

Improving the Mathematics Tutoring Center at NUST through Structured Online Teaching Modules



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WPI



**NAMIBIA UNIVERSITY
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Improving the Mathematics Tutoring Center at NUST through Structured Online Teaching Modules

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Abstract

The mathematics tutoring center at the Namibia University of Science and Technology (NUST) provides supplemental learning resources to students. Despite this, required introductory mathematics courses experience high failure rates. This project aimed to improve the effectiveness of the tutoring center for these (and other) students through the use of e-learning software (ASSISTments). Coupling interviews and surveys with a research experimental design, we found positive sentiments regarding the application of ASSISTments and identified key reasons students struggle with the *Basic Mathematics* course.

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Executive Summary

Many students in Namibia finish secondary education with a poor mathematics foundation. Most tertiary education requires some form of mathematics courses for graduation meaning students with weak backgrounds have trouble finding success in these courses. Many students at the Namibia University of Science and Technology (NUST) lack the basic mathematical knowledge to pursue their chosen fields, creating problems for professors and students alike. NUST created a Mathematics and Statistics tutoring center as a supplemental learning tool for students in an attempt to address this issue. The center offers students access to computers along with individual and group consultations lead by tutors. The tutoring center currently does not utilize an e-learning software, leaving students with no guidelines for how the computers should be used.

The goal of this project was to increase the overall efficiency of the Mathematics and Statistics tutoring center through the use of structured online teaching modules with the program ASSISTments. Our project targeted students struggling in the *Basic Mathematics* course in an attempt to increase their performance as well as design, test, and recommend a proper application of ASSISTments that the Mathematics and Statistics Department could use in the future. To achieve our goal, we created three objectives:

1. We assessed the structure, student attitude towards and effectiveness of the mathematics tutoring center.
2. We determined the effectiveness of the ASSISTments software in improving students' math performance.
3. We created recommendations and future plans for the use of ASSISTments at NUST.

Assessment of the NUST Mathematics and Statistics Tutoring Center

Through our interviews with faculty, observations of classes, and the survey we administered to students, our team created a schedule and detailed methodology for our time at NUST. From our survey, we found that many students were aware of the tutoring center, and that many of the students who used the center believed that it improved their performance in mathematics courses. The students who did not use the center regularly reported that it was because of their distance from campus or a lack of time due to other obligations. Students reported that greater space, more available tutors, and increased hours would improve the center. A small percentage of students asked for an e-learning platform to provide distance students access to tutoring without having to travel to the center. The ASSISTments program suggests a free, alternative solution to each of these issues raised by students.

Evaluation of ASSISTments in the tutoring center

We performed an experimental analytical three-week study with the *Basic Mathematics* course at NUST. We worked with this specific course because it offered the highest number of full-time/part-time students. The study consisted of 14 student volunteers divided into two groups, a test and control, created through stratified random sampling. The control group was

asked to utilize the tutoring center while the test group was asked to utilize the center in conjunction with the ASSISTments modules. We set a minimum of one hour per week in the tutoring center, with the stipulation that students in the test group must complete their assigned modules prior to attending the hour each week. This stipulation allowed tutors to see which areas students in the the test group were struggling with and personalize the session, thus increasing efficiency.

To measure the effectiveness of ASSISTments, we used a series of assessments and quizzes. In the beginning of our test period, we distributed a pre-assessment to establish a baseline for which skills and subjects that students already knew. This assessment was created using concepts that the students would cover during the course of our study. This same assessment was given out at the end of the testing period to measure how much each student in the study progressed. Between the two assessments, we distributed a midway quiz that tested students' knowledge up until that point. Scores from these assessments allowed us to monitor progress made throughout the study and see how students performed after using ASSISTments.

After the first week's module, we administered an online survey to students in the test group to gather reactions to the program. By incorporating this student feedback, we were able to improve our modules for the rest of the data collection period, and also gather information regarding how students felt about ASSISTments. All students reported that they were either likely or very likely to use ASSISTments again. Not all students, however, felt that the use of the program would increase their use of the computers in the center. We believe that this is because students would rather take advantage of ASSISTments' flexibility and use the program anywhere that is convenient for them.

It's important to note that there was a severe lack of participation in our study from students. Originally 14 students took the pre-assessment, but only 10 of those students attended class regularly (75% of the time). Only 8 students completed any part of the study (i.e. tutoring or ASSISTments modules), but none of the students completed everything. Because of this, no conclusions could be drawn regarding the effectiveness of ASSISTments on improving the scores of students.

When examining the demographic information we collected, our team noticed a correlation between student attendance and assessment scores. We split the students who took both the pre- and post-assessment into two groups, one that attended 11 or more hours of class, and one that attended 10 or less hours of class. The group that attended more hours had higher median scores on both the midway quiz and the post-assessment.

Development of Recommendations

Following our study, our group held a workshop for all faculty and staff in the Mathematics and Statistics Department interested in ASSISTments. During the workshop we created accounts for everyone in attendance and demonstrated how to utilize the basic functionality of the program. We also showed these educators where tutorial videos for ASSISTments could be found so that they had a resource to consult if they had any further

questions after our departure. A Google Survey was administered following the workshop that provided us with feedback regarding how likely they were to use ASSISTments in their classroom. These results helped in the development of our recommendations to the university.

FINAL RECOMMENDATIONS

We recommend that the Mathematics and Statistics tutoring center at NUST incorporates ASSISTments. If tutors were able to see which problematic areas students had in common before a session, it would make for more productive group consultations. It would also allow for tutors in the center to assign skill builders to students who need more help.

We recommend that the Mathematics and Statistics Department at NUST use ASSISTments within math courses. Lecturers can assign content to students and tailor their lecture material towards areas where students struggle using the reports that ASSISTments provides. They can also use this information to create assignments and suggest topics for supplemental learning to students. By continually assigning modules that count for marks/grades, student accountability can be increased.

We recommend that for the *Basic Mathematics* course, attendance be made mandatory. Regarding the problem of a low passing rate for the *Basic Mathematics* course, we concluded that improving the efficiency of the tutoring center will not help. Students are not putting in the necessary effort to pass this course. If students cannot make time to attend class regularly, they will not make time to get supplemental help from the tutoring center. This is supported by our finding that higher attendance correlates with higher scores on assessments.

We recommend that further research be done with the use of ASSISTments at NUST. Our study occurred during the second semester, during which there is a significant lack of full-time and part-time students in rudimentary mathematics courses. A study conducted during the first semester could provide increased participation from more part-time and full-time students. A new study could provide more comparable data from students who already use the tutoring center frequently. Some classes for STEM majors at NUST have students who frequently utilize the center, and these students may be more willing to actually attend tutoring center hours, attend classes, and complete assignments and ASSISTments modules.

Authorship

Jessica Brewster, Jordan Myers, Brandon Navarro and Quinton Schimmel all contributed to the work of this project. All team members contributed to and edited each section. Below is a summary of how the report was written.

Jessica Brewster- Jessica contributed to the introduction and conclusions and recommendations chapters, and wrote sections 2.1.4, 2.2, 2.3, 3.3, and 4.1. Ms. Brewster also was the primary editor for section 2.1 and the lead on creating presentations, as well as formatted all the title pages.

Jordan Myers- Jordan contributed to the introduction, executive summary, and conclusions and recommendations chapters, and wrote sections 2.1.1, 2.1.2, and 3.1. Ms. Myers also created the table of contents, table of figures, and was responsible for the formation of the paper into a cohesive document.

Brandon Navarro- Brandon contributed to the introduction and wrote section 2.1.3 along with the abstract. Mr. Navarro was also a primary editor for the conclusions and recommendations chapter and the executive summary, as well as the lead in the development of all ASSISTments modules.

Quinton Schimmel- Quinton contributed to the introduction, and wrote sections 3.2, 4.2 and 4.3. Mr. Schimmel was also a primary editor for the introduction, methodology, and conclusions and recommendations chapters, and was the lead in performing the statistical analysis for the results and analysis chapter.

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Introduction

Mathematics is an essential component of human knowledge and is becoming more of a practical necessity for everyone to know and use globally (Bangura, 2011). An understanding of mathematics helps develop a general capacity for deductive reasoning and problem solving. These skills are applicable to everyday life and are used in a myriad of careers, resulting in a correlation between proficiency in basic math skills and employment rates (Ronald, 2006). In countries around the globe, students are required to take multiple courses in basic mathematics and literacy throughout their childhood in an attempt to develop a strong rudimentary background, foster specialized learning, and improve important skills necessary for future success. Yet, despite the practical importance of mathematics and efforts to promote math literacy, many students continue struggling to grasp major concepts in their mathematics education (Royse & Rompf, 1992).

The World Bank has worked to discover why certain students struggle with science, mathematics, and information and communication technology (SMICT) education (Ottevanger, Akker, & Feiter, 2007). A study was conducted that focused on African countries including Ghana, Namibia, Nigeria, and Tanzania; it was determined that the major challenges impeding students' progress in these countries included poorly-resourced schools, overcrowded classes, a curriculum that is not practical for students' daily lives, a lack of qualified teachers, and inadequate teacher education programs. These issues may cause students who are placed in these systems to develop misconceptions and a weak background in mathematics, making it more difficult for them to comprehend abstract concepts.

The challenges in SMICT education create a need for improvement in many countries. Curricula has progressed to include technology to implement new teaching methods as well as teacher-specific resource centers which have begun to be used in various countries. These centers provide areas for teachers to consult materials and attend meetings, aiding teacher development and training (Ottevanger, Akker, Feiter, 2007). Tutoring is a key supplemental learning method that can deepen background knowledge on subjects while personalizing learning to specific students depending on learning style and abilities. This one-on-one attention is crucial to learning for certain students (Chin, Rabow, & Estrada, 2011). Although tutoring has traditionally been a face-to-face practice, the advancement of technology has increased the possibilities in which tutoring can be utilized. Studies have shown that online tutoring techniques have proven successful in developing students' mathematical abilities (Tsang, 2007). In addition to tutoring and other teaching techniques, educational leaders are pushing for education reform to ameliorate the issue of insufficient resources. Various university-specific programs address the problem of inadequate teacher education programs (Wiseman & Wolhunter, 2013).

Many students at the Namibia University of Science and Technology (NUST), located in Windhoek, Namibia, lack the basic mathematical knowledge to pursue their chosen field when they graduate from secondary schools; students can decide against enrolling in seemingly unimportant math classes prior to tertiary education, creating problems for both students and professors. NUST encourages students requiring additional help in mathematical fields to utilize

the Mathematics and Statistics Tutoring Center, which is open to all students and consists of both group sessions and individual consultations. The tutoring system does not currently utilize computer-based technology, however the university recently acquired ten new computers that can potentially be used to review and re-educate students on mathematical concepts. Thus far, the university's efforts have not sufficiently utilized online tutoring.

The goal of this project was to collaborate with the Mathematics and Statistics Department at NUST to create a trial of the ASSISTments online tutoring program. We aimed to utilize the tutoring center's recently acquired computers and increase the efficiency of the center. Analyzing the current conditions at NUST allowed us to first test our hypothesis, which stated that incorporating ASSISTments modules into the current tutoring center would increase its efficiency and effectiveness. Throughout a three-week period, in which we tested the usefulness of incorporating ASSISTments into the tutoring center with students in the *Basic Mathematics* course, we found that students are very interested in and willing to use ASSISTments. The program, however, needs further research regarding its effect on student learning at NUST. This report details necessary background information, our methodology, findings, analyses, and recommendations regarding the future application of ASSISTments at NUST.

Background

A basic knowledge of mathematics is fundamental to an array of careers. Thus, there is a global push to improve mathematics education in an effort to enhance students' innovation and technical skills. The implementation and optimization of supplemental learning methods is paramount to this effort. This chapter discusses students' challenges with mathematics and the importance of supplemental learning systems.

2.1 Mathematics Education

The importance of a strong mathematics education is far-reaching. It has numerous benefits, including the development of critical analytical skills like creativity, innovative thinking, problem-solving, and inquiry. These are all considered rudimentary skills necessary in today's society and can be fostered by a mathematics education which incorporates open-ended problem solving and the application of reasoning skills (Adams & Hamm, 2010). Those that develop creativity and innovation are more prepared to offer original ideas in a variety of fields including medicine, business, and transportation (Loveless, 2000). In addition, economists estimate that between 50 and 80 percent of economic growth results from innovation and growing knowledge (Mulgan, 2006). The need for an adequate mathematics education will only increase over time because of the technical demands that workplaces will require in the future. The careers of the future are predicted to involve discrete mathematics, operations research, statistics, data analysis, information processing, and coding - all of which require sophisticated knowledge of mathematics and the problem-solving skills that come with it. The benefit of the skills obtained from a proper mathematics education pervades beyond the economic level; an analytical and inventive thought process is essential for proposing solutions to a constantly evolving set of aesthetic, moral, and political issues (Adams & Hamm, 2010).

2.1.1 Educational Challenges

Despite the skills gained from an enhanced mathematics education, numerous challenges can inhibit mathematical proficiency. A lack of qualified teachers, teachers' inability to educate students with different mathematical backgrounds, lack of resources, and overcrowded classrooms are all examples of problems that are hindering the effectiveness of math education (Ale, 1981). These factors often stem from schools having inadequate funding. Having underqualified teachers results in inconsistent learning for students, contributing to gaps in understanding key concepts and may impede student learning in future classes. Education systems will continue to have underqualified teachers if they do not have an adequate teacher education system. This is particularly prevalent in circumstances in which teacher education programs are seen as unappealing at the university level, therefore attracting students with weaker skill levels. Textbooks and other basic classroom resources are often in short supply, requiring students to share important learning materials (Ottevanger, Akker, Feiter, 2007). This

sharing can lead to students not having the supplemental instruction of textbooks when they need it. A large class size can also negatively impact the learning process by affecting student attentiveness. A systematic observation study showed that children in large classes were more likely to be off-task than children in smaller class sizes (Blatchford, 2004).

Studies have shown that a correlation exists between attitudes towards and experiences with math and how a person performs in the subject (Royse and Rompf, 1992). People's attitudes towards math influence both their career and academic pursuits. Researchers have shown that having a family member in a science, technology, engineering and math (STEM) related field can have a strong influence over one's career choice (Whalen & Shelley II, 2010). This career choice is an important influence into whether students will continue with a comprehensive education in mathematics. Negative experiences with mathematics results in a loss of desire for students to continue with their education in the subject (Larkin & Jorgensen, 2015). Certain students also lack self-confidence in mathematics. Anxiety, for example, has proven to affect whether students are interested in pursuing mathematics since it reduces memory retention capabilities as well as abilities to excel on major exams (Royse and Rompf, 1992).

