STUDENTS' PREFERENCES IN MATHEMATICS LABS

Ali Shaqlaih and Mehmet Celik
Division of Liberal Arts and Life Sciences
University of North Texas at Dallas
Dallas, TX 75241
Ali.Shaqlaih@unt.edu, Mehmet.Celik@unt.edu

ABSTRACT

A mathematics lab plays a crucial role in students' academic life particularly with activities related to Mathematics. Many universities have mathematics labs in different formats; handled by different strategies and have different institutional goals. The purpose of this study is to highlight students' preferences and attitudes towards mathematics labs in two-year and four-year colleges. A quantitative comparative study along with a qualitative analysis is carried to see the students' preferences on the role of the mathematics lab and how its use differs by gender, major, ethnicity, university level (freshmen, sophomore, junior, senior), and university type (two-year, four-year colleges). The study found that two-year college students use the lab more frequently than four-year college students. Moreover, two-year college students favor using the mathematics lab on utilizing their instructor's office hours. Furthermore, African American students and Hispanic students use the lab more often than other ethnicities. Among many studies that have been conducted on mathematics labs, this is one of the few that addresses the students' preferences towards an out of class activity environment such as mathematics lab. The results of the study will impact student life officers' decisions regarding mathematics labs management. Implementing the recommendations of the study will enhance the efficiency of the mathematics lab and will make it comfortable and more accommodating to students needs. The study initiates future research on students' academic needs through investigating their preferences rather than assessing their performance. This study focuses more on freshman and sophomore student population, therefore the implementation of the results is restricted to colleges that have similar student body and academic majors.

Keywords: Mathematics Lab, Mathematics Tutoring

Introduction

A constructive environment for ongoing study helps students to develop their understanding and maintain the learnt concepts for future use. College and university communities take action by providing such atmosphere for students, so classroom activities are pushed beyond the lecture halls. It is outside of the class where students meet and share something interesting they learn in lectures. This knowledge sharing is influential on students' education. The impact of this interaction is so powerful that it is independent of students' majors. Sometimes students combine their shared knowledge and that turns out to be a new application. Mathematics lab, also known as “Math Lab”, “Mathematics Center”, “Math Tutor Lab”, “Mathematics Help Center” is one of the settings where these class activities take place. Generally, it is a place where students seek help from a tutor for their mathematics questions. However, the services a mathematics lab provides differ from college to college. For example, some colleges require students to get an appointment, other do it in a walk-in bases, some provide services only to low level mathematics courses where others serve all mathematics courses. In a mathematics lab, students can participate in activities related to mathematics, such as, studying, discussing mathematics problems, and asking questions to tutors. Activities beyond classrooms play vital role in students’ education life (Carini, Kuh, and Klein, 2006). With the increasing rate of working students attending college (U.S. Department of Education and National Center for Education Statistics, 2002), a mathematics lab can substitute the limited available time of professors as students can come to the lab after daily work. Moreover, the lab as a place for out of class activities can also increase retention rate (Gilardi and Guglielmetti, 2011). Furthermore, as blended learning becoming more demanded (Allen and Seaman, 2010), mathematics lab can play an essential role in providing more assistance to students. It can also offer many options to learners, such as individual tutoring, peer tutoring, group activities, and computers with needed software installed.

Some of the problems that colleges are facing nowadays are lack of college readiness, high failure rates, and less interest towards mathematically-based subjects (Engineering Council, 2000). Mathematics labs are established to overcome these types of problems (Croft et al., 2011). However, we have seen many students who do need support but they never or rarely go to the Mathematics lab to ask for help. Why? Are students not aware of the lab mission? Is it the lab structure that students do not like? Is it the tutor help not meeting students’ expectations? Do students prefer to go to their instructor’s office hours rather than to the math lab? Universities usually inform students that there is mathematics support available in the mathematics lab, but it seems that they do not consider students’ preferences; the unstated hypothesis is that if students need help in mathematics they will go to the Mathematics lab. To what extend is this assumption valid? This study intends to investigate the validity of this hypothesis by looking into students’ attitudes, attendance and preference on getting help from the Mathematics lab. Furthermore, it also explores how this hypothesis differs with respect to gender, classified major, ethnicity, student university level, and university type.

Literature Review

A mathematics lab in a university is a place designed for activities beyond the classroom walls mainly related to mathematics. It appears that out of class activities in a university plays a crucial role in students’ learning. Carini et al. (2006) looked into whether out of class activities in colleges involving students has any significant influence on standard GRE (Graduate Record Examination), tests developed by RAND (RAND Corporation (Research and Development)), and GPA (Grade Point Average) scores. They found that students who scored low in SAT (Scholastic Assessment Test) benefitted from out of class activities in colleges, consequently scoring higher in GRE and RAND tests. This is also consistent with results from previous related research (Pascarella and Terenzini, 1991, 2005; Tinto, 1993). However, it was also pointed out that there were no significant influence of those out of class activities on students' GPA because of the scores being cumulative not semester wise. The study also revealed that universities with organized out of class activities were more effective, and so their students' GRE scores, RAND scores, and GPA went higher than other universities. Thus, institutions should give more attention to providing students with an environment beyond lecture halls where students can continue the learning process.

Since working students population has been rapidly increasing nationwide (U.S. Department of Education and National Center for Education Statistics, 2002), retaining students at universities can be challenging. In this case, out of class activities can play an important role in keeping students at the university. Gilardi and Guglielmetti (2011) studied first-year students' retention at universities; for traditional and non-traditional students. The results revealed that non-traditional students are more likely not to continue to their second year at the university because of lack of interaction and lack of collaboration with other students. In order to keep those type of students continue their education, the university/college needs to create settings which provides more outside classroom engagements opportunities such as workshops, mathematics labs, inviting speakers to colloquiums and seminars, and creating learning groups. These types of activities give students opportunistic settings to interact and collaborate with other students and faculty. The study also showed that out of class activities create strong bonds to the university. Moreover, these activities keep students in the university when they are constantly fighting to maintain their outside of the university responsibilities such as having jobs and families. The investigators pointed out interesting results. For instance, non-traditional students leave the university mainly because of job related reasons. However, because traditional students lack life experience, they do not value being educated. The study concluded that out of class activities do not play any significant role in retaining traditional students. To increase retention rate of traditional students, the investigators suggested to put more frequent emphasize on real life applications. Mathematics lab would be a great place to deliver and discuss such applications.

