an ability to explain concepts, sometimes using multiple approaches. Finally, students want tutors who will be both patient and encouraging when they are helping them. Some of the findings of this study correspond with those reported by Johnson (2014); however, more studies are needed to determine how student-tutor interactions in math centers play a role in students' perceptions of math centers and their attendance in math centers.

The second research question asked, "*What are students' perceptions of a math center?"* Those respondents who attended a math center regularly (once per month or more) tended to find the math center helpful, feeling it was dedicated to their mathematical success. They also felt it helped improve their performance in mathematics and provided a positive learning environment. All of the items received at least 75% ratings of "agree" or "strongly agree." This might be,

however, an artifact of those students who received this question. The online survey directed students to different questions based on their responses. The intention of the original survey design was to provide feedback from those students who attended the math center for more than exam preparation. Yet, this might artificially inflate the agreement ratings. For this reason, work is currently underway on this corpus of data to consider all of the student responses, be they positive or negative, to the free-response items to consider student perceptions from all students regardless of the number of times they attended the math center.

Finally, we consider the third research question, "*What impacts students' attendance at a math center?"* While 82% of the respondents felt like they were encouraged to attend the math center, 14% of the respondents never attended. The data shows that out of that 14%, only 45% did not attend because they did not feel they needed help. The results of this study suggest that future research is needed that focuses on the students who are not coming to the math center and the reasons for their lack of attendance. An interesting follow-up study would focus on those who did feel they needed help but still didn't attend, especially since 23% of those who never attended said the reason for this was because they did not feel prepared to ask questions.

Limitations and Contributions

There are definite limitations to this study. The most obvious is the poor response rate (which was about 1%). This is not surprising considering it was an optional, anonymous, online survey. Another limitation is that the survey data was primarily collected to benefit the institution and department, and the participants came from a single institution. However, there are still elements of this study that might be beneficial to others studying math centers. The data provides insight as to what students want and expect from a math center, especially related to the tutoring provided there. It also provides information as to why students might not attend the math center.

As the body of research literature on math centers expands, we hope to see three different, yet potentially overlapping, types of studies related to math centers. First, we would like to see more statistically rigorous studies, such as those recently published by Mills and Rickard (2018) and Byerly, Campbell, and Rickard (2018). There is also room to do qualitative studies to explore a number of math center issues, including some of those that have been raised above regarding future work.

Finally, a third line of research that would be assist the field of mathematics education would be more inter-institutional studies. One of the contributions this study provides is the coding system for students' math center expectations which was developed for the free-response items. Others studying math centers might want to use, revise, or expand on the categories and subcategories used in this system to study data that has been collected. In this manner, there would be a mechanism to compare the student expectations of math centers across institutions.

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