2.1.2 Strategies to Improve Education

Multiple strategies can combat the challenges that educators face. The Trends in the International Mathematics and Science Study (TIMSS) provides reliable data on the mathematic and scientific achievement of students in the United States as compared to other countries (Witzel, Riccomini, & Schneider, 2008). TIMSS reveals which countries are excelling in mathematics education and the factors that influence their success. Singapore consistently ranks among the top countries for math education, causing researchers to study why the "Singapore approach" is so effective. The approach involved frequent use of visualization and model-drawing strategies, with an emphasis on mental math and word problems rather than memorization with repetitive drills.

Some students enjoy learning basic mathematics and continue to take more advanced courses. Students' attraction to learning math is often tied to the way it has been taught to them (Attard, 2011). Students have cited that mathematics lessons including interactive factors such as games or activities were more interesting than those of traditional math instruction. This, in conjunction with activities involving the ability of choice and creativity, sparked higher interest in mathematics. Activities and games used for teaching relate to real world situations and demonstrate to students the role mathematics has in their future careers. The use of real-life examples instead of traditional problems helps bridge the gap between mathematics and student comprehension (Loveless, 2000). It was also found that when an instructor paid close attention to different learning styles, strengths, or acted excited about the subject, students responded better to the material being taught.

A study was conducted in Australia including multiple school systems to discover methods of engaging students in mathematics with collaboration and real-world relevancy. Students were more likely to be enthusiastic about a subject when they understood the

importance of learning it (Attard, 2011). Relating curriculum to students' current and future lives can create connections between classroom and surroundings. The curriculum involved in the study also included activities such as games and scenarios that differed from normal-styled classes where teachers stand at whiteboards. When asking students about these lessons, students following the involved and interactive curriculum were able to recall much more about their engaging lessons than others.

Numerous school districts around the globe have evaluated their curricula to determine the effectiveness of engaging students' interest in their academics. The United States has many school districts that have revamped their mathematics curriculum to emphasize problem-solving techniques over computation skills, allowing students to develop the tools necessary to succeed inside and outside of the classroom (Loveless, 2000). By focusing on active learning, schools are able to create an educational environment that is catered toward its students. Incorporating current technology into education is a method of active learning which can help students relate their education to their daily lives as well as use their learning outside of just the classroom.

2.1.3 Supplemental Learning

In addition to optimizing the traditional classroom, many schools implement supplemental learning techniques to aid in students' understanding of material. Tutoring is a popular method of supplemental learning that is used worldwide. Tutors can individualize learning for students and give them critiques in a more confidential setting (Chin, Rabow, Estrada, 2011). Although it does not solve the overall problems such as a lack of resources or irrelevant curricula, it helps mitigate the problem of students not having a strong foundation in a subject. Tutoring programs have been shown to improve both students' learning and the educational resources in schools. However, the success of a program is directly connected to the organization of the system.

Parkinson (2009) analyzed peer-assisted learning support (PALS) - supplemental tutoring in addition to lectures - to understand how it affected the performance of students in mathematics. Students included in the study received six tests, spread evenly throughout a semester. This was to compare the progress of the control group and students who received PALS (Parkinson, 2009). Those who regularly attended supplemental tutoring for one to two hours per week substantially improved in averaged scores relative to the control group. The study also concluded that lower-achieving students derive a higher benefit from attending PALS than higher-achieving students.

With the growth of technology in education and the philosophy of distance learning, many online tutoring techniques have been developed. This method of supplemental learning increases students' understanding as well as self-efficacy. There is evidence that online learning has improved all areas of academics, but it has been particularly successful in mathematics instruction (Tsang, 2007). For example, students who engage in computer-based instruction for as little as one hour during the week show higher percentile test scores than students with no online learning. An improvement in students' attitudes towards learning was shown as well.

Most e-learning platforms give students more autonomy over their learning resulting in students becoming more engaged and involved (Clark & Whetstone, 2014).

The use of online techniques, both with math education and other topics, has become popular among many students worldwide because of its flexibility. With the help of online education, work can be completed in a student's free time and at a pace that is comfortable for them (Raymond, Jacob, Jacob, & Lyons, 2016). However, weaknesses in online education tools prevent some students from being able to utilize programs. Different students have different learning styles and online tools are typically unable to accommodate each style (Mestre, 2006). The majority of current online education modules consist of text and/or videos explaining a new concept followed by a quiz to test understanding of a topic. Although this is a preferable and highly effective system for visual and intuitive learners, it fails to accommodate students who need an active environment to help them understand a complex concept.

One main difference between using online education tools and a traditional classroom setting is personal interaction (Lau et al., 2018). In many cases, online learning lacks peer discussions and forces a student to learn the required material on their own. This works well for low to mid-level learning; in higher levels of education, group discussions are required for students to understand and retain information. Thus, students who require peer consultation and regular discussions with professors struggle with online learning (Mestre, 2006). As a result, a large number of students are not able to learn effectively through online modules and are forced to seek a more personal education setting. Although online education traditionally caters towards students who learn best in logical text-based environments, having curriculum that includes both online modules and face-to-face interactions can solve this issue. E-learning is becoming more popular on a global scale, and with this growth comes the development and improvement of online tools.

One method of online learning is ASSISTments, a free web-based e-learning platform developed by Neil and Christina Heffernan. Neil and Christina are both employed at Worcester Polytechnic Institute (WPI). The program they developed allows educators to create and assign online modules that students can complete on their own time. Although ASSISTments was originally developed for math education, the comprehensive functionality of the program allows for the possibility of teachers to use it for nearly any subject. A benefit to this program is that it not only gives students immediate feedback on the specific problems they are working on, but also acts as a powerful data tool for teachers. By creating detailed reports on student performance (Figure 2.1), ASSISTments gives educators the ability to specify their lessons depending on the scores and needs of students, thus increasing the efficiency of student learning.

| Student/Problem [Anonymize] | Avg | PRAVJF | PRAVJG | PRAVJH | PRAVJD |
|---------------------------------|------|-----------------|----------------|--------------------|-------------------|
| Problem Average | 81% | 34% | 89% | 50% | 91% |
| Common Wrong Answers | | 1.2, 57% | | 6x+4, 45% | |
| Correct Answer(s) | | 12 | 9 | 12x+8 | 1/24 |
| Albert Einstein | 92% | ✗ 1.2 66% | ✓ 9 100% | ✓ 8+12x 100% | ✓ 1/24 100% |
| Nelson Mandela | 25% | ✗ 0.6 0% | ✗ 7 66% | ✗ x+8 0% | ✗ 3/5 33% |
| Oprah Winfrey | 66% | ✗ 1.2 66% | ✓ 9 100% | ✗ 6x+4 0% | ✓ 1/24 100% |
| Yoko Ono | 100% | ✓ 12 100% | ✓ 9 100% | ✓ 12x+8 100% | ✓ 1/24 100% |

Figure 2.1 A screenshot taken from the ASSISTments website showing an example of a report educators can receive (ASSISTments, 2013).

The ways in which educators can use ASSISTments also contributes to its effectiveness as a versatile pedagogical tool. Teachers have the ability to choose from a variety of textbooks that are available within ASSISTments and create and implement their own material into the program. Educators can also build and improve students' mathematics foundation by assigning 'skill builders,' which are problem sets where students continue to work on the designated material until they get a number of questions correct in succession. In ASSISTments, skill builders for mathematical concepts range from second to eighth grade levels (according to US educational standards) and are already available for teachers to assign, making the program an excellent remediation tool for students who are struggling with basic math concepts.

Another feature that ASSISTments offers is 'PLACEMENTS,' which allows educators to create a test from pre-selected skills. If a student answers any of the initial questions incorrectly, the test automatically expands to include relevant prerequisite skills. Once the student completes the test, the educator gets a report that reflects how the student performed, and the student gets a list of skill builders to complete for the concepts on which they performed poorly. This functionality allows teachers a way to assess the gaps in students' understanding, as well as aid the students in building a stronger mathematics foundation.

A recent study from SRI Education in 2016 found that the ASSISTments program was able to benefit both students and teachers in several ways; the first of which being that ASSISTments was able to provide students with higher scores on standardized testing. Students using ASSISTments scored an average of 8.84 points higher on standardized testing than students who were part of the control group who did not use ASSISTments (Roschelle, Feng, Murphy, & Mason, 2016). Encouragingly, ASSISTments provided a greater benefit to students who started the experiment with lower prior mathematic achievement, (Table 2.1). Although

these studies were conducted in the United States, there is reason to believe that ASSISTments could greatly benefit countries around the world.

| <i>Median Split Investigating Interaction Between Prior Math Scores and Treatment Condition as it Affects Unadjusted TerraNova Scores</i> | | | | | |
|---|---------|-----------|------------|-----------------------|--|
| Condition | | | | | |
| Prior math score | Control | Treatment | Difference | Effect size, <i>g</i> | |
| At or below median | 605.94 | 665.29 | 14.35 | 50.1 | |
| Above median | 711.95 | 717.8 | 5.84 | 50.1 | |

Table 2.1 Chart showing how ASSISTments was able to improve students’ performance, particularly those with lower mathematical understanding. Adapted from (Roschelle, Feng, Murphy, & Mason, 2016).

A strong mathematics education has a wide range of individual and societal benefits, making it an extremely valuable resource to all countries. However, in countries struggling with mathematics education, students are often challenged because they either lack competent teachers or fail to master basic concepts (Ale, 1981). This problem could be mitigated by utilizing the functionality of ASSISTments, such as assigning modules for practice, skill builders, or a PLACEMENTS exam. ASSISTments has the potential to be extremely helpful in math education at the primary and higher education levels, however little research has been performed thus far on the efficacy of the program in college-level mathematics.

2.1.4 Sub-Saharan African Education

Many countries globally still struggle to facilitate effective mathematics education, despite a growth in mathematics education resources. The Global Education Monitoring Report (GEM), published by the United Nations Educational Scientific and Cultural Organization (UNESCO), analyzes educational environments around the world. The study, last performed in 2017, provides numerous statistics that outline areas which are in need of improvement, particularly for Sub-Saharan African education systems (UNESCO, 2017). The study showed that the percentage of classrooms with trained teachers in primary education in Sub-Saharan Africa was 62%, as compared to a global average of 86%. The problems created by a lack of qualified teachers is only worsened by the fact that the average pupil to teacher ratio in primary education was 39/1 in Sub-Saharan Africa, and 23/1 globally. Comparatively, the pupil to teacher ratio in secondary education averages at about 18/1 globally, instead of 21/1 in Sub-Saharan African countries. These problems lead to some students developing misconceptions and gaps in their understanding of the curriculum they are studying.

The UNESCO GEM report compared 48 Sub-Saharan African countries to 161 other countries around the world. Out of the 48 Sub-Saharan countries analyzed, Namibia was especially lacking in regard to educational standards. For example, the average amount of students over-aged for their grade in Namibia was 26.9%, while the average for all Sub-Saharan African countries was 24.0%. Both of these averages are put into perspective when related to the global average of 3.1%.

2.2 Namibian Education

Education and literacy in Namibia continue to grow both in availability and quality. Before the country's independence, education for all Namibians was extremely rare and significantly harder to achieve than after independence (Pendleton, 1996). Up until 1990, while Namibia was still South African territory, children were sent to primary schools correlating with their ethnic groups. There were different schools for a variety of people, including the Herero, Nama, Owambo, et cetera. Often, students chose not to continue on to secondary schooling, their reasons ranging anywhere from a lack of interest to a need for staying home to earn money for their families. Approximately 98% of black civilians, 86% of colored civilians, and 38% of white civilians did not continue their education past primary schooling during times of South African rule in Namibia.

In 1993, three years after Namibia's independence, 70% of the Namibian population over the age of 16 completed eight or less years of education (Winterfeldt, Fox & Mufune, 2002). Only three years later, more than 90% of school age children were enrolled in some sort of schooling. A study in 1999, however, found that 73.4% of enrolled students were taking commerce and management classes, while only 9% of students were taking engineering related subject classes. This early lack of participation in natural science studies may be a reflection of poor performance in mathematics in secondary schools throughout Namibia.

2.3 Namibia University of Science and Technology (NUST)

2.3.1 History

Prior to Namibia's independence on March 21, 1990, the country's two major colleges included Namibia's Technikon and Namibia's College for Out-of-School Training (COST) (NUST, 2018). In 1994, the Technikon and COST were combined as another separate polytechnic known as the Polytechnic of Namibia. The Polytechnic of Namibia became independent and autonomous in 1996 and at this point, more than 90% of school age children in the Namibian population were enrolled in some sort of schooling (Winterfeldt, Fox & Mufune, 2002). Almost 20 years later, the Polytechnic was renamed the Namibia University of Science and Technology (NUST) and since its opening, NUST has made remarkable progress on improving the Namibian population's enrollment rates in education.

2.3.2 Part-Time, Full-Time, and Distance Students

NUST offers three modes of study: full-time, part-time, and distance education (DE). Full-time students take a full load of courses on a regular basis, similar to part-time students who also take regular classes but often only a couple times per week, thus often moving at a slower pace (NUST, 2018). According to the NUST handbook, full-time and part-time students are expected to attend lectures regularly, complete all required assignments, participate actively in class, and attend at least 80% of contact sessions, practical's, and excursions.

NUST considers DE its most unique mode of study since this method allows students to study more often from home (NUST, 2018). DE has its advantages, since most students enrolled under this mode are students with full-time jobs, families, and other responsibilities causing limited time to dedicate to higher education. Some DE students reside too far from NUST to attend classes regularly and by registering as DE students, can avoid the heavy expenses of coming to Windhoek frequently or living in Windhoek. DE students meet only once a week, at most. However, DE yields many disadvantages as well. DE students use the same syllabi as full-time and part-time students; however, the courses progress at a significantly slower pace because the classes meet less often. Due of this, most work assigned by lecturers includes packets and other assignments that can be completed at home, without the help of lecturers (NUST, 2018). Although DE can be convenient for students who do not have the time, financial standing, or proximity to campus, students in DE get the least attention from lecturers, regulated practice, and use of on-campus resources. For these reasons, the failure rate for many classes offered at NUST is highest with DE students relative to any other mode of study.