In a mathematics lab, activities such as discussing real life applications of Mathematics can be used to motivate students toward the importance of education. Douthitt (1973) studied the outcomes of a mathematics lab for freshman college mathematics. He presented evidences from his study that mathematics lab helped college freshmen succeed in Mathematics. Moreover, his study stated that mathematics lab supported and stimulated students and prevented them from withdrawing or failing. He observed that the mathematics lab is mostly preferred by students with shortages in mathematics; however, students good at mathematics helped other students in the mathematics lab within a group study. His conclusion was that mathematics lab is beneficial not only for students lacking mathematics but also for students with strong mathematics knowledge to develop their teaching skills and maintain their conceptual knowledge in the subject. There are many activities that can be created in the mathematics lab besides tutoring and motivational discussions on mathematics applications. For example, blended mathematics courses can be supported by mathematics lab activities from which students will benefit as well as the mathematics department and the university. Williams (1973) investigated the activities in the mathematics lab at a Community College. In this setting, the mathematics lab purpose was to serve each student individually. The tutors were students accompanied with experienced teachers. Other activities were offering “individualized courses” (which corresponds to nowadays online courses) dealing with College Algebra and two remedial courses. While taking those courses, it was also possible for students to attend weekly instructor meetings in the mathematics lab to ask general questions or ask about concepts from the lectures. The investigator observed that students willing to increase their scores in those mathematics courses preferred to retake the course(s) as individualized. Moreover, a decrease in the Withdraw/Fail rate in those courses had been observed. Furthermore, the Lab brought also savings on the instructional costs.

Activities in a mathematics lab are beneficial for mathematics and non-mathematics majors taking mathematics courses. Inglis and Simpson (2008) compared mathematics students with non-mathematics students on the process of reasoning from ideas to a conclusion. Their result showed that mathematics students were more successful than the non-mathematics students. Along the lines of mathematics versus non-mathematics students is another interesting study by Boester, Weinberg, and Wiesner (2006). They conducted a survey to understand college students’ preference and usage of mathematics textbooks. They reported that most of the pre-service elementary teachers (non-mathematics students) were using mostly the examples in the book to do their assignments. The pre-service teachers preferred textbooks with many examples and with emphasis on key formulas. The study concluded that students use their textbooks more when they are reminded by their instructors.

The purpose of students’ participation in a group activity is to motivate them, make their university life easier, and foster their success. Yan and Kember (2004) investigated ‘student organized learning groups’. According to their observations, some groups’ purposes were to exchange lecture notes or review questions. In these groups students neither discussed concepts from the course nor did they try to learn something from each other. In other groups, students were getting into discussions and were trying to learn from each other and understand the targeted concepts. Yan and Kember (2004) reported that the learning groups were organized more often during exam weeks. The type of the group that a student joined depended on the course’s demands. If reading lecture notes and following algorithmic procedures sufficed to solve problems that enabled students to pass the exam then students joined the first type of group. If the course required students to use analytical and critical thinking to create algorithms as solutions to problems then they had a tendency to participate in the groups where they discuss the material and share each other’s ideas.

Students come together in a group study in a mathematics lab to exchange ideas, ask each other questions, swap lecture notes or discuss some applications of concepts that they have been taught. All these actions help students enhance their problem solving skills as well as their learning process overall. Wilson, Fernandez, and Hadaway (1993) explored the problem solving process from different point of views. One of the approaches proclaimed that to be a good problem solver one needs to know the fundamental mathematical tools (such as definitions, theorems, counter examples and the relations in between) needed to solve the problems. It was observed that a good mathematics problem solver tends to classify the problems according to the mathematical tools (Silver, 1979). Another approach pointed that solving a mathematics problem through an algorithm cannot be described as a problem solving, but creating such an algorithm for a set of problems having similar mathematical characteristics can be presented as a problem solving activity. A third approach concluded that hints can enhance problem solving skills (Polya, 1962, 1965, 1973). The fourth approach is the one which brings all (the techniques, hints, ideas, mathematical tools used in the previous problem solving processes) together and create a theory which leads to heuristic ideas on the process of solving new problems, consistent with Polya's approach (Polya, 1962, 1965). The authors pointed some interesting results: students think that mathematics develops their problem solving skills and their creativeness; however, students also said that they learned mathematics by memorizing the material first. Similar believes and claims of students have been observed in other studies (Carpenter et al., 1983; Schoenfeld, 1988, 1989).

A rational question to ask at this point is whether this contrasts, analytical thinking versus memorization, occurs because of the absence of heuristics ideas on the problems or understanding of the mathematical concepts. Trigo and Manuel (1990) studied how "mathematical problem solving instructions" work for students' problem solving process in a college calculus course. An interesting observation was that students first tried to manipulate a solution for their problem from another similar model problem without even understanding the concepts. Students were more inclined to memorize the solution of a particular problem with the purpose to use it as a procedure on other problems. Moreover, the study observed that students tend to avoid questioning existence of other approaches to the problem. However, if an idea was suggested then students were more likely to use it and explore the problem further. Moreover, students were more interested in having the answer correct rather than trying to understand the idea behind the solution. The study concluded that students needed time to get familiar with the problem solving strategies. Then the question is whether stating the problem or the hint differently will speed up students' familiarity with the problem solving strategies. Trismen (1988) studied the outcomes of providing different posed hints on a problem solving process (Trismen, 1981, 1982). Problems used in his study were challenging and each one was accompanied by sets of hints which were aiming to give the same heuristic idea toward the solution but each hint was stated in a slightly different manner. The results about one chosen problem were as follows: only 9% of the students solved the question without using any hints. 38% of the students were able to solve the problem correctly by using one of the hints. He concluded that besides hints being effective tools during a problem solving process it is also important how the hints are exposed. Moreover, he pointed out that a little change in the wording of the problem can create a big difference in the process of solving it. This presents the importance of strategies in helping students. The current study fills the gap in searching for the preference of students in getting help in the mathematics lab. In particular, it investigates the preference of students of getting hints to their questions rather than obtaining complete solutions.

Purpose of Study

Universities inform students about the mathematics support available in the Mathematics lab, but students' preferences are often overlooked; the unstated hypothesis is that if students need help in mathematics they will go to the Mathematics lab. However, students who need support in mathematics may not go to the Mathematics lab to ask for help. This study aims to explore the validity of this hypothesis by looking into students' attitudes, attendance and preference on getting help from the Mathematics lab. Furthermore, it investigates how the following themes differ from students' perspective in using the mathematics lab according to gender, classified major, ethnicity, student university level, and university type: (1) Attendance, (2) Preferences in use, (3) Improvements to serve students resourcefully.

Methodology

Participants

The sample of this study included one hundred and ninety six undergraduate students with a response rate of 100%. The general population in this study is undergraduate students in the United States; however the target population was the undergraduate students in Southern United States. The accessible population was undergraduate students in five different colleges (four-year and two- year colleges in Southern United States). An Ad hoc Sampling technique was used in which stratified random sampling had been employed to get the data for the study (Grazizno, A and Raulin M., 2013). The participants were selected from five different universities/colleges in Southern United States. The stratifying factor on the school choices was school type: 'two-year colleges' and 'four-year colleges'. Then a random sampling was utilized in selecting the students who were enrolled in a mathematics class.

Quantitative analysis is used; in particular, SPSS was utilized to analyze the data. The data were entered in SPSS and reviewed by two different people to ensure accuracy. 36.7% of participants were from two-year colleges and 63.3% from four-year colleges. 50.3% were males and 49.7% were females. 25.9% African American, 27.9% were Hispanic, 36% Caucasian, 3.6% were Asian. 10.9% of participants were Mathematics major, 17.4% Business major (include Accounting, Finance, Marketing, General Business, Business Entrepreneurship, Legal Information Management, and Business Administration), 11.4% Health Sciences (include Pre-medicine, Medicine, Nursing, and Dental Assistant), 45.0% Sciences and Engineering (include Petroleum Engineering, Mechanical Engineering, Physics, Chemistry, Biology, Computer Science, Information Technology, Meteorology, Aerospace Engineering, Communication Studies, Electrical Engineering, Biochemistry, Micro-Biology, Zoology, Energy Management, Geography, Radiology, Forensic Science, Graphic Design, Chemical Engineering, and Computer Engineering), 15.2% Social Sciences (include Sociology, Psychology, International Studies, Law, Education, Criminal Justice, Fine Arts, Journalism, Human Resource Management, History, and Social Work). From Student university level point of view, 28.3% were freshmen, 26.8% sophomore, 26.3% junior, 17.2% senior, 1.5% post-Bac.

Instruments and Procedures

To best examine the hypotheses, if students need help in mathematics they will go to the Mathematics lab, some quantitative and qualitative data has been collected from students who can best tell how they want to be served in the Mathematics lab. Rather than looking at students' performance or lab administrators' preferences, the focus was on students' preferences on the use of Mathematics lab. This could be captured by designing survey with quantitative and qualitative responses from students. A survey was developed by the authors (see Appendix) and was printed on 8.5 x 11 inches sheets of white papers. Data was collected in the first half of 2011. Participating students were asked to complete the surveys while they were in mathematics labs or in their classes. The data was coded as follows: gender (1=male, 2=female), 'classified majors' (1=Business, 2=Health Sciences, 3=Mathematics, 4=Sciences and Engineering, 5=Social Sciences), ethnicity (1= African American, 2= Hispanic, 3= Asian, 4= Caucasian), student university level (1=freshman, 2 =sophomore, 3= junior, 4= senior, 5 = post bachelor), classified student university level (1=freshman and sophomore, 2=junior and senior), university type (1= two-year college, 2= four-year college).

The following five-point scale was used: 5-Strongly Agree, 4-Agree, 3-Uncertain, 2-Disagree, 1-Strongly Disagree. The survey questions focused on (1) How often in a week do students go to the mathematics lab and do they go more often in an exam week? (2) How students prefer to get help in the mathematics lab. (3) The students' preferred ways of studying in the Mathematics Lab (studying alone or in a group, looking for hints or for a solution, to be helped by an instructor or by a peer tutor, to be tutored in a group or looking for individual attention) (4) Do students feel shy to ask a tutor in the mathematics lab for extra help? (5) Do students feel distracted in the mathematics lab by other students'\tutor' discussions? (6) Do students prefer getting help from their instructor, from an instructor at the mathematics lab, peer tutor at the lab, or a private tutor? (7) Do students prefer having computers with the needed software installed in the mathematics lab?

Testing hypothesis procedures are undertaken in this analysis. It is important to note that the assumptions for the utilized tests are satisfied. Indeed, samples are independent because of the random selection. Test for equal variances was conducted and showed that indeed the hypothesis of equal variances is valid. Furthermore, the assumption that the sample is normally distributed is met by Central Limit Theorem as the sample size is more than 40, (Salkind, 2011). The null and the researcher hypotheses are stated in the traditional way. Whereas the null hypothesis is a statement of no relationship between the variables (see the results section for variables identification), the research hypothesis is a definite statement that there is a relationship between the variables (Salkind, 2011). The tested hypothesis can be characterized by the following three trends; (1) frequency of going to the mathematics lab, (2) perception in using the mathematics lab, (3) tips for improving the mathematics lab environment from students' perspectives. Different statistical tests were utilized to get full understanding of the analysis. All statistical analyses were performed at a significant level of 95%.