2.3.3 NUST Mathematical Requirements

NUST application rates and a demand for higher education have been steadily increasing since the university's establishment. As of May 2017, NUST had 11,226 enrolled students, with a significant number concentrating on Managerial Science degree programs (NUST, 2018). In 2018, faculties offered at NUST include Management Sciences, Human Sciences, Engineering, Health & Applied Sciences, Computing and Informatics, and Natural Resources & Spatial Sciences. A main difference between Management Sciences and other sciences such as Engineering and Health & Applied Sciences lies in the recommended background courses from secondary school, specifically in mathematics.

Almost all NUST degrees in 2018 besides those within Management Sciences require above average backgrounds in mathematics (NUST, 2018). A bachelor's degree in Mechanical and Marine Engineering, for example, requires a minimum mark of 3 (on a scale of 1-4, with one being excellent and 4 being satisfactory, or just enough to pass) in secondary school mathematics, reflecting average knowledge and skills (Grading System in Namibia, 2012). An Environmental Health Sciences degree requires a C-symbol from the National Skills Standard Council (NSSC) in order to be accepted into the program (NUST, 2018). A degree of Entrepreneurship or Sports Management, on the other hand, has prerequisites consisting of only a D-symbol from NSSC.

Management Science related degrees may require less of a background in mathematics for admission, but this does not mean that a solid mathematical background is not useful for these students (NUST, 2018). Classes within these degrees can and usually include marketing, financial control, principles of macroeconomics, statistics for economics, management skills, and financial accounting. Students studying within the Managerial Sciences are required to take one of three offered rudimentary math classes: *Basic Mathematics*, *Introduction to Mathematics*, and *Business Statistics*. Some students, entering NUST with minimal math requirements, need tutoring to sufficiently meet the expectations of their classes.

2.3.4 NUST Efforts

The *Basic Mathematics*, *Introduction to Mathematics*, and *Business Statistics* classes each have different course outlines, but essentially all focus on fundamental and rudimentary topics (NUST, 2018). The *Basic Mathematics* course, for example, lectures on set theory, matrices, percents, ratios/proportions, et cetera. First semester *Basic Mathematics*, *Intro to Mathematics*, and *Business Statistics* classes are usually composed of mostly full-time and part-time students. In the second semester, however, the majority of students taking these classes are DE students. Figure 2.2 below shows the percentages of each mode of students in each mathematics class offered to non-STEM majors in second semester, 2018.

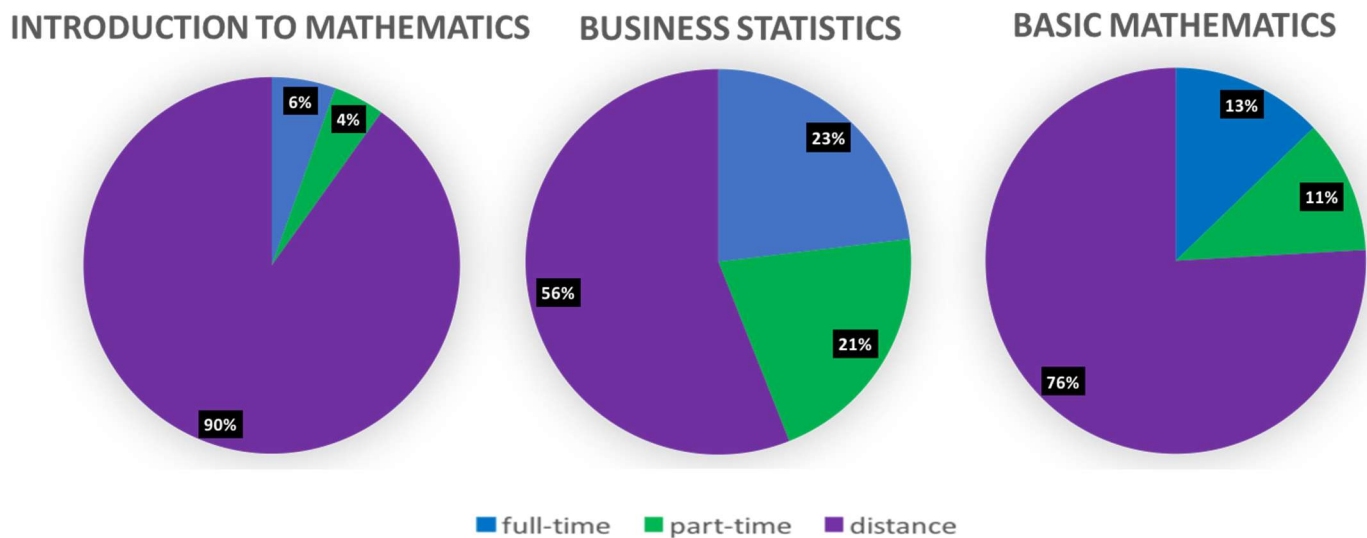


Figure 2.2 Percentages of part-time, full-time, and distance students for three mathematics classes during the second semester at NUST 2018 (NUST, 2018).

DE classes also have vacation school (NUST, 2018). Vacation school is a night class with a lecturer and practice problems. Held on campus, vacation school is designed for distance students far from campus that need practice, since it is held only during mid-semester breaks.

NUST also offers a math tutoring center (Figure 2.3) for students needing additional help from tutors, practice problems, or a quiet place to study and work. The center has recently acquired ten new computers, but has yet to utilize these computers for math tutoring purposes (NUST, 2018). Gabriel Mbokoma, the manager of the tutoring center, works closely with students utilizing the center and the tutors who work there. Posted outside of the center is a list of rules (Figure 2.4) and a poster about the center (Figure 2.5).



Figure 2.3 NUST Mathematics and Statistics Tutoring Center with recently acquired computers (NUST, 2018).

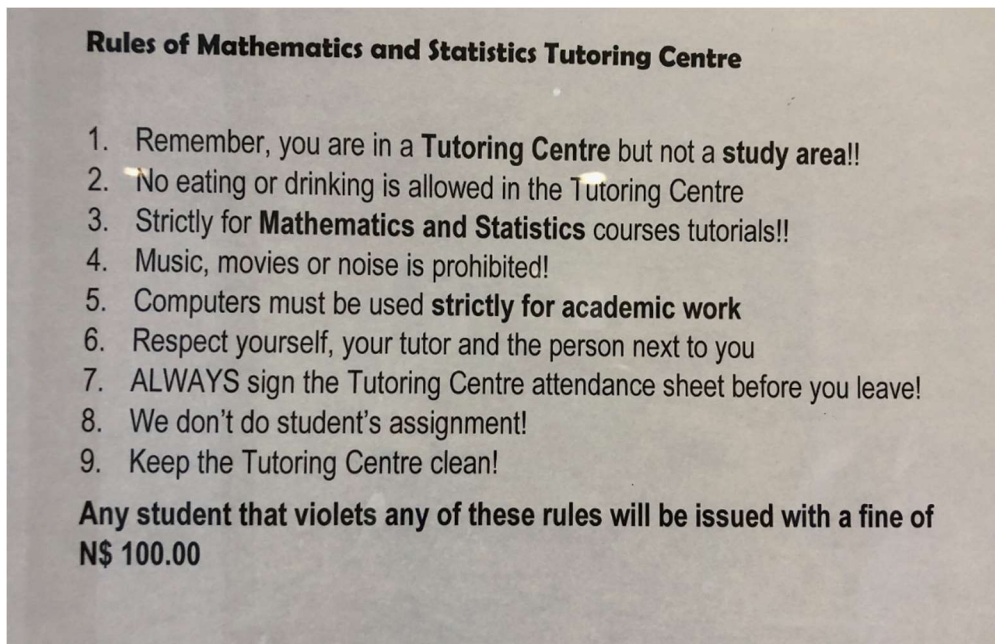


Figure 2.4 Rules, flyer, and schedule posted outside of the Mathematics and Statistics Tutoring Center at NUST (NUST, 2018)

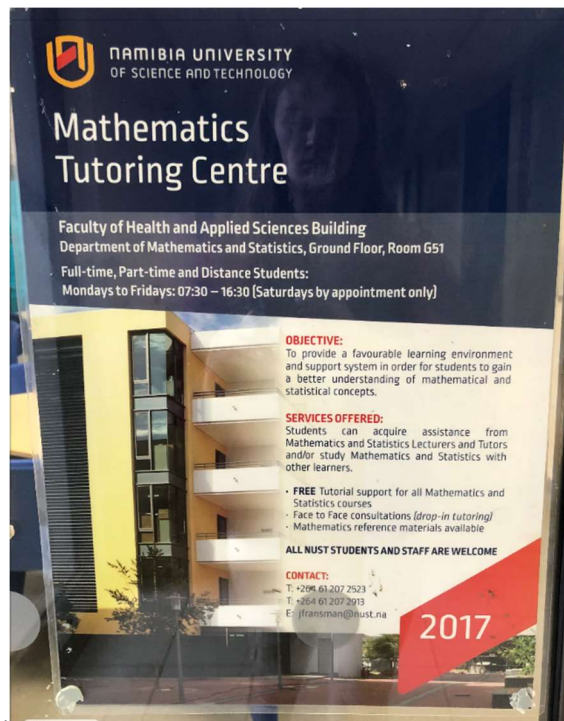


Figure 2.5 Flyer posted outside of the Mathematics and Statistics Tutoring Center located on the NUST campus (NUST, 2018).

Methods

The goal of this project was to improve the Mathematics and Statistics Tutoring Center at NUST through the development and testing of structured online teaching modules that would continue to serve as a tutoring tool for the School of Health and Applied Sciences. We achieved this by addressing the following research objectives:

1. Assess the structure, student attitude towards, and effectiveness of the Mathematics and Statistics Tutoring Center.
2. Determine the effectiveness of the ASSISTments software to improve students' math performance.
3. Develop recommendations and future plans for using ASSISTments within the tutoring center at NUST.

3.1 Assess the structure, student attitude towards and effectiveness of the Mathematics and Statistics Tutoring Center at NUST.

During the first week in Namibia, our team established contact with our sponsor and relevant persons in the Health and Applied Sciences division at NUST. We used semi-structured interviews with NUST faculty, especially Gabriel Mbokoma who is the manager of the tutoring center, to gain insight into the current conditions under which the center runs. Our team scheduled meetings with faculty and asked them questions based on our prior research regarding NUST and the tutoring center. We also met with our sponsor, Dr. Onesmus Shuungula, and several other related professors within the Mathematics and Statistics Department to clarify project guidelines, develop a schedule - (presented as a Gantt chart in Appendix A), begin gathering information about the math tutoring center and NUST as a whole, and to organize protocol and other factors to acknowledge throughout our project.

In these semi-structured interviews, we introduced the purpose of our project to provide context about our goals, and potential outcomes (Rea, 2014). Following a process of rapport building with the faculty, semi-structured interviews allowed for a conversational tone where our team could create and modify the conversation based on previous answers (Wengraf, 2001). Our questions were centered around the current state of the tutoring center - how many students use it, the times that the center is most crowded, how the tutoring center is run and other similar questions.

Our team also attended vacation school for two courses, *Basic Mathematics* and *Introduction to Mathematics*, on August 23, 2018 to administer a structured survey to each student in attendance. The students were there for the purposes of learning, so our team chose to do a survey instead of interviews to be less invasive to the class. We attended the vacation school in person in case any questions arose from the students, and because many distance students are difficult to contact through any method other than face-to-face interaction.

The survey was designed to collect the current student sentiments towards the tutoring center and any relevant changes the students suggested for making the center more effective. We kept the survey anonymous to protect identities of students and to get more honest answers from participants. The data obtained from the survey allowed our team to assess the feasibility of our future plans. We used primarily open-ended questions to allow students to expand on their answers and not feel pressured to answer one extreme or the other (Rea, 2014). Our introduction to the students in attendance, the specific questions asked, as well as the demographic questions we asked participating students can be found in Appendices B.1, B.2, and B.3, respectively. The survey responses were transcribed into excel and the responses were graded with a rubric created by our team (Appendix B.6). Student responses graded 1-4 were used to determine averages and percentages representing students' thoughts and suggestions for improvement. Key words were identified by grouping responses that shared the same sentiment, which could then be used to analyze our data. An overall score of the tutoring center's performance was also calculated by finding the average of all student responses which were quantitatively graded. This survey was considered when making our recommendations for the tutoring center in the future.

Our team also utilized participant observation during vacation school, which we were invited to attend as tutors. This participation gave us insight into the extent to which some students were struggling with basic mathematics and with which basic math skills they struggled with most. We also developed an idea of the types of questions students asked the tutors along with the relationship between the student and teacher. We documented our observations in notebooks.

In addition to the survey distributed during vacation school, our team passed out the same questionnaires to students using the tutoring center to gain insight into how students viewed the tutoring center and what could be improved. We passed out questionnaires (Appendix B.2 and B.3) during the second week at NUST to every student in the tutoring center at random times provided by Mr. Mbokoma. The questionnaires were coded with a rubric (Appendix B.6). This survey was conducted in the same manner as the questionnaires passed out to the students at vacation school. This method allowed our team to answer any questions the students had about the questionnaires and allowed our team to introduce the purpose of the survey to students (Rea, 2014).

3.2 Determine the effectiveness of the ASSISTments software to improve students' math performance

To test our hypothesis that incorporating ASSISTments modules into the tutoring center would increase its efficiency and effectiveness, we performed an experimental analytical study. A list of terms and definitions we used to explain our hypothesis can be found in Appendix C. Our study was applied to students taking the *Basic Mathematics* course at NUST since it allowed us to gather consistent and in-depth information. This course offered the highest percentage of part-time and full-time students, allowing our 8-week time constraint to not become as limiting a factor.

We collaborated with our sponsors and the NUST lecturers who instruct *Basic Mathematics* to recruit a group of student volunteers to participate in our study. In an effort to ensure continued participation throughout the duration of the study, we worked with the professors to speak to the students and recruit a representative sample of participants that both had the time and were willing to provide consistent attendance (Rea, 2014). Our total sample size consisted of 14 students. These students were divided into two groups: a control group who utilized the tutoring center but not the ASSISTments module, and a test group who utilized the tutoring center with ASSISTments (Meinert, 2012). The control and test groups utilized the tutoring center for a minimum of one hour each week. The test group, however, also completed a 30-minute ASSISTments module prior to attending an hour in the center each week. This approach gave the tutors time to see what the student was struggling on before the student arrived in the center. We could not control the maximum number of hours students used the tutoring center, so we had to be aware that some students using the center for more than the minimum number of hours. These time periods were determined by consulting the lecturers of this course to estimate reasonable expectations of the students' use of the tutoring center.