Results

Attendance to the Mathematics Lab

Descriptive statistics showed that on average a student makes 1.47 visits per week to the mathematics lab. Recall that the assumption on independence of samples is being met by sampling process; test for equal variances showed that samples have equal variances; and the population is normally distributed by Central Limit Theorem. Therefore, all assumptions for the used tests are satisfied, (Salkind, 2011). The first null hypothesis to test is that there is no difference in the means of the number of times that students from different ethnicities (African American, Hispanic, Asian, Caucasian) visit the lab. ANOVA indicated statistically significant difference in the means of number of times that students visit the lab across ethnicity ($F(5,190) =2.51$, $p=0.03$). Descriptive statistics showed that African American students go to the mathematics lab the most (on average 1.90 visits per week per student). On the other hand, Caucasian students go to the lab on average 1.10 visits per week per student. Another null hypothesis to test is that there is no difference in the means of the number of times that students from different university type (two-year college or four-year college) visit the lab. ANOVA indicated statistically significant difference in the means of number of visits to the mathematics lab across university type ($F(1,196)=51.91$, $p<0.01$). In particular, two-year college students visit the mathematics lab more than the four-year college students (the mean for two-year college students is 2.30 visits per week per student and the mean for four-year college students is 0.99 visits per week per student). No statistically significant differences between the means in number of visits to the mathematics lab was found across gender, classified major, and student university level.

In general, students visit the mathematics lab more often during an exam week than a regular week. A null hypothesis to test is that there is no difference in number of visits to the lab during an exam week than a regular week. One sample t-test indicated an average response of 3.4 which is significantly larger than 3, on a scale of 5 where 3 is uncertain, ($Mean=3.40$, $SD=1.2$, $p<0.01$). ANOVA indicated a statistically significant difference in the means across ethnicity ($F(5,190)=2.48$, $p=0.03$). In particular, African American students' means response was 3.71 and the Caucasian students' means response was 3.10. ANOVA indicated a statistically significant difference in the means across university type ($F(1,196)=14.089$, $p<0.01$). In particular, two-year college students' means response was 3.81 and four-year college students' means response was

3.17. No statistically significant difference was found across gender, classified major, and student university level.

One sample t-test did not indicate a statistically significant difference in the students' preferences of going to their instructors office hours rather than going to the lab (mean=2.98 on a scale of 5 where 3 is uncertain, p=0.87). On the other hand, ANOVA indicated a statistically significant difference in the means across university type (F(1,196)=10.011, p<0.01). In particular, two-year college students' means response was 2.62 and four-year college students' means response was 3.20. No statistically significant difference was found across gender, ethnicity, classified major, and student university level.

Preferences in Using the Mathematics Lab

One sample t-test indicated that students in general do not have a particular preference for studying alone or in a group (Mean =3.19 on a scale of 5 where 3 is uncertain, p=0.06). ANOVA indicated statistically significant difference in the means of students' preference of studying alone rather than in groups across gender (F(1,195)=4.826, p = 0.03). In particular, males prefer studying alone more than females (Males: Mean=3.41, SD=1.37; Female: Mean=2.97, SD=1.43). ANOVA indicated statistically significant difference in the means across ethnicity (F(5,189)=3.02 , p=0.01). In particular, Caucasian students preferred studying alone the most and African American students preferred studying alone the least across all other ethnicities (Caucasian: Mean=3.59, SD=1.34; African American: Mean=2.69, SD=1.39). No statistically significant differences between the means were found across classified major, student university level, and university type.

One sample t-test indicated that students do not prefer getting solutions to their questions over getting hints. ANOVA indicated statistically significant difference in the means across classified major (F(4,178)=3.85, p <.01). In particular, Tukey Post-Hock test indicated that this difference is caused by variations between 'Health Sciences' and 'Mathematics' and also by variations between 'Sciences and Engineering' and 'Health Sciences'. 'Health Sciences' major's mean of preference on getting solutions rather than getting hints was the highest and Mathematics major's mean was the lowest (Health Sciences major: Mean=3.67, SD=1.28; Mathematics major: Mean=2.45, SD=1.05). ANOVA indicated no statistically significant differences between the means across gender, ethnicity, student university level, and university type.

Descriptive statistics showed that out of 196 students, 118 (60%) prefer to get help from 'their instructors' while they are in the mathematics lab, 38 (19%) prefer 'an instructor' at the lab, 24 (12%) prefer 'peer tutor at the lab', and 16 (8%) prefer a 'private tutor'. Chi-square test indicated no statistically significant difference in the students' preference from whom to get help in the mathematics lab across gender, ethnicity, classified major, student university level, and university type.

One sample t-test indicated that students prefer individual tutoring rather than group tutoring in the mathematics lab (Mean=2.66, p<0.01). ANOVA showed statistically significant difference of the students' means across student university level (F(4,192)=2.93, p=.02). In fact, senior students' means of preferring group tutoring to individual tutoring in the mathematics lab is the highest (senior: Mean=2.91, SD=1.36). On the other hand, sophomore students' mean is the lowest (sophomore: Mean=2.40, SD=0.99). Tukey Post-Hock Test indicated that there is no difference caused by any two pairs of student university level. In fact, one-sample t-test indicated that sophomores and juniors means are significantly different from 3 (3=uncertain, sophomore mean=2.40, p<.01; junior mean=2.60, p<.01). This indicates that sophomores and juniors prefer individual tutoring rather than group tutoring. On the other hand, ANOVA indicated no statistically significant differences in the means across gender, ethnicity, classified major, and university type.

One sample t-test indicated that students prefer instructor guiding to peer tutoring in the mathematics lab (Mean=2.78, p<.01). ANOVA indicated statistically significant difference of the students' means in preferring peer tutoring to instructor guiding in the mathematics lab across ethnicity (F(5,189)=2.44, p=0.04). In particular, Hispanic students' mean is the highest and Caucasian students' mean is the lowest (Hispanic students: Mean=3.15, SD=1.13; Caucasian students: Mean=2.56, SD=0.99). Moreover, ANOVA indicated statistically significant difference in the means across student university level (F(4,191)=2.66, p=0.03). In fact, freshmen's mean of preferring peer tutoring to instructor guiding in the mathematics lab is the highest (freshman: Mean=3.04, SD=1.04) and seniors' mean is the lowest (senior: Mean=2.59, SD=1.16). ANOVA indicated no statistically significant difference in the means across gender, classified major, and university type.

One sample t-test indicated that students go to the mathematics lab just to ask questions that they couldn't solve (Mean=3.25, p<.01). ANOVA indicated statistically significant difference in the means across ethnicity (F(5,189)=2.35, p=.04). In fact, African American students' mean is the highest and Caucasian students' mean is the lowest (African American: Mean=3.55, SD=1.30; Caucasian: Mean=3.06, SD=1.31). ANOVA indicated no statistically significant differences in the mean across gender, classified major, student university level, and university type.

Improvements to Serve Students Resourcefully in the Mathematics Lab

One sample t-test indicated that students do not feel distracted by other students'\tutor' discussions in the mathematics lab (Mean=2.63, p<0.01). ANOVA indicated statistically significant differences in the means of students feel distracted by other students'\tutor' discussions in the mathematics lab across ethnicity (F(5,190)=2.66, p=0.02). In fact, Caucasian students' mean is the highest and the African American students' mean is the lowest (Caucasian: Mean=2.92, SD=1.12; African American: Mean=2.25, SD=1.23). ANOVA indicated statistically significant difference in the means across university type (F(1,196)=4.30, p=0.04). More specifically, four-year college students' mean of students feel distracted by other students'\tutor' discussions in the mathematics lab is the highest and two-year college students' mean is the lowest (four-year college: Mean=2.76, SD=1.17; two-year college: Mean=2.40, SD=1.22). ANOVA indicated statistically significant difference in the means across student university level (F(4,192)=3.363, p=0.01). In fact, senior students' mean is the highest and freshman students' mean is the lowest (senior: Mean=3.06, SD=1.01; freshman: Mean=2.45, SD=1.25). ANOVA indicated no statistically significant difference in the means across gender and classified majors.

One sample t-test indicated that students like the mathematics lab to have computers with the needed software installed (Mean=3.97, p<0.01). ANOVA indicated statistically significant differences in the means of students like the mathematics lab to have computers with the needed software installed across classified majors (F(4,178)=4.01, p<0.01). In fact, social sciences major's mean is the highest and mathematics major's mean is the lowest (social sciences students: Mean=4.52, SD=0.92; mathematics students: Mean=3.65, SD=1.35). ANOVA indicated no statistically significant differences in the means across gender, ethnicity, student university level, and university type.

One sample t-test indicated that students do not feel shy to ask a tutor in the mathematics lab the same question more than once (Mean=3.97, p<.01). ANOVA indicated no statistically significant difference in the means across gender, ethnicity, classified major, student university level, and university type.

Discussion & Analysis

Attendance to the Mathematics Lab

Administrators should consider the result about average visits per student per week to the lab being 1.47 while assigning tutors in the lab. ANOVA across university type suggests that more tutors in the mathematics lab are needed in the two-year colleges than in the four-year colleges. In fact such result is expected for many reasons. First, two-year colleges offer more low level mathematics courses (in particular developmental mathematics courses) and students in such course are in more need for help (Douthitt, 1973). Second, two-year college students are mainly freshmen and sophomores who are mainly enrolled in low level mathematics classes for which the help is provided in the lab. Third, working student population has been rapidly increasing in the US and since two-year colleges have larger number of part-time students enrollment (students working full time are mostly part time students) than four-year colleges (U.S. Department of Education and National Center for Education Statistics, 2010), the mathematics lab becomes an asset for two-year college students to fit their busy schedule.

To investigate this issue further, the university level category has been divided into two groups; 'group one' consists of 'freshman and sophomores', 'group two' consists of 'juniors and seniors'. A two sample t-test showed a statistically significant difference between those two groups' means (F(1, 195)=4.12; p=.04). In particular, 'group one' goes more to the lab than 'group two' ('group one': Mean=1.66, SD=1.45; 'group two': Mean=1.26, SD=1.26). This also suggests that four-year colleges' with a large population of 'freshman and sophomore' should hire more tutors to the mathematics lab. In summary, 'freshman and sophomores' are in more need for the lab than 'juniors and seniors' because 'freshman and sophomores' are enrolled mainly in low level mathematics courses. In general, students enrolled in low level mathematics courses go to the lab more often than students enrolled in higher level mathematics courses. A similar result was conveyed by Douthitt, 1973. One sample t-test indicated that students go more often to the lab during an exam week which agrees with Yan and Kember, 2004. This suggests appointing more tutors in the lab during the exam weeks.

ANOVA across ethnicity indicated that the means are different, but Tukey Post-Hock Test indicates that the difference is not caused by any pair of ethnicities. Moreover, one sample t-test (run on individual ethnicity with hypothesized mean=3 (uncertain)) indicates that African American students' (mean=3.71, p<0.01) and Hispanic students' (mean=3.53, p<0.01) means are significantly different from 3. This implies that African American students and Hispanic students go to the lab more often during an exam week. Thus, colleges/universities which have a large population of African American and Hispanic students may consider increasing number of tutors, hours, and space in the lab during exam weeks.

ANOVA across school type indicated that the means are different. One Sample t-test indicated that two-year college students (mean=3.81, p<0.01) mean is significantly different from 3 (3=uncertain) whereas four-year college students' mean is not. We conclude that two-year college students go to the lab more often during an exam week than four-year college students. This again suggests, more tutors in the mathematics lab for the lower level mathematics courses should be appointed during exam weeks. ANOVA indicated that the means across university type are different in preference of going to the instructor's office hours rather than going to the mathematics lab. One sample t-test indicated that two-year college students mean is significantly different from 3 (3=uncertain, mean=2.62, p<.01) whereas four-year college students' mean is not significantly different than 3. This indicates that two-year college students prefer going to the mathematics lab rather than going to the instructor's office hours. This again suggests that administrators should schedule more lab hours and tutors in the two-year colleges. This result is also consistent with the outcomes about students' frequency of going to the lab.