14 test subjects were divided into two groups using stratified random sampling. Since full-time and part-time classes are taught by different lecturers, we divided participants from each mode of study evenly between the test and control groups to obtain an equal representation of full-time and part-time students in each group. The eight participants from the part-time class were each assigned a number 1-8. A random number generator was then used to assign each student to one of the two groups until we had 4 students in each group. This process was repeated for the six participants in the full-time class. We also documented the demographics of the students. We collected information regarding year of study, age, major/area of study, whether or not the student had outside employment, mode of study for the class as well as the general mode of study (distance, part-time, or full-time), distance of a student's residence from campus, year of study, and each student's overall course load.

We were transparent during the study and relayed all the information to the students as it related to them (Meinert, 2012). We did this by meeting with each participant outside of class and informing them about our study. We also kept an open line of communication by collecting all the participants phone numbers, giving us the ability to relay any pertinent information, and giving them the ability to contact us with any questions they had.

There are a number of biases that could affect study outcomes of which we had to be aware (Meinert, 2012). These include treatment-related selection bias, non-response bias, response bias. Utilizing random assignment allowed us to remove all treatment-related selection bias. We mitigated both response and non-response bias through the provided incentives, but we still had to be aware of the fact that we did not obtain a representative sample of the general student population and that only certain types of students volunteered for the study. Any student who initially participated in the study and then dropped-out before its termination was omitted from our analysis.

Before implementing the ASSISTments program, we administered an in-class pre-assessment on the material that would be covered during the three-week study to the *Basic Mathematics* classes (Appendix E.1). The answer key for these assessments can be found in Appendix E.2. The assessment was also used to recruit participants for the study by collecting points of contact for each student that took the assessment and then asking them to participate. We then attempted to have a meeting with all student participants in the study prior to its start. We were only able to meet with five students from the test group, and none from the control group. The script for what was said to these students along with the follow-up messages that were sent to the entire participating population can be found in Appendix B.4 and Appendix B.5, respectively. The meeting was used to inform students on the study and collect demographic information that could potentially affect students' scores. Students that did not attend the meeting were given the demographic information survey later in the study.

We asked the students in the test group to first complete an introduction module. The purpose of this module was to make sure that the students were able to create an account and to familiarize them with the program. The module itself was comprised of a few basic math concepts that the students were expected to know for the class. Upon completion of the module, students were then prompted with a survey to record any immediate feedback they had about the program (Appendix B.7). The rubric we used to assess the open-ended question of the survey can be found in Appendix B.8. Our group chose to do an online survey because the students were already on the program and the surveys could be implemented into the ASSISTments module itself. Our group decided to ask primarily closed questions because the survey was online rather than in person, meaning the students wouldn't be able to ask clarifying questions (Rea, 2014). This feedback was used by our group to create better and more robust modules that were used during the actual course of the experiment.

These modules were created by communicating with the professors teaching the *Basic Mathematics* course, who were able to provide our group with both the syllabus for the course along with questions that could be used to measure the students understanding of the content. In addition to communication with the lecturers, our group attended all *Basic Mathematics* classes held on Tuesdays and Thursdays for both part-time and full-time students. The class's schedules can be found in Appendix D. This choice of research design allowed us to take notes on the content the lecturers were teaching. Because the two classes had a different amount of class time during the week, we needed to know where each class was relative to the syllabus in order to structure the online ASSISTments modules. By keeping up with the material taught in class, it allowed us to tailor our modules towards what the lecturers were teaching in class in case it did not line up with the class syllabus provided.

3.2.1 ASSISTments Trials

To effectively use ASSISTments in the test group, we acted as mediators between the students and the tutors. We analyzed the students' progress in ASSISTments and passed on relevant information including areas where the students struggled and times they would attend

the tutoring center, to the tutors to use in the individual consultations. To limit any bias that this might introduce, we worked with Gabriel Mbokoma to decide what information was pertinent for the tutors.

To measure the effectiveness of ASSISTments, we used a combination of surveys, interviews, a midway quiz, and pre and post assessments. The midway quiz (Appendix E.3) with its answer key (Appendix E.4), as well as the pre and post assessment (Appendix E.1), were distributed in class to reduce the impact we were having on their free-time. We used an answer key (Appendix E.2) to grade this as well as a rubric (Appendix E.5) to grade all assessments. All surveys, the midway quiz, and assessments were evaluated by our sponsor and the course lecturers before they were seen by the students.

3.2.2 Data Analysis

Our pre-assessment and post-assessment data was stored in a Google Drive document and analyzed using MATLAB R2017a. Descriptive statistics were calculated so that comparisons could be made between various groups. Mean, median, standard deviation, minimum, and maximum assessment scores of the test and control groups were calculated. Next, we used a two-sample t-test to determine whether or not we had enough evidence to support our alternative hypothesis (H_A) – the group that incorporated ASSISTments into their studying ($n = 7$) would learn more than the group that did not use ASSISTments ($n = 7$). After checking our data for meeting assumptions of normality and independence, we compared the increase of the average score between the pre-assessment and post-assessment. The midway quiz could not be directly compared to the pre- and post-assessments because the questions were not the same. Instead, the midway quiz was used as further evidence to support any conclusions drawn from the pre- and post-assessments. We accounted for and minimized treatment-related feedback bias throughout the calculations by analyzing both quantitative and qualitative data to form a conclusion. (Meinert, 2012).

After assessing the effectiveness of ASSISTments, we continued to analyze the data by regrouping students. Over fifty different groups were created and analyzed in an attempt to discover other factors affecting student performance. Students were grouped based on mode of study, either full-time or part-time, as well as the number of hours students spent in class during the study. To group students based on the number of hours of class they attended, we first plotted the distribution of hours and calculated the median. The median was then used to split the students into two groups, those who attended class for 11 hours or more, and those who attended less than 11 hours. We then analyzed the pre-assessment, post-assessment, and midway quiz scores of these groups, as well as the full-time and part-time groups by repeating the same process we used for the test and control groups. We calculate descriptive statistics - mean, median, minimum, maximum, and standard deviation - for the scores of each group on the pre-assessment, the post-assessment, and the midway quiz. We could not compare the midway quiz to the pre- and post-assessment for the same reason as with the test and control groups, however, we used it as further evidence of trends we found on the pre-assessment and post-assessment.

In an effort to increase and maintain both attendance and participation for our study, our group received help from the department. First, we used a departmental incentive in which a senior lecturer, Dr. Victor Katoma, visited classes to persuade students to help us with our study. This visit increased our communication with the students but was not successful in increasing participation in the study. As a next step, the lecturers added another incentive by offering academic motivation. Lecturers told students that if they helped us with our study, his or her grade could be increased.

3.3 Develop recommendations and future plans for using ASSISTments within the tutoring center at NUST

After determining the efficacy of ASSISTments, our group deemed it necessary to inform all interested staff and faculty in the Mathematics and Statistics Department about the program. ASSISTments would provide educators a tool that allows them to measure the following: attendance rates of students, time spent working on assignments, and individual student progress towards completing assigned work. To inform and teach faculty about how they could implement ASSISTments in their own classes, we held a workshop on October 8th in the Health and Applied Sciences building led by our team members. A presentation was prepared by our group to assist in giving instructions and explanations, while faculty who attended were given the opportunity to have hands-on practice with the program. Features such as creating an account, creating modules, how to look at data from problem sets, and where to go if help is needed, were covered. In addition, a brief Google Survey with three quantitative questions was administered to faculty who attended to gather feedback (Appendix F). It was important for our team to note how faculty felt about the program and how many faculty members were planning on using ASSISTments in their future curriculums.

To accomplish our goal of developing an online program for the tutoring center at NUST, we presented our research findings to the Department of Mathematics and Statistics at the University. We included a report of all of our findings, keeping the confidentiality of all students and professors interviewed, along with a presentation. This report included our recommendations for use of ASSISTments for different tutoring methods we developed, and the best process to use to track students' progress at the center.

Results and Analysis

By completing our objectives and analyzing data, our team was able to organize results in an overall attempt to increase the efficiency of the tutoring center and student learning through the use of ASSISTments. Throughout our first objective, we found that the tutoring center is effective for the students using it, but inconvenient for those who are not. Our second objective was unsuccessful in determining whether ASSISTments improved student learning, however data drawn from methods including the pre-assessment and post-assessment, midway quiz, and the ASSISTments surveys were still able to provide insightful and valuable information. Overall, lack of participation and attendance of students was a key setback, however we were still able to perform relevant analyses.

4.1 Assess the structure, student attitude towards and effectiveness of the mathematics tutoring center.

We analyzed survey data from 33 students and found that students who are aware of and use the tutoring center find it a valuable supplemental tool for improving their mathematics skills (n=18 out of 19 respondents who are aware of the center and use it frequently). However, a significant number of students at NUST are unable to utilize the center due to either distance from campus (n = 7 out of 32 respondents) or a busy schedule (n = 6 out of 32 respondents). Out of 32 respondents to the question, “How often do you use the tutoring center? If you don’t use it regularly, why not? If you use it frequently, why?” 96.9% have heard of and knew about the resource, with 59.4% using the center frequently or on a regular basis. 40.6% have never or rarely use the tutoring center, where 84.6% of those students were distance students (Figure 4.1). As such, it is clear that out of the population we surveyed, distance students had the most issues with using the tutoring center.

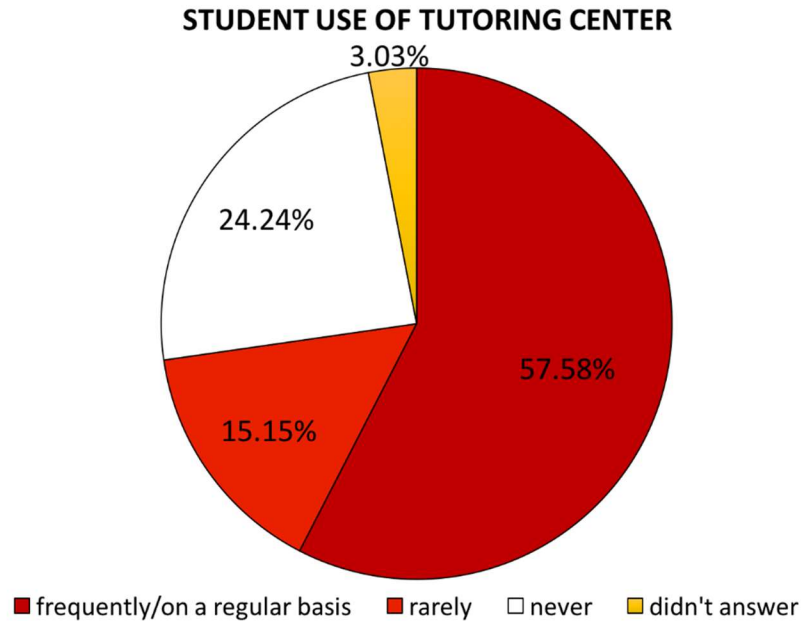


Figure 4.1 Representation of how frequently students at NUST use the Mathematics and Statistics Tutoring Center

When students were asked what they would like to change in the tutoring center, there was a wide variation found in student responses. We found that 18.18% of students taking the survey wanted tutor availability to be increased or wanted tutoring sessions to be focused on the topics they were studying. 12.12% thought that the center needed more physical space, while another 12.12% mentioned that the tutoring center is limited by the amount of time in which it is open. Finally, 6.1% of students mentioned how the use of an e-learning platform would benefit the tutoring center.

Through semi-structured interviews performed with the faculty of NUST, we ascertained that lecturers and department faculty believed that increasing the efficiency and effectiveness of the tutoring center would best benefit students. The passing rates of the basic level mathematics courses are low. Through our direct observations as tutors during vacation school, we saw that students within the same course had different levels of mathematics education. Although the lecturer had certain topics to cover, some students were not confident with the basic concepts underlying these topics and in turn were unable to solve even the most basic questions. After discussing these observations with the faculty of NUST, we believed that adding in ASSISTments to the tutoring center would mitigate some of these discrepancies in foundation. The faculty also acknowledged that only a small percentage of students from each class utilize the tutoring center. They hoped that in addition to increasing the effectiveness of the tutoring center, ASSISTments would also create more student interest in the tutoring center.

4.2 Determine the effectiveness of the ASSISTments software to improve students' math performance

4.2.1 Testing student performance between the test and control groups in the *Basic Mathematic* course

The pre-assessment distributed on September 11, 2018 was comprised of topics and concepts that lecturers would be teaching throughout our testing period. This gave us the opportunity to test students' knowledge on a series of subjects both before and after they learned it in class and we had introduced them to ASSISTments. This allowed us to analyze the increase in students' scores and draw conclusions based on results from different groups of students.

The mean of the pre-assessment scores, for the students participating in our study that took both the pre-assessment and the post-assessment ($n=9$), was $34.2\% \pm 13.06$. The median score was 34.4%. The highest score was 56.3% and the lowest score was 12.5%; the large spread in students' scores reflects the significant differences in mathematical backgrounds between students. The post-assessment revealed a noticeable increase in scores from the pre-assessment, with a mean of $54.6 \pm 16.0\%$ and a median score of 55.2%. There was a high score of 80.2% and a low score of 31.3% (Figure 4.2). It should be noted that the amount of participation in class and in the study varied from student to student, increasing some student's scores by large margins. Others saw little or no increase in score, as seen by the large standard deviation. In addition, only the students that took both the pre-assessment and the post-assessment were analyzed; students that took the pre-assessment but not the post-assessment were omitted. There are other factors that could affect the scores of students, such as outside job requirements, course load, and other similar demographic information.