Preferences in Using the Mathematics Lab

There is a statistically significant difference across gender on means of preference of studying alone to studying in groups. In particular, males prefer studying alone more than females. To investigate this difference further, one sample t-test (run on ethnicity and gender) was used. The result indicated that 'African American female' students mean is significantly different from 3, (mean=2.5, p=0.04). Thus, 'African American female' students prefer to study in groups in the mathematics lab. On the other hand, 'Caucasian male' students mean is significantly different than 3, (mean=3.7, $p<0.01$) so 'Caucasian male' students prefer to study alone in the mathematics lab. It will be a good idea to consider these results in a students' orientation. 'Student life' office should encourage 'Caucasian male' students to participate in any group work or activities on campus. Tukey Post-Hoc Test indicated that African American students have the least mean on the preference on studying alone rather than studying in a group. That is, they prefer studying in groups. Furthermore, they go to the Lab the most among all other ethnicities. Moreover, they have the highest mean in going to the lab during an exam week as well as going to the lab just to ask questions that they could not solve. A combination of these results points out that African American students are using the Mathematics Lab the most among all other ethnicities. However, they are not using it in an efficiently because they go to mathematics lab mostly to ask questions that they could not solve.

ANOVA indicated that the means of students' preference on getting solutions rather than getting hints across classified majors are different. Furthermore, Tukey Post-Hock Test indicated that this difference is caused by 'Health Sciences and Mathematics' and also by 'Science and Engineering and Health Sciences'. Moreover, one sample t-test (run on individual classified majors with hypothesized mean=3 (uncertain)) indicated that 'Health Sciences' major prefers getting solutions rather than getting hints (mean=3.67, $p=0.03$) (Trigo and Manuel, 1990). On the other hand, one sample t-test (run on individual classified majors with hypothesized mean=3 (uncertain)) indicates that Mathematics majors prefer hints rather than getting solutions (mean=2.45, $p=0.03$). In fact, giving students hints rather than solving the problem can enhance their problem solving skills (Polya, 1962, 1965, 1973; Wilson et al., 1993). The nature of the Health Sciences compared to Mathematics might be one of the reasons behind this statistically significant difference. In Health Sciences students usually are more concerned about solutions to their questions whereas in Mathematics the reasoning for the solution is crucial. This is also supported by Inglis at el. (2008) which stated that mathematics students are better in reasoning. Tutors in the mathematics lab should ask the students about their majors and help them accordingly. That is, while helping health sciences students, tutors could solve similar examples, related to their major, so the students can manipulate. On the other hand, when helping mathematics majors, tutors should discuss the notions and the mathematical tools which will facilitate understanding the idea behind the solution. In particular, it is important how the hints are exposed to the students (Trismen, 1981, 1982, 1988).

Descriptive statistics shows that 60% of students prefer to get help from their instructor in the mathematics lab, 19% prefer to get help from an instructor in the mathematics lab, 12% prefer 'peer tutor at the lab', and 8% prefer a 'private tutor' in the mathematics lab. In fact, previous research shows that peer tutoring is one of the most effective tutoring (Carmody and Wood, 2009; Griffin and Griffin, 1998; Hoyles et al., 2002; Oates et al., 2005), but this study illustrates that peer tutoring is one of the least preferred by students. Effective methodologies might not always be most preferred but universities should encourage peer tutoring.

One of the reasons of students' preference to get help directly from their instructor might be that students are not only concerned about getting answers to their questions but also concerned about issues that only their instructor can answer. For example, the instructor not only can answer but also can comment on how important that particular question is for the test, quiz, or any assessments. Another reason might be that getting a solution or a hint for a question from the instructor may be less confusing than getting a solution or a tip-off from another instructor/tutor who might give a different approach. This result combined with the result of frequencies of attending the lab suggest that instructors in mathematics courses, especially on the low level courses or in two year colleges, should spend some of their teaching hours in the lab. For example, rather than giving instructors to teach three mathematics courses, they should be assigned two mathematics courses and spend more time in the lab. In fact, this will create an active learning mathematics environment that will make students grasp the material better.

From the results section, students prefer individual tutoring rather than group tutoring in the mathematics lab. This is understandable because students coming to the lab are expecting individual attention which they might not get in group tutoring. A possible advantage of individual tutoring is that students get more attention, and so immediate action could be taken on misconceptions on individual bases. Furthermore, individual tutoring helps students to see how a tutor thinks of the problem rather than just seeing the solution. Moreover, it also helps the tutor to identify how students think of the problem and therefore develop a suitable pedagogical approach for teaching certain concepts accordingly. To promote students success by cooperative learning, individual tutoring can be taken as a threshold to group tutoring which is both socially and financially beneficial.

ANOVA shows that the means of students' preference on peer tutoring to instructor guiding in the mathematics lab across ethnicities are different. Moreover, Tukey Post-Hock Test indicates that this difference is attributable to Caucasian students and Hispanic students. Furthermore, one sample t-test indicated that Caucasian students' mean is significantly lower than 3 (3=uncertain). Therefore, Caucasian students prefer instructor guiding. On the other hand, Caucasian students have the lowest average attendance to the mathematics lab (1.1 attendances per week per student). In fact, 57% of Caucasian students prefer getting help from an instructor while they are in the mathematics lab. Possible explanation for low attendance of Caucasian students might be due to not always having an instructor in the mathematics lab.

ANOVA indicated that the means of students' preference on peer tutoring to instructor guiding in the mathematics lab across student university level are different, and One Sample t-test indicated that seniors' mean is significantly different from 3 (3=uncertain), so the conclusion is that senior students prefer instructor guiding to peer tutoring. Results section shows that African American students tend to go to the Lab only when they have questions that they couldn't solve. Combining this result with the result which states that African American students go to the lab the most among all ethnicities (1.90 times per week), tells us the encouragement should be toward making African American students understand that the lab is not only for asking questions that they could not solve but also for studying and discussing the material with their peers.

Improvements to Serve Students Resourcefully in the Mathematics Lab

With regard to students feeling distracted by other students'\tutor' discussions in the lab ANOVA (across ethnicity) combined with Tukey Post-Hock Test indicate that Caucasian students and African American students differ most. Moreover, one sample t-test shows that African American students' mean is the only one that is significantly different from 3 (mean=2.25, 3=uncertain) which means African American students do not feel distracted by other students'\tutor' discussions in the mathematics lab. This is consistent with the results about African American students' preference of studying in groups and being the most frequent attendee to the mathematics lab.