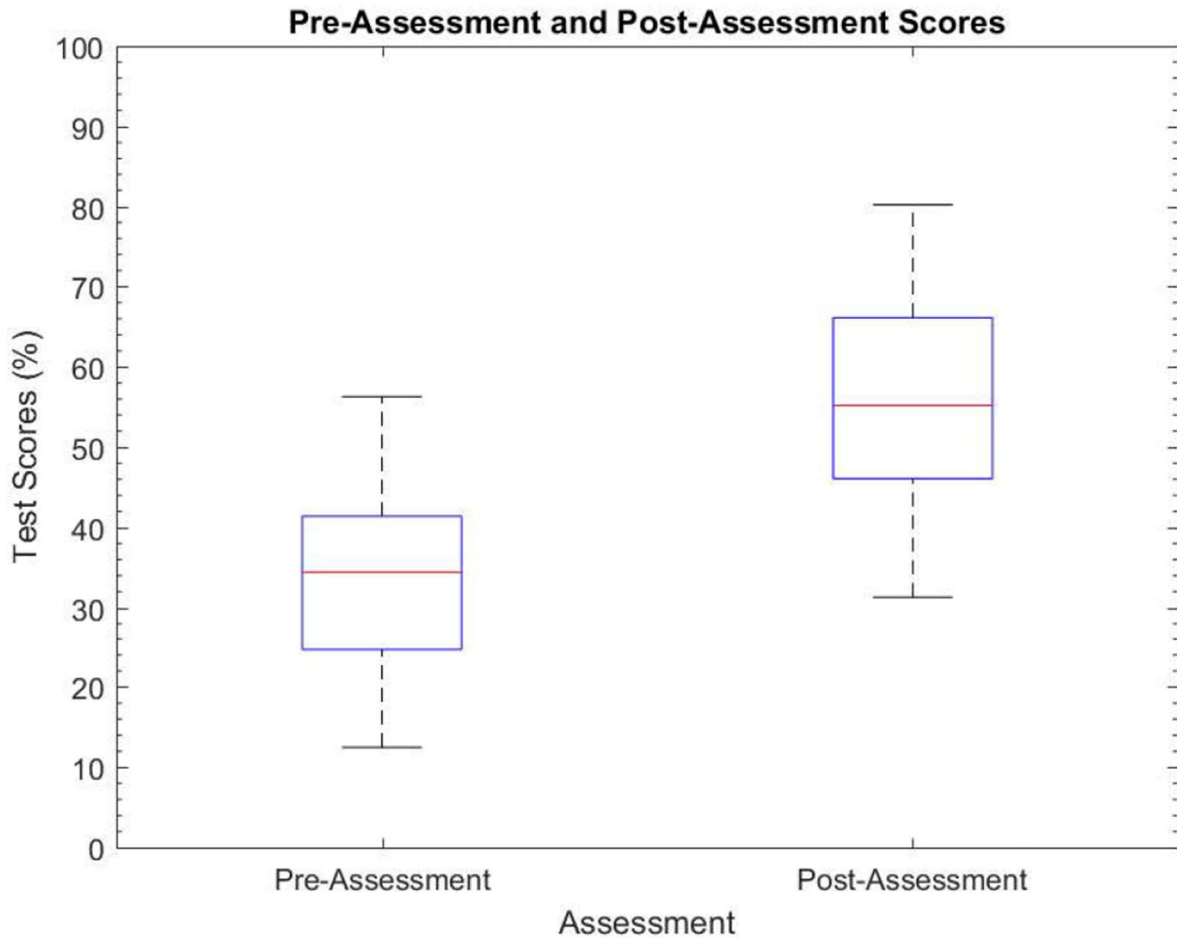


Figure 4.2 Distribution of pre-assessment and post-assessment scores

As expected, there was no significant difference between the test and control groups for the pre-assessment (Figure 4.3). The mean scores of the control and test groups were $28.4\% \pm 13.5\%$ and $39.1\% \pm 14.6\%$, respectively. The control group had a median score of 32.5% and the test group had a median score of 39.1%.

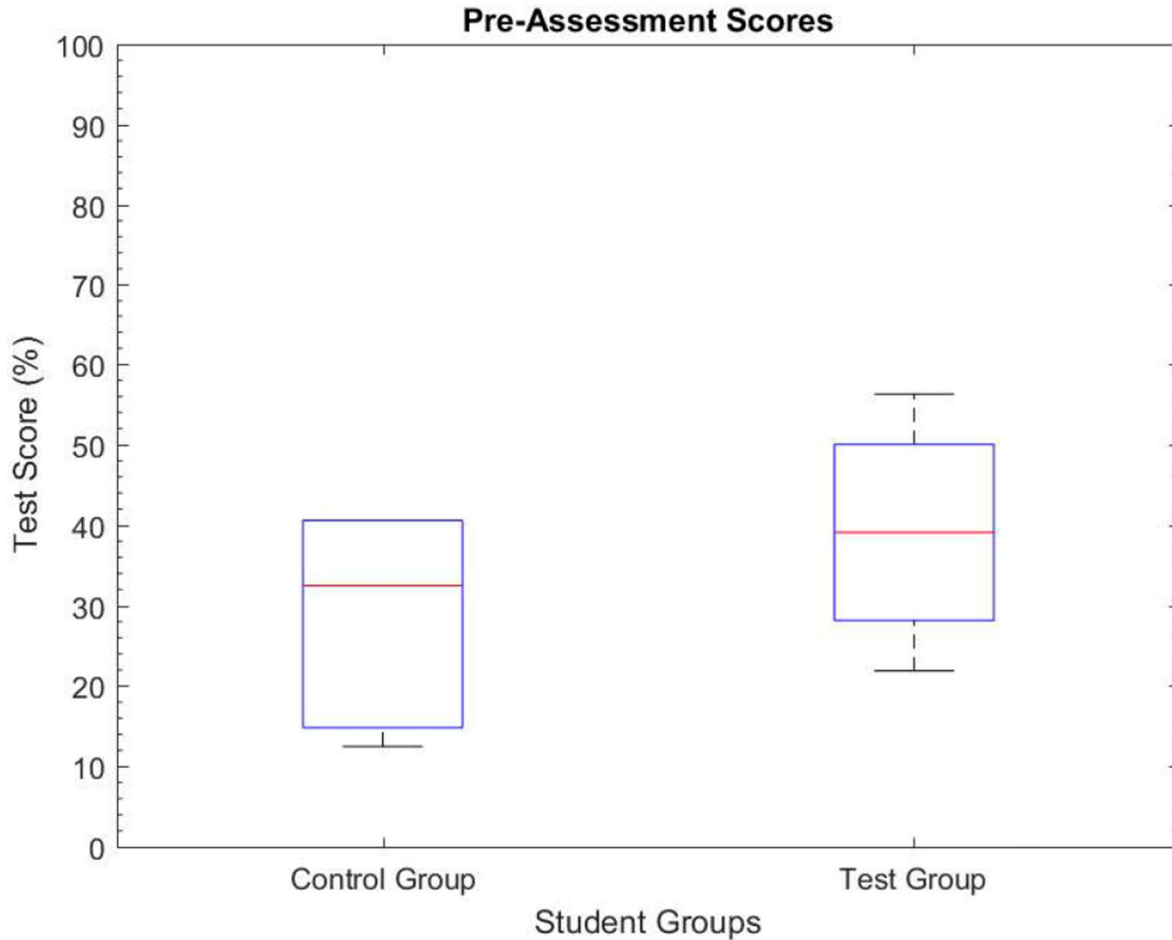


Figure 4.3 Pre-assessment scores of the test and control groups

Our alternative hypothesis (H_a – the group of students that incorporated ASSISTments into their studying would learn more than the group that did not) suggested that there would be a significant difference in scores between the test and control group on the post-assessment. The data, however, showed that there is no noticeable difference between the test and control groups (Figure 4.4). The control group had a mean score of $56.5\% \pm 18.5\%$ on the post-assessment and a median of 52.1%. The test group had a mean score of $52.3\% \pm 14.7\%$ and a median of 56.2%. The lowest score from each group was the same (31.3%), and the highest score from each group was similar (80.2% for the control group and 65.6% for the test group).

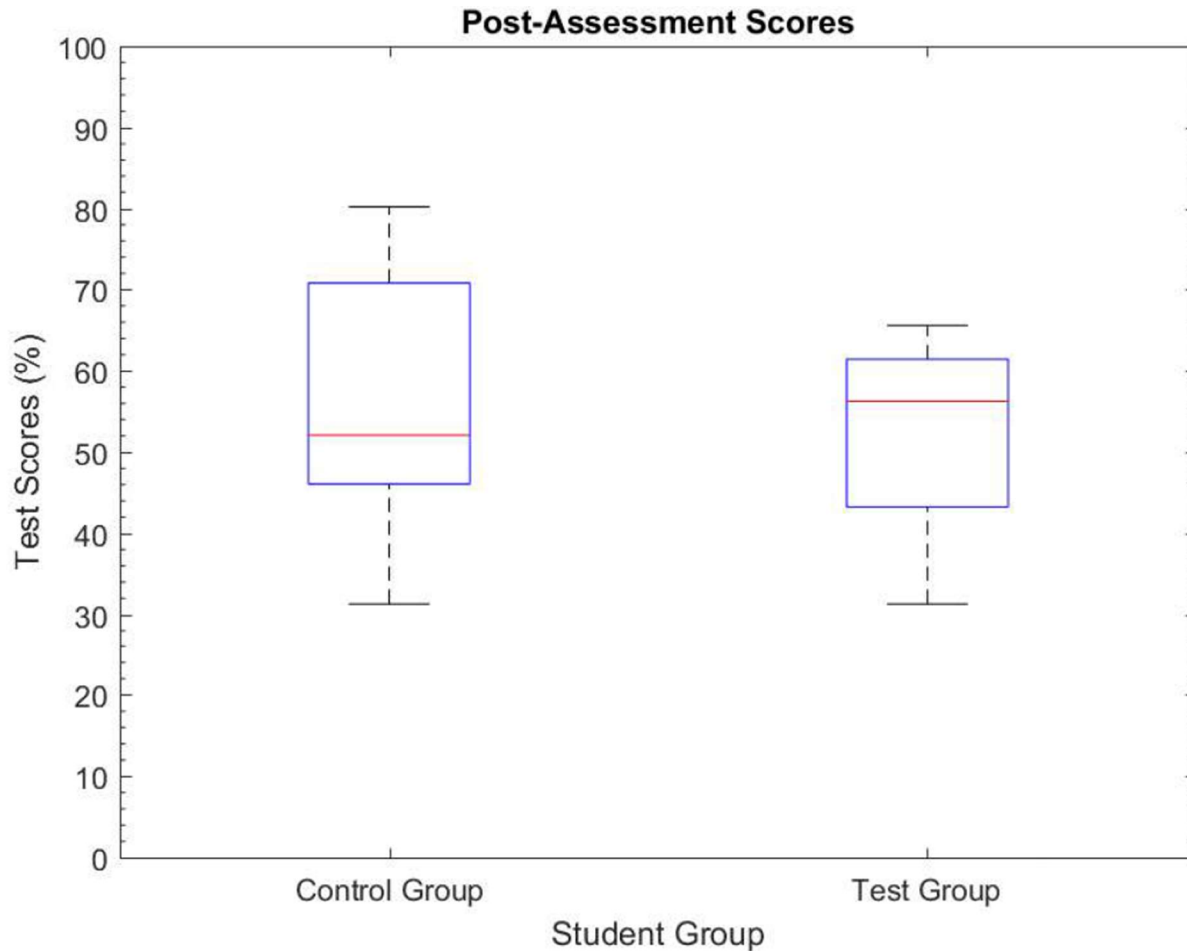


Figure 4.4 Post-assessment scores of the test and control groups

By comparing the pre-assessment to the post-assessment, it is evident that there is no significant difference in the increase in scores from the pre-assessment to the post-assessment between the test and control groups (Figure 4.5). We did not have enough student participation in our study to compute a two-proportion t-test and determine if there was enough evidence to reject the null hypothesis and support our alternative hypothesis. Although we had 9 students that we could compare, there was a very wide disparity in how often students attended classes. This disparity, along with most students not completing ASSISTments modules or attending the hour in the tutoring center, made it impossible to compare the data with any degree of certainty.

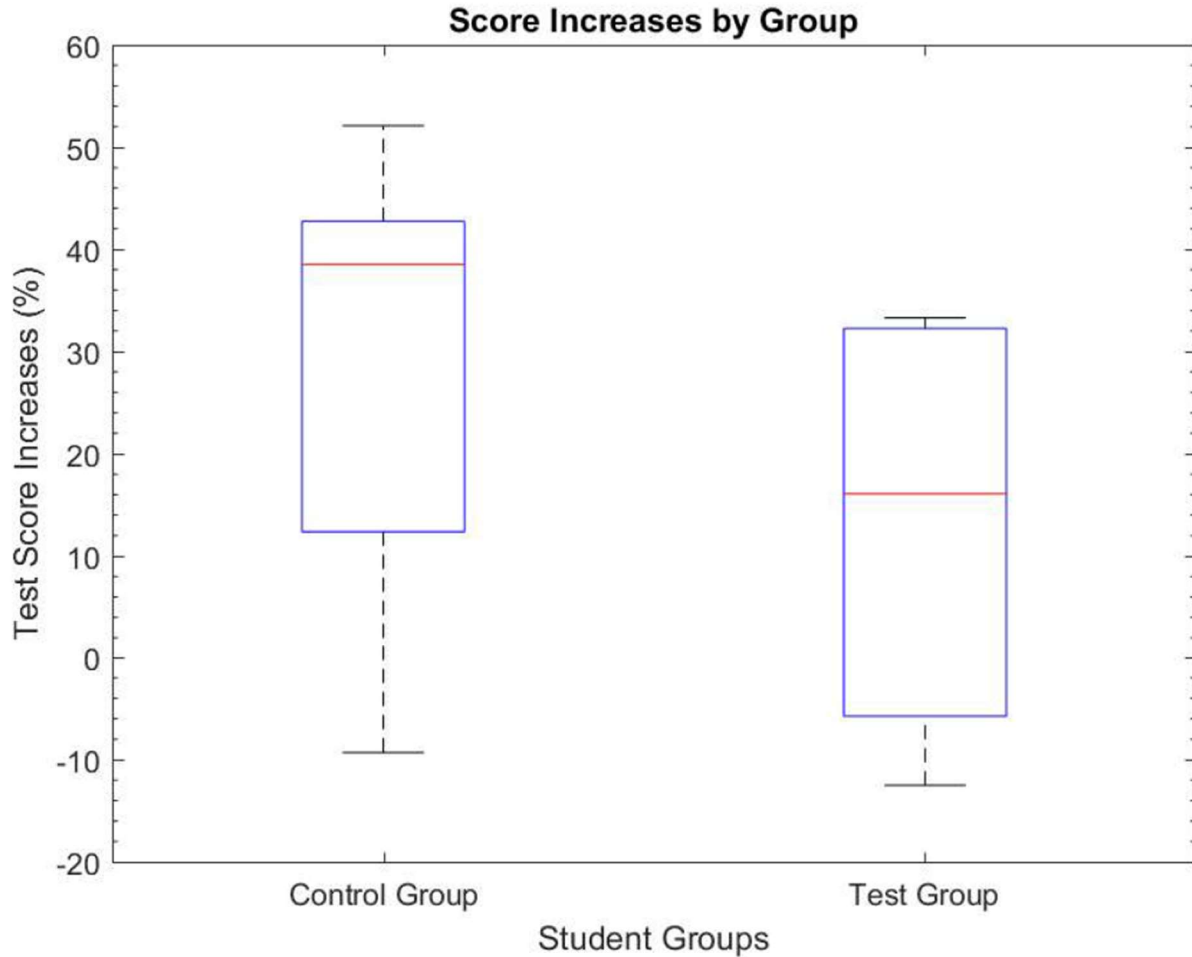


Figure 4.5 Increase in scores from the pre-assessment to the post-assessment of the test and control groups

The midway quiz that was distributed on September 27, 2018 further showed that there was not enough evidence to support that the test group's scores were higher than those of the control group's because of ASSISTments (Figure 4.6). Although only 4 students from the control group and 3 students from the test group took the midway quiz, the control group's scores were generally higher than the test group's. The mean score of the control group was $73.6\% \pm 4.9\%$, while the mean score of the test group was $57.3\% \pm 28.9\%$. These different standard deviations show the lack of participation in both the test and control groups. The 3 students in the test group scored very similarly while the 4 students in the control group scored anywhere from 25.0% to 87.5%. The median score of the control group was 70.8% while the median score of the test group was 58.4%.