From the school type perspective, one sample t-test showed that two-year and four-year college's students do not feel distracted by other students'\tutor' discussions in the mathematics lab. This means that students do not mind having group discussions in the lab. In fact, this will enrich the mathematical lab environment as it encourages students to participate in open discussions.

From the perspective of having computers with the needed software installed in the mathematics lab, one sample t-test indicated that all majors are in favor. ANOVA (across majors) combined with Tukey Post-Hock Test indicated a statistically significant difference in the means of Social Sciences students and mathematics students. One reason for this difference might be that Social Science students enroll mostly in introductory mathematics classes (such as College Algebra, Business Calculus, and Statistics) in which computers are needed. On the other hand, mathematics major students are more concerned about the theoretical part of the problem, such as methods of proofs, counter examples, and concepts used in the solution. Lastly, one sample t-test indicates that students do not feel shy to ask a tutor in the mathematics lab the same question more than once. This might be a positive sign because if students need help they will ask for it. On the other hand, students should be prevented from misusing the lab by asking for help immediately without showing any effort on the questions. Therefore, more effort should be put to create an environment in which the lab is not only a place to help students answer their mathematics problems but also to think and talk further about ideas and notions in mathematics. For example, a group of students can gather in the lab to discuss with a tutor some applications of derivatives in daily life. These discussions will enrich the students understanding of the concepts of derivative and will motivate them toward the subject.

Conclusions, Recommendations and Future Work

This study pointed out many noteworthy results. First, from the point of students' presence in the lab, two-year college students' attendance to the lab is more frequent than four-year college students'. Moreover, during an exam week, two-year college students' presence is even higher. Furthermore, two-year college students prefer going to the mathematics lab rather than going to their instructor's office hours. In addition, 'freshman and sophomore' students go to the lab more often than 'junior and senior' students. From the ethnicity point of view, African American students and Hispanic students go to the lab more often than other ethnicities during an exam week. Second, In general, students prefer individual tutoring on group tutoring and they also favor getting help from their own instructor. Furthermore, African American students (specifically females) prefer to study within a group in the lab. Mathematics major students prefer getting hints rather than getting solutions, whereas Health Sciences students prefer getting solutions to their questions rather than getting some type of a hint. Third, from the lab environment point of view, college students do not feel distracted in the lab. Moreover, Social Sciences students prefer computers with needed software installed. Furthermore, students do not feel shy to ask a tutor in the lab the same question more than once.

Based on the findings above some recommendations can be pointed out. In colleges with diverse student population or with a large population of 'freshman and sophomore' students (with smaller transfer students body), administrators may consider scheduling more lab hours and assigning more tutors, especially during exam weeks. Moreover, tutors in the labs should be prepared primarily on helping students in low level mathematics courses. On the other hand, group studies and peer tutoring should be encouraged (Douthitt, 1973). In addition, tutors should use different strategies to help students from different majors. Above all, arrangements of hints play a vital role in helping students on the problem solving process (Trismen, 1981, 1982, 1988). Lastly, labs need to have computers with the needed software installed and lab's tutors should be trained/asked not to provide solutions but to guide the students to solve the problems. Most educational research results have been based upon assessments such as analyzing GPA, GRE scores, and SAT scores. However, this study brought an alternative approach to investigate methods for improving students' service. Indeed, its recommendations are based on students' perspectives rather than students' performance. Therefore, topics such as motivating students to make a better use of the lab, guiding students to manage their time and resources can be revisited for further investigation with this approach. Since an Ad Hoc sampling technique was used, one should be careful in generalizing the findings of this study and should do so to only to a population with similar characteristics of the target population (Graziano, A. and Raulin, M., 2013).

References

Allen, E., Seaman, J. (2010). *Learning on demand: Online education in the United States, 2009*. Needham, Mass.: Sloan-C.

Boester, T., Weinberg, A., and Wiesner, E. (2006). Undergraduates' use of mathematics textbooks, Proceedings of the 28th annual meeting for the North American Chapter of the International Group for the Psychology of Mathematics Education.

Carini, R. M., Kuh, G. D., and Klein, S. P. (2006). Student Engagement and Student Learning: Testing the Linkages, *Research in Higher Education*, Vol. 47 Issue 1, p1-32.

Carmody, G. and Wood, L. (2009). Peer Tutoring in Mathematics for University Students, *Mathematics and Computer Education*, Volume: 43, Issue: 1, Pages: 18-28.

Carpenter, T. P., Lindquist, M. M., Matthews, W., & Silver, E. A. (1983). Results of the third NAEP mathematics assessment: *Secondary school. Mathematics Teacher*, 76 (9), 652-659.

Croft, A.C., Gillard, J.W., Grove, M.J., Kyle, J., Owen, A., Samuels, P.C., Wilson, R.H. (2011). Tutoring in a Mathematics Support Centre, a Guide for Postgraduate Students. Published by The National HE STEM Programme, University of Birmingham, Edgbaston, Birmingham UK.

Donald, A. Trismen, D. A. (1988). Hints: An Aid to Diagnosis in Mathematical Problem Solving, *Journal for Research in Mathematics Education*, Vol. 19, No. 4 (Jul., 1988), pp. 358-361.

Devore, J. L. (2012). Probability & Statistics for Engineering and the Sciences (8th ed.), Boston, MA: Brooks/Cole.

Engineering Council, (2000). Measuring the Mathematic Problems, report by Learning and Teaching Support Network (Maths, Stats & OR), The Institute of Mathematics and its Applications, The London Mathematical Society, The Engineering Council, London.

Douthitt, C. (1973). The Effects of a Laboratory on Achievement in College Freshman Mathematics, *The Two-year College Mathematics Journal*, Vol. 4, No. 1, pp. 55-59.

Griffin, M. M. and Griffin, B. W. (1998). An Investigation of the Effects of Reciprocal Peer Tutoring on Achievement, Self-Efficacy, and Test Anxiety, *Contemporary Educational Psychology*, Vol. 23, pp. 298-331.

Gilardi, S., Guglielmetti, C. (2011). University Life of Non-Traditional Students Engagement Styles and Impact on Attrition, *The Journal of Higher Education*, Vol. 82, No. 1.

Graziano, A., Raulin, M. (2013). Research Methods, Aprocess of Inquiry (8th ed.), Boston, MA: Pearson.

Hoyles, C., Wolf, A., Kent, P., and Molyneux-Hodgson, S. (2002). *Mathematical Skills in the Workplace*, Retrived August 22, 2006, (2002) from http://www.ioe.ac.uk/tlrp/technomathematics/skills2002/.

Inglis, M., & Simpson, A. (2008). Conditional inference and advanced mathematical study. *Educational Studies in Mathematics, 67*, 187–204.

Kantowski, M. G. (1974). Processes involved in mathematical problem solving. Unpublished doctoral dissertation, The University of Georgia, Athens.

Oates, G., Paterson, J., Reilly, I., and Statham, M. (2005). Effective Tutorial Programmes in Tertiary Mathematics, *International Journal of Mathematics Eduaction in Science and Technology*, Vol. 36, No. 7, pp. 731-740

Polya, G. (1973). *How to solve it.* Princeton, NJ: Princeton University Press.

Polya, G. (1962). *Mathematical discovery: On understanding, learning and teaching problem solving* (vol.1). New York: Wiley.

Polya, G. (1965). *Mathematical discovery: On understanding, learning and teaching problem solving* (vol.2). New York: Wiley.

Pascarella, E. T., and Terenzini, P. T. (1991). *How College Affects Students*, Jossey-Bass, San Francisco.

Pascarella, E. T., and Terenzini, P. T. (2005). *How College Affects Students: A Third Decade of Research*, 2, Jossey-Bass, San Francisco.

Salkind, N. J. (2011). Statistics for People Who (Think They) Hate Statistics. 4th ed. Thousand Oaks, CA: Sage Publications, Inc.

Schoenfeld, A. H. (1988). When good teaching leads to bad results: The disasters of "well taught" mathematics classes. *Educational Psychologist*, 23, 145-166.

Schoenfeld, A. H. (1989). Explorations of students' mathematical beliefs and behavior. *Journal for Research in Mathematics Education*, 20, 338-355.

Silver, E. A. (1979). Student perceptions of relatedness among mathematical verbal problems. *Journal for Research in Mathematics Education*, 10(3), 195-210.

Tinto, V. (1993). *Leaving College: Rethinking the Causes and Cures of Student Attrition* (2nd ed.), Chicago, IL: University of Chicago Press.

Trigo, S. and Manuel, L. (1990). College students' methods for solving mathematical problems as a result of instruction based on problem solving. Ed.D. dissertation, The University of British Columbia, Canada.

Trismen, D. (1981). The development and administration of a set of mathematics items with hints (Report No. RR 81-5). Princeton, NJ: Educational Testing Service.

Trismen, D. (1982). Mathematics items with hints (Report No. RR 82-11). Princeton, NJ: Educational Testing Service.

U.S. Department of Education, National Center for Education Statistics (2002). Nontraditional Undergraduates, NCES 2002–012, by Susan Choy. Washington, DC: 2002.

U.S. Department of Education, National Center for Education Statistics (2010). Table 202: Total fall enrollment in degree-granting institutions, by level of enrollment, sex, attendance status, and type and control of institution: 2009, Digest of Education Statistics.

Williams, R. C. (1973). The Mathematics Laboratory and the Single Student, *The Two-year College Mathematics Journal*, Vol. 4, No. 1, pp. 40-47.

Wilson, J. W., Fernandez, M. L., and Hadaway, N. (1993). Mathematical problem solving. In P. S. Wilson (Ed.), *Research Ideas for the Classroom: High School Mathematics* (pp. 57-78). New York: MacMillan.

Wilson, J. W. (1990). Report of the Georgia Plan problem solving workshop, 1989-90. Unpublished document, The University of Georgia, Athens, GA.

Yan, L. and Kember, *D.* (2004). Engager and avoider behavior in types of activities performed by out-of-class learning groups*, Higher Education* 48: 419–438.

Appendix - *Student Survey*

Gender:	□ Male	□ Female	
Ethnicity:	□ African American	□ American Indian or Alaska Native	□ Asian Native or Hawaiian\ Pacific Islander
	□ Caucasian	□ Hispanic or Latino	□ Other
Major Area of Study:	______________________		
Student University Level:	□ Freshman □ Sophomore □ Junior □ Senior □ Post Bac.		
University Type:	□ Two-years College □ Four-year College		

1) How often in a week do you go to the mathematics lab?
□ None □ One time □ Two times □ Three times □ More than three times

2) I go to the mathematics lab just to ask the questions that I couldn't solve.
□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly Disagree

3) I prefer to study alone rather than to study in a group at the mathematics lab.
□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly Disagree

4) I prefer going to my mathematics instructor office rather than going to the mathematics lab.
□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly Disagree

5) In the mathematics lab, I prefer getting solutions to my questions rather than getting hints.
□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly Disagree

6) I feel distracted in the mathematics lab by other students'\tutor' discussions.
□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly Disagree

7) I do not feel shy to ask a tutor in the mathematics lab the same question more than once.
□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly Disagree

8) I prefer peer tutoring to instructor guiding in the mathematics lab.
□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly Disagree

9) I prefer group tutoring to individual tutoring in the mathematics lab.
□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly Disagree

10) I go to the mathematics lab more often during an Exam week.
□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly Disagree

11) I like the mathematics lab to have computers with the needed software installed.
□ Strongly agree □ Agree □ Uncertain □ Disagree □ Strongly Disagree

12) From whom do you prefer to get help in mathematics questions?
□ My Instructor □ An instructor at the mathematics lab □ A peer tutor at the mathematics lab □ A private tutor