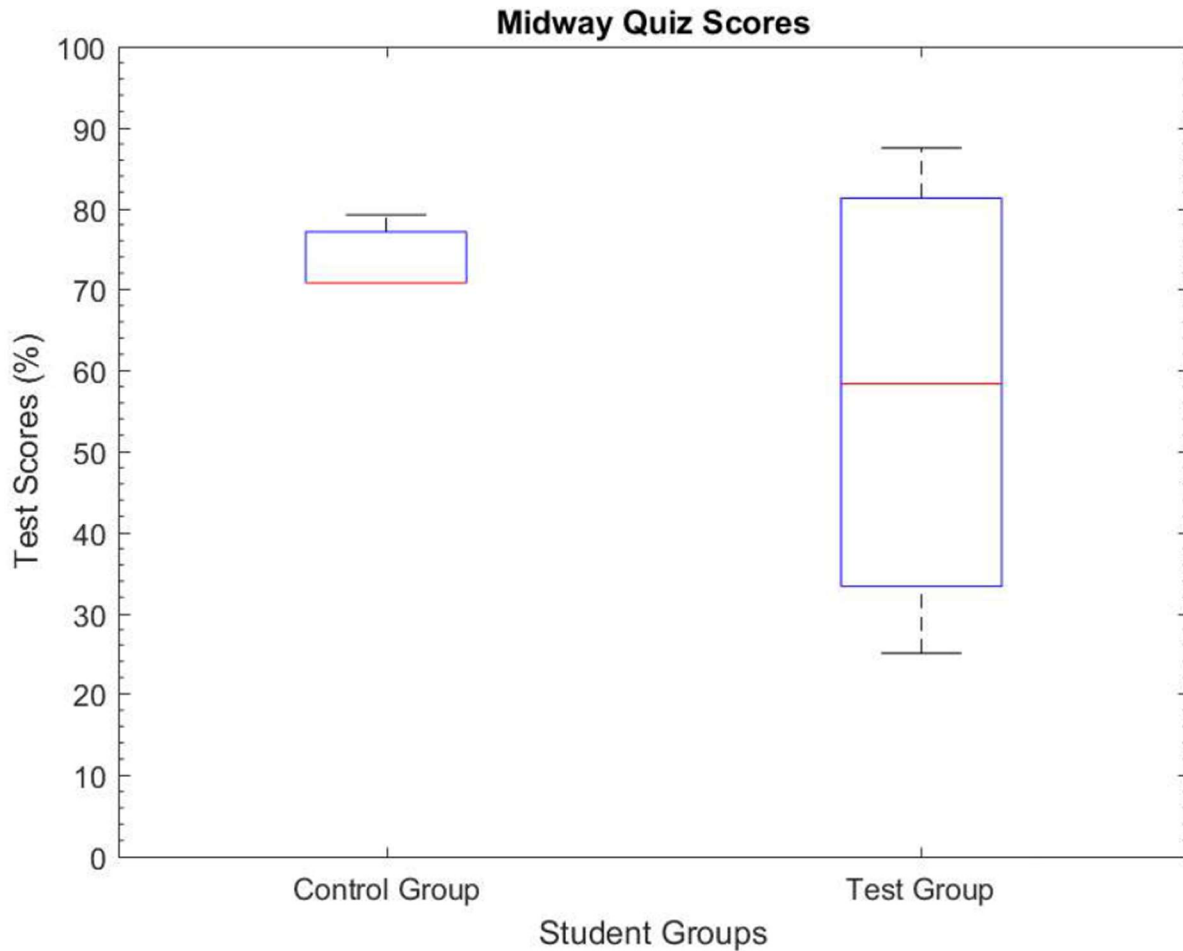


Figure 4.6 Midway quiz scores of the test and control groups

These results can be attributed to a number of factors, primarily revolving around students' lack of participation in the study. Out of 14 participants in the study, only 6 attended class regularly (75% or more of classes) and 8 completed either one of the ASSISTments modules or went to a tutoring session. That being said, 0 students completed all ASSISTments modules assigned to them and/or an hour of tutoring each week. In addition to participation, we also had trouble with student attendance. The students in the control group spent an average of 0.9 more hours in class each week than the test group. These two main factors, in addition to student course load, age, job status, et cetera, render this analysis inconclusive for our hypothesis. However, despite the inconclusive results of our three-week testing period regarding the potential of incorporating ASSISTments into NUST, other data we collected shows strong support for the program.

4.2.1 Testing the relationship between class attendance and student performance in the *Basic Mathematic* course

Although we did not have sufficient evidence to support our first alternative hypothesis, we were able to definitively show the differences in learning success between the full-time and part-time students in the *Basic Mathematics* course. By altering the way we grouped data for the pre-assessment, midway quiz, and post-assessment, our results showed a direct correlation between the number of hours of class attended each week and students' performance on the testing material we distributed. Full-time students meet three times a week for a total of four hours, while part-time students meet only twice a week for a total of less than three hours (2.75 hours). We began our second analysis by comparing all of the full-time students that participated in our study to all of the part-time students that participated in our study. Then, looking at all students in our study, we split them into two groups depending on the total number of hours they attended class during our three-week testing period.

On the pre-assessment, the distribution of test scores from students in the part-time and full-time classes was very similar (Figure 4.7). The full-time students who took both the pre-assessment as well as the post-assessment had a mean score of $36.7\% \pm 16.8\%$ and a median score of 37.5%. The lowest score recorded from the full-time class was a 15.6% and the highest score recorded was a 56.3%. The part-time students who took both the pre-assessment as well as the post-assessment had a mean score of $34.5\% \pm 15.5\%$ and a median score of 32.5%. The lowest recorded score for the full-time students was a 12.5% and the highest score was a 55.2%.

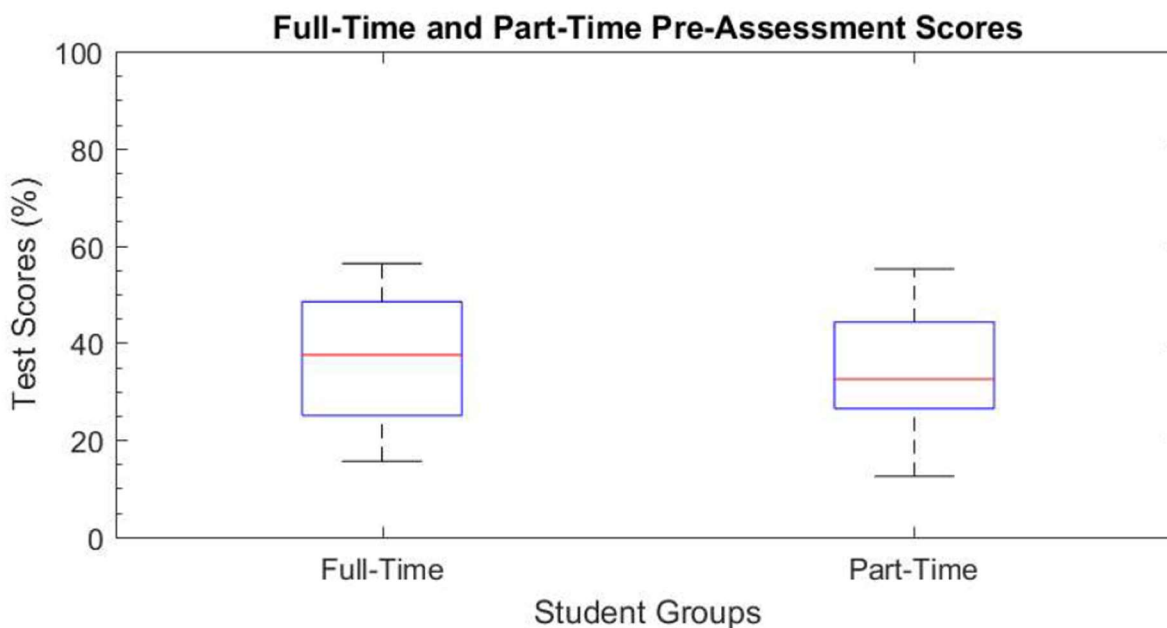


Figure 4.7 Pre-assessment scores of the full-time and part-time students

The post-assessment scores showed a noticeable difference between the full-time and part-time students. The full-time students had a mean and median score of $65.5\% \pm 11.1\%$ and 62.5%, while the part-time students had a mean and median score of $44.2\% \pm 11.8\%$ and 51.0%.

The highest score from the part-time students (55.2%) was lower than the lowest score from the full-time students (56.6%). Figure 4.8 shows the different distributions between the full-time and part-time students for the post-assessment, while figure 4.9 shows the overall score increase from the pre-assessment to the post-assessment for both the full-time and part-time students.

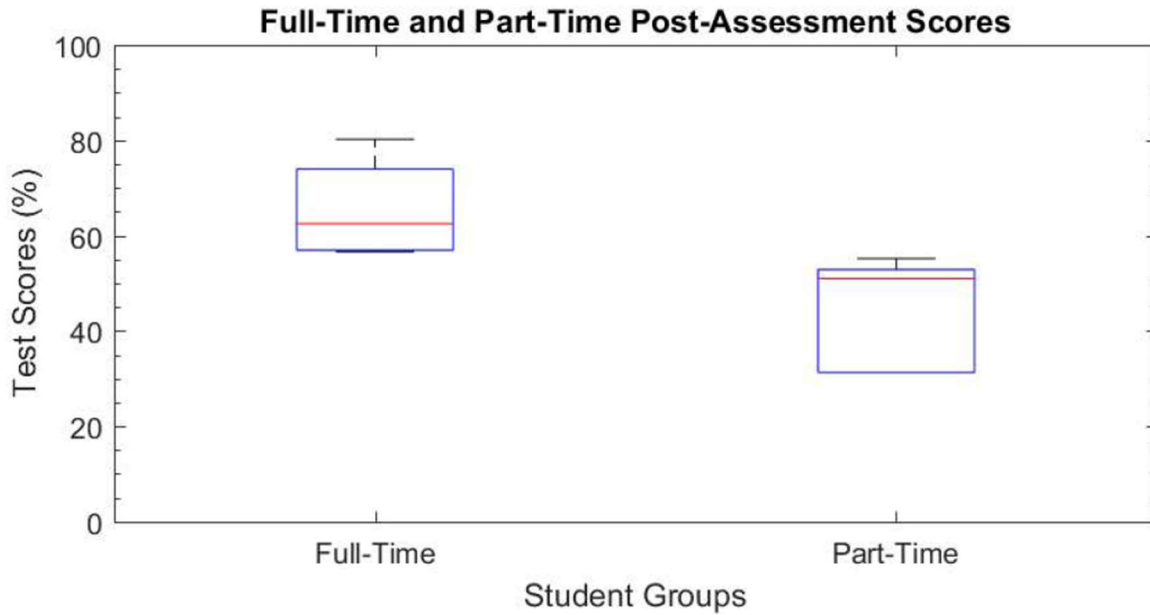


Figure 4.8 Post-assessment scores of the full-time and part-time students

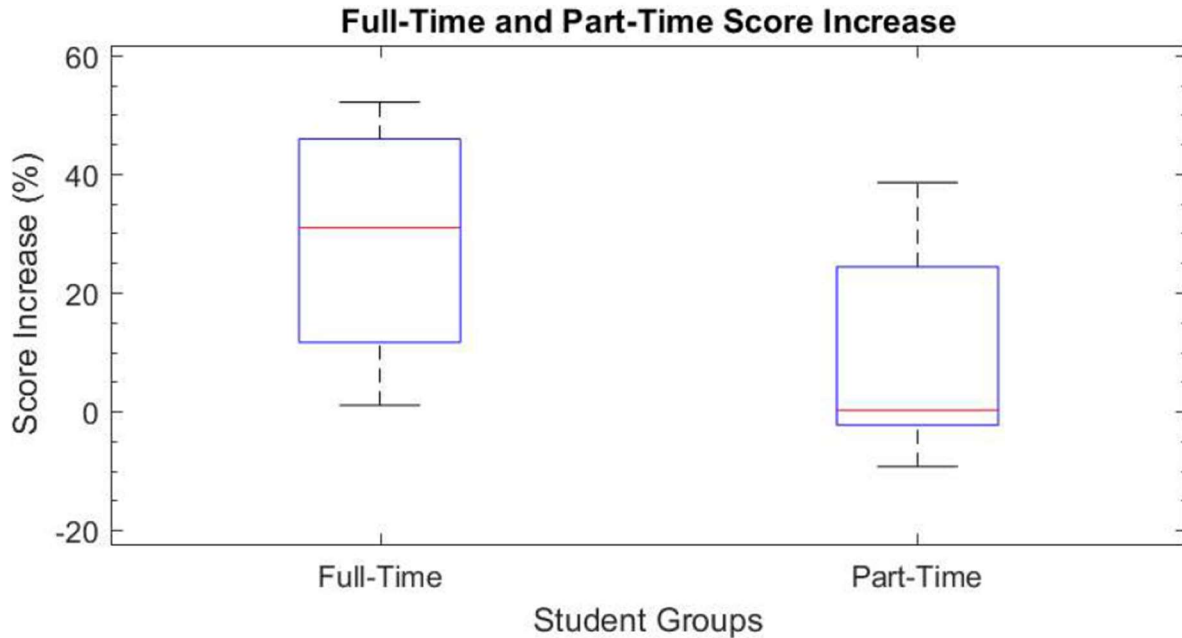


Figure 4.9 Increase of scores from the pre-assessment to the post-assessment of the full-time and part-time students

The largest difference between full-time and part-time students can be seen when analyzing the data from the midway quiz (Figure 4.10). The mean score of the full-time students (4 students who took the midway quiz) was $79.2\% \pm 8.4\%$, which was the same as the group's median score. The mean score of the part-time students (3 students who took the midway quiz) was $53.1\% \pm 23.9$ with a median score of 56.2%.

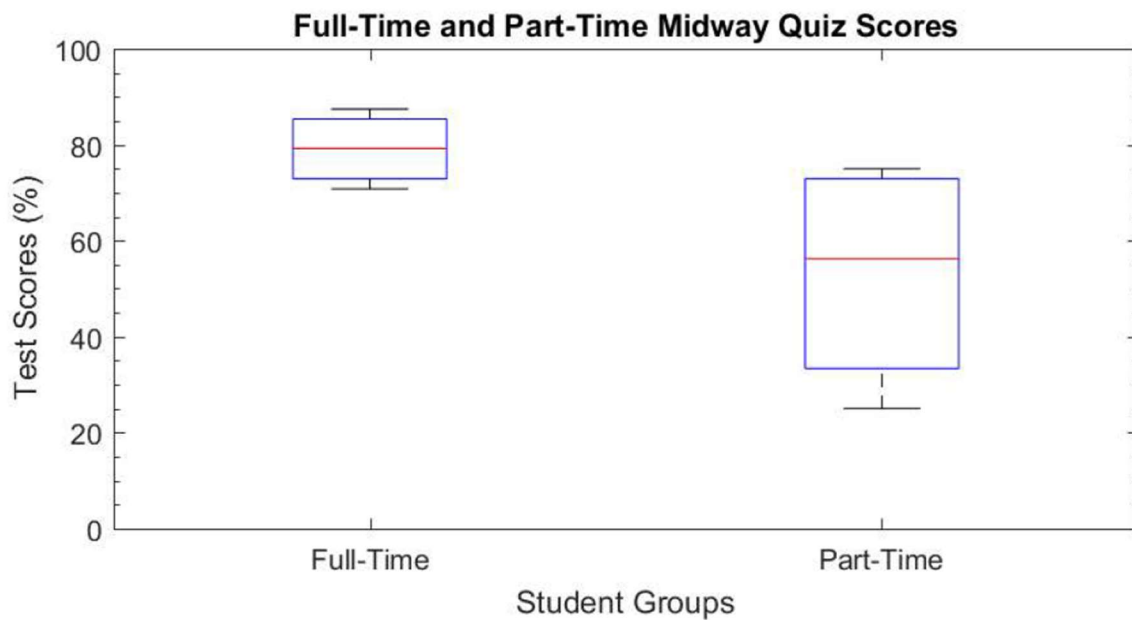


Figure 4.10 Midway quiz scores of full-time and part-time students

We also analyzed the data by splitting the students into Group 1 and Group 2. Students placed in Group 1 attended 11 hours of class or more during our three-week study, while Group 2 attended less than 11 hours of class. The pre-assessment scores of both Group 1 and Group 2 were fairly similar (Figure 4.11). Group 1 had a mean score of $33.4\% \pm 16.0\%$ and a median score of 32.5%. Group 2 had a mean score of $32.8\% \pm 14.1\%$ and a median score of 37.5%. Group 1's lowest score was a 15.6% and their highest score was a 56.3%. Group 2's lowest score was a 12.5% and their highest score was a 43.8%.

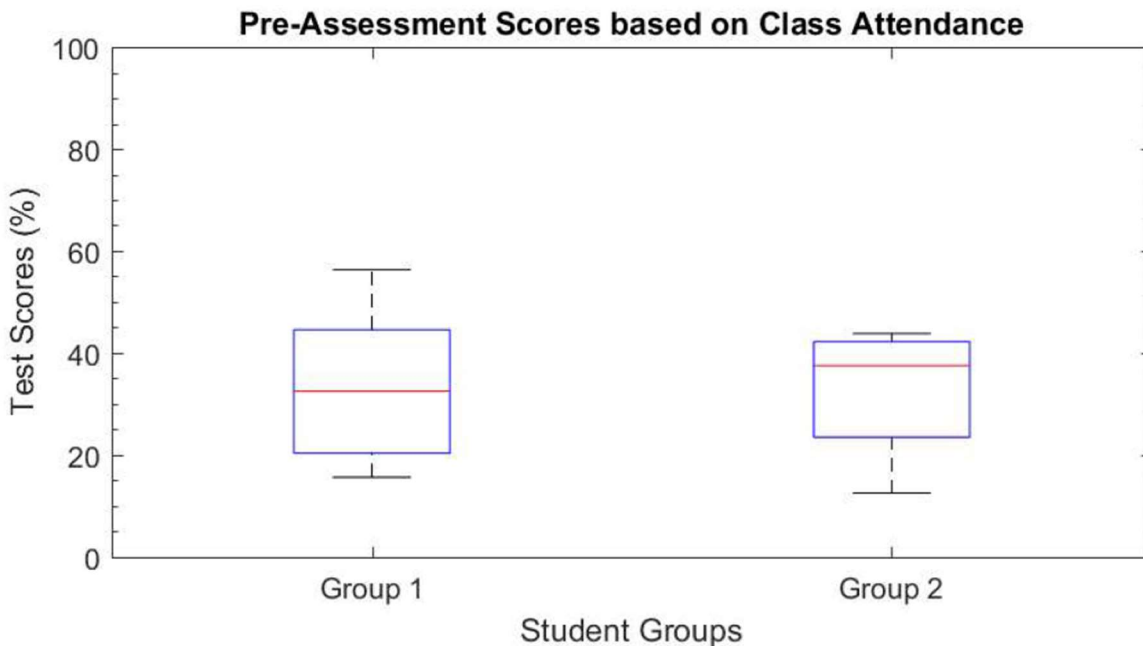


Figure 4.11 Pre-assessment scores analyzed by class attendance

The post-assessment scores of Group 1 were higher than those of Group 2 (Figure 4.12 and 4.13), supporting our hypothesis that the main reason behind the high failure rates of the *Basic Mathematics* course is students' lack of attendance. Group 1 had a mean score increase from the pre-assessment to the post-assessment of 30.1% to reach an average score of $62.5\% \pm 11.5\%$. The average increase in scores from the pre-assessment to the post-assessment for Group 2 was only 12% to reach an average score of $44.8\% \pm 16.7\%$. The median score of Group 1 was 57.3%, while the median score of Group 2 was 41.2%. The highest score in Group 2 was a 51.0% and the lowest was a 31.3%. The highest score in Group 1 was an 80.2% and the lowest score was a 52.1, which is still higher than Group 2's high score.

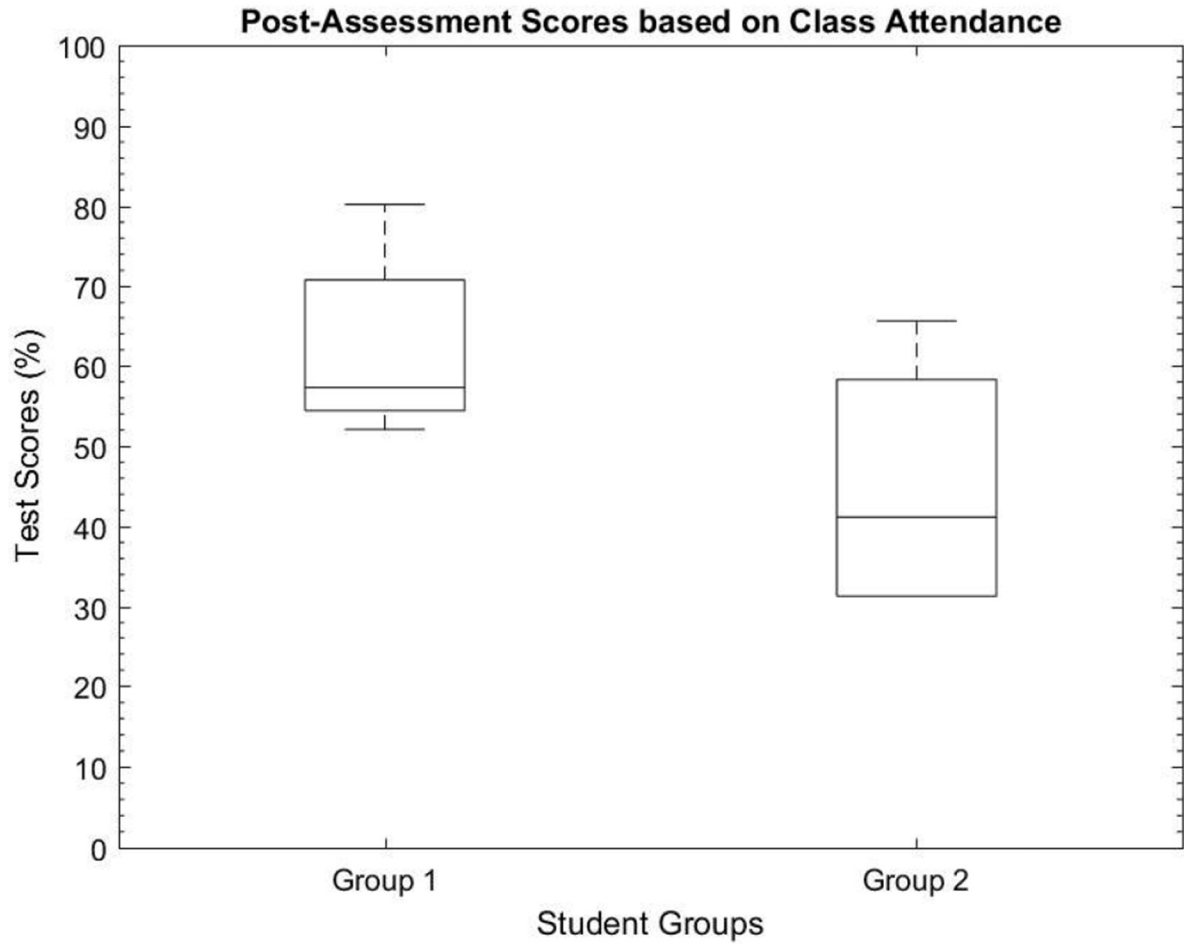


Figure 4.12 Post-assessment scores analyzed by class attendance

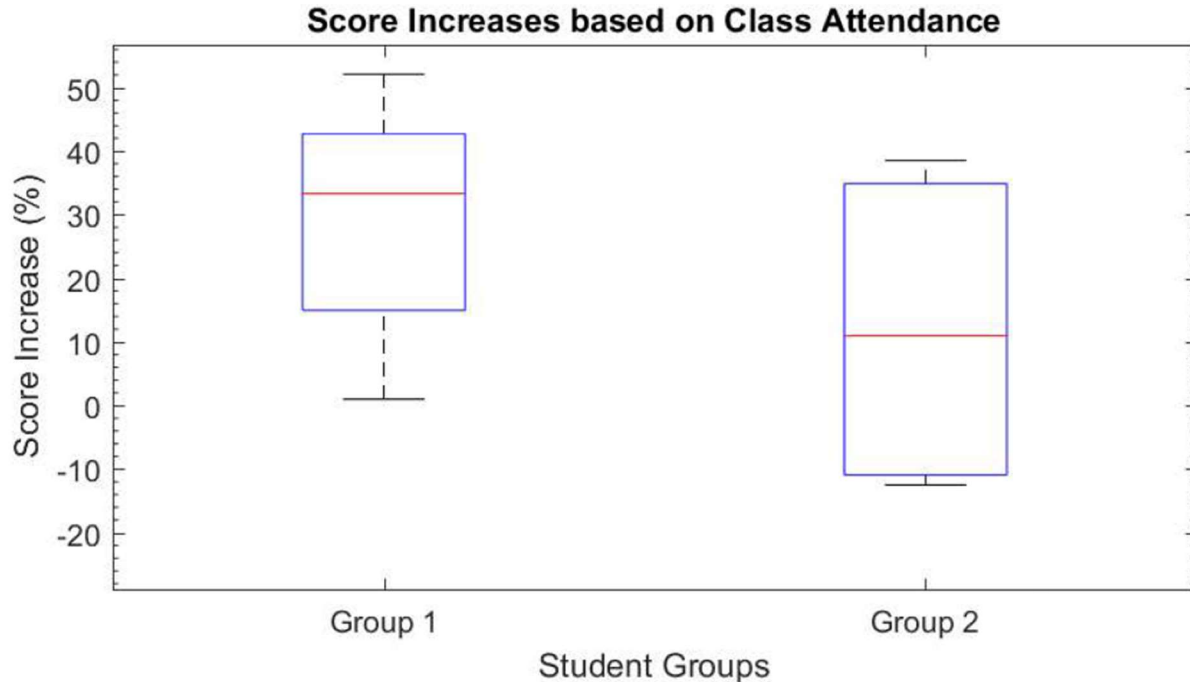


Figure 4.13 Increase of scores from the pre-assessment to the post-assessment analyzed by class attendance

There was also a notable difference in scores between the two groups on the midway quiz (Figure 4.14). Group 1 had a mean score of $73.9\% \pm 4.02\%$ and a median score of 72.9% . Group 2 had a mean score of $51.4\% \pm 32.4\%$ and a median score of 41.7% . Group 2 had a standard deviation of 23.4% , while Group 1's standard deviation was only 4.0% . We hypothesize that because the students in Group 2 did not attend class as regularly as Group 1, they were not able to learn as much from lecturers as the students in Group 1. The students in Group 2 are then required to rely more on their intellect and ability to work through a problem logically, causing a wide variety of scores as a result of a wide variety of mathematical backgrounds and ability. Group 1 students, on the other hand, all learned the same method of approach from their lecturer.

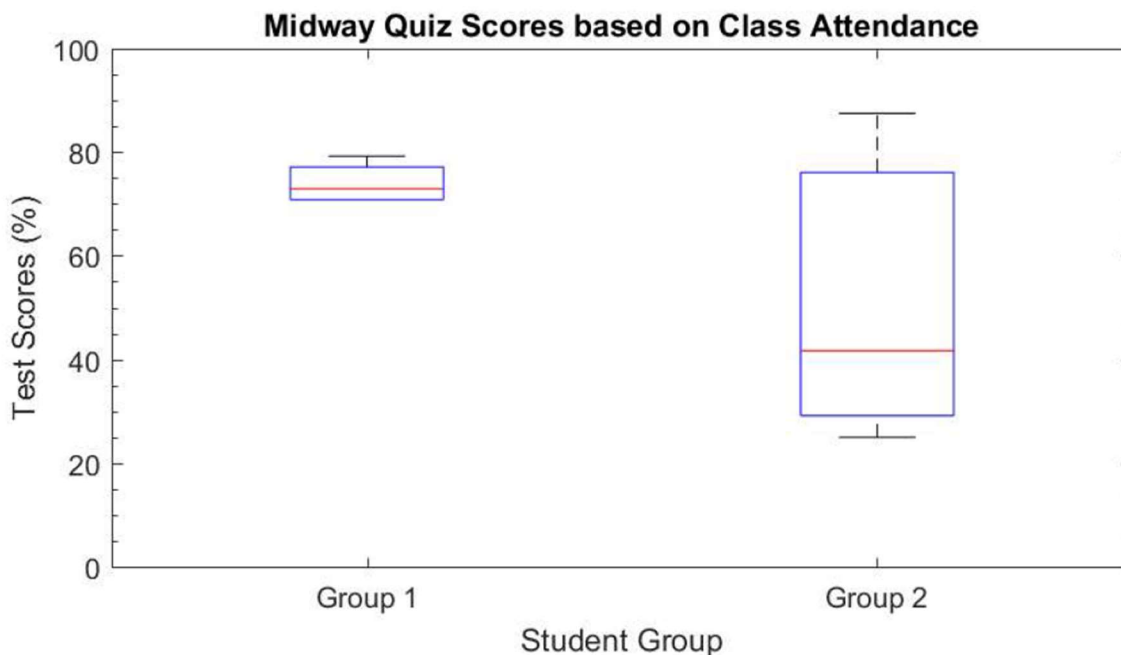


Figure 4.14 Midway quiz scores analyzed by class attendance

The results of our analysis point strongly towards the trend that an increase in hours of class attended by students resulted in better performances on tests and other assessments. Different factors, however, could have affected their performances and altered the results. We found no correlation between the use of ASSISTments modules and the students' scores, however this was due to a lack of participation. There were students that completed ASSISTments modules or spent time in the tutoring center, while others did not. This could indicate that class attendance may not be the sole reason why some students scored better than others.

In the part-time class, 1 out of the 5 students who took both the pre- and post-assessments completed 2 out of 3 ASSISTments modules and attended 2 out of 3 of the required hours in the tutoring center. Another student logged on to ASSISTments but did not complete any modules. No other students from the part-time class did any ASSISTments modules or attended any tutoring sessions. Because there were only 5 total students in the part-time class that participated in both the pre and post-assessment and were considered for data analysis, the 1 student who participated could have largely affected the descriptive statistics of that group (Group 2). In the full-time group, all 4 students who took both the pre and post-assessments attended 1 out of the 3 required hours in the tutoring center. This could have raised their scores more than if they simply attended class. Varied demographic information of the students, such as outside job requirements, course load, and other factors, could have also affected their scores.

When the students were separated into groups based on the total number of hours of class they attended during our study, the amount of effort they put in to the study itself could have affected the data. In the group that attended more than 11 hours of class, 2 out of the 5 total students attended one hour of tutoring. Another student attended two hours of tutoring and

completed two ASSISTments modules. Out of the 4 students in the group that attended less than 11 hours of class, 1 student attended one hour of tutoring. None of the other students in that group attended tutoring sessions or completed any ASSISTments modules. Although attending one hour of tutoring or completing an ASSISTments module may not largely affect students' scores, it may have affected our results.

4.3 Develop recommendations and future plans for using ASSISTments within the tutoring center at NUST

4.3.1 Student feedback

After completing the first assigned ASSISTments module, students were given a brief survey to provide our team a general idea of their respective thoughts about the program. Only 3 out of 14 participating students completed modules, and in turn, the survey. When asked “On a scale of 1-5, how easy was ASSISTments to use (1 = not easy at all, 5 = very easy),” 2 students reported “5”, while only 1 student answered “2.” All 3 students reported that they have rarely or never used the computers in the tutoring center, while 2 believe that ASSISTments would increase this usage. Our group has reason to believe that students who used ASSISTments really liked it, since all 3 students answered either a “4” or “5” to the question “How likely are you to use this program again to help you with your mathematics class (1 = not likely, 5 = very likely)?”

Although responses and participation were limited for this survey, we were able to gather valuable information. Student attitude, overall, was positive towards ASSISTments. The last question of the survey was open-ended and allowed students to provide a brief explanation of why they would or would not use ASSISTments again. Collectively, students liked the program's ease of use and specifically the idea that ASSISTments can be utilized at any time and any place at students' own convenience. Students also mentioned that ASSISTments offers a great mode of practicing math and other topics but is not the best method for learning material for the first time. Exact student responses can be seen in Figure 4.15.

“I would use this program again because it is simple and fast to use, it does not take up much time and it can be done anywhere and anytime.”

“I would most likely used this Program to practice and more for test and exams.”

“I find the program to be useful on the grounds that it is more of practice than theory so for one who had read before, this would be the best platform to try and see if they understood what they read on. hence, I would use this program again in trying to better my mathematics.”

Figure 4.15 Student quotes from the open-ended ASSISTments survey question

4.3.2 Faculty feedback

All faculty involved in our project showed great interest in using ASSISTments as well as considerable curiosity about the program’s features and effectiveness. Faculty members were given access to an ASSISTments “test account,” allowing them to see both a student’s and teacher’s point of view on the website. One faculty member at NUST said “The program is very good as it allows the student to learn while getting immediate feedback,” when asked why they like ASSISTments. Faculty in the Department of Mathematics and Statistics at NUST were very excited to be introduced to an e-learning program as interactive, easy to use, and convenient for assessing progress as ASSISTments. ASSISTments is convenient for both students using it for practice and lecturers using it for assigning, grading, and assessing.

Out of the 6 faculty members in attendance of our workshop for ASSISTments on October 8, 2018, 5 staff members responded to the Google Survey administered at the end of the workshop. The mean faculty rating regarding comfortability with ASSISTments was a 4.2 out of 5 (“5” meaning “very comfortable”), with the lowest score being a 4. The mean score of their likeliness to use ASSISTments in the future in their classrooms was rated a 4.2 out of 5 (“5” meaning “very likely”) with the lowest score being a 3. The group’s mean score for how much they liked ASSISTments was a 4.2 out of 5 (“5” meaning “liked a lot”), with the lowest score being a 3.

Conclusions and Recommendations

We found that there was a direction correlation between attendance and scores on assessments. In addition, improving the tutoring center would not address the underlying problem of lack of effort in mathematics classes from students. Therefore, most of our recommendations focus on increasing student participation and accountability.

5.1 Summary of key findings

5.1.1 Student use of the tutoring center and ASSISTments

Our preliminary survey showed that a majority of students were aware of the tutoring center but not utilizing it. Furthermore, the results of the survey highlighted that students who used the center believed that it was an integral part in their success with learning mathematics at NUST. Those students who did not use the center regularly cited reasons including distance from campus and a lack of time due to other obligations. A large number of surveyed students had recommendations for how the tutoring center could be improved, including more tutors/physical space in the center, extended hours of operation, and the implementation of an e-learning platform.

These issues that students raised have the potential to be resolved through the implementation of ASSISTments. If tutors had access to the student reports that ASSISTments provides, they could better group students who had similar gaps in their knowledge before they attended the center, thus improving the efficiency of the center. By decreasing the amount of time students spend in the center, more space would be available. Having the ability to group students based on their specific needs would also increase availability for tutors. The use of an e-learning platform would allow distance students to receive extra practice from anywhere, without traveling to Windhoek. Students can get immediate feedback on areas they need to improve, as well as interactive hints to aid in understanding. NUST's tutoring center is currently not available after 5 p.m., but an e-learning platform would allow students to practice skills and complete assignments on their own time. For all these reasons, we recommend that the Mathematics and Statistics Department use ASSISTments within the mathematics tutoring center.

Although ASSISTments was designed to be implemented into a classroom setting, using the program within the tutoring center could be beneficial, but only under the correct circumstances. We recommend that to begin the process of implementing ASSISTments into the center, the program should be tested with students who use the tutoring center regularly. This would allow feedback regarding how to best adapt the program for the tutoring center. For certain mathematics courses taught at NUST, the tutoring center provides scheduled group consultations that are often attended by the same group of students. Tutors could initially use ASSISTments with these students to ensure student participation and regular use of the program. Tutors could also use the reports ASSISTments provides to discover where students fall short

prior to group or individual consultations, allowing them to better focus their instruction. Skill builders also provide lecturers with an excellent remediation tool for students who need further assistance with fundamental concepts.

Since online tutoring techniques have been shown to develop students' mathematical abilities, we recommend that lecturers incorporate ASSISTments into their courses (Tsang, 2007). Incorporating current technology into education is a form of active learning which caters to individual students to help them apply their knowledge outside of the classroom (Loveless, 2000). By using ASSISTments and therefore active learning, lecturers would have the ability to assign personalized skill builders to students to address the gaps they have in their mathematics background. This would prevent lecturers from having to review material that students are expected to already know. PLACEments is another functionality of ASSISTments that could aid in helping students strengthen their mathematics foundation. At the beginning of a semester, instructors could use PLACEments to determine students' knowledge on basic mathematical concepts. Another benefit that ASSISTments could provide is the ability for lecturers to share both material and modules with one another. In countries struggling with mathematics education, students are often challenged because they either lack competent teachers or fail to master basic concepts (Ale, 1981). This problem could be mitigated by utilizing the functionality of ASSISTments, such as assigning modules for practice, skill builders, or a PLACEments exam.

5.1.2 Effects of low participation and attendance in the *Basic Mathematics* course

Although ASSISTments could improve the efficiency of the tutoring center and classroom learning, it will not solve the lack of effort students put into their mathematics and statistics courses. Many students participating in our study did not complete their assigned modules or tutoring center hours on time, or even at all. The most common reason cited for this was a lack of time due to the demands of their other courses or jobs. For example, students enrolled in the hospitality program spent most of their time focused on classes and projects relating to the hotel school. In an effort to increase and maintain both attendance and participation for our study, our group received help from the Mathematics and Statistics Department in the form of incentives. Students were explained the importance of our project to the future of NUST and were offered 'extra credit' for participating in our study. Despite the department's efforts, participation did not increase.

Throughout our observations of the *Basic Mathematics* course, we noticed that the lack of participation extended beyond our study and into the classroom. We observed that many students would not complete homework or would show up sporadically for class. This led us to believe that the problem wasn't with the tutoring center itself but rather with students' attitudes towards the *Basic Mathematics* course. If students are not putting in the effort to attend class or doing the necessary work for the class, then they cannot be expected to seek out supplemental help to improve their knowledge. Even if there are resources available to students for extra help, they will not increase the passing rates of students with no motivation. It is important for students within the *Basic Mathematics* course to put effort into this course and others because almost all

NUST degrees currently offered within the Management Sciences require above average backgrounds in mathematics (NUST, 2018).

Our study showed a direct correlation between attendance and student performance. We recommend that for rudimentary mathematics courses, attendance becomes mandatory. We found that the reason students have trouble passing the *Basic Mathematics* course is most likely due to them not attending classes, and therefore not learning the required material. By making attendance count toward grades, NUST would be encouraging student accountability, participation, and attendance.

5.1.3 Student and faculty feedback on ASSISTments

Despite our lack of statistical data regarding the effectiveness of incorporating ASSISTments into the tutoring center, we were still able to collect feedback about the program. All the students who used ASSISTments had positive sentiments and comments about it. Students said they were either likely or very likely to use the program again; they noted that the program was easy to use, offered a great mode of practice, and liked how it provided immediate feedback. Students also noted, however, that ASSISTments would be better for daily practice and assignments rather than actually learning material. Most students also said that using ASSISTments would not increase their use of the computers in the tutoring center. We believe that this is because ASSISTments can be used outside of the center and at a time that is convenient for the student. The idea that students can work in their free-time and at a pace they are comfortable with increases the popularity and effectiveness of online tutoring for learners (Raymond, Jacob, Jacob, & Lyons, 2016).

NUST faculty was very excited about the use of ASSISTments throughout our entire project and was able to supply us with very useful and positive feedback. Multiple faculty members, similar to the students, identified that a valuable aspect of ASSISTments was its ability to provide immediate feedback on assignments. All faculty that attended our workshop stated that they were either comfortable or very comfortable with using ASSISTments, and most faculty stated that they liked the program. The majority of faculty noted that they would be open to implementing ASSISTments into their classrooms. We believe that those who are hesitant to incorporate ASSISTments into their classrooms are unsure of its impact on student learning.

We recommend that the Department of Mathematics and Statistics, potentially in cooperation with Worcester Polytechnic Institute, conduct further research into the use of ASSISTments within the NUST curricula. Studies have been previously performed on ASSISTments' effectiveness in primary and secondary schools but has yet to be studied in tertiary education (Roschelle, Feng, Murphy, & Mason, 2016). A study performed during the first semester would provide a wider sample size of students and higher participation that would allow for more statistically significant data, and thus more concrete conclusions. If the study was based on one specific class's performance, like ours was, we strongly recommend that a class is chosen that already has a majority of students both attending class and using the tutoring center. This would presumably make it easier to ensure that students attend the center since they already

do so on a regular basis. Mandatory attendance for classes and completion of assignments would also significantly increase participation for this study. Further research into ASSISTments at NUST has the potential to provide data suggesting that the use of the program would be beneficial for both faculty and students.

5.2 Limitations of our study and concluding remarks

Although our study highlighted many findings and recommendations, there were some limitations which we had to be aware of. Because we ran the study during the second semester, there was a lack of part-time and full-time students enrolled in the rudimentary mathematics courses (*Basic Mathematics*, *Introduction to Mathematics*, and *Business Statistics*). We only focused our study on the *Basic Mathematics* course, which meant that we would not be able to assume that the results applied to other courses. We also had to consider that there were two different lecturers between the part-time and full-time students in *Basic Mathematics*. We acknowledged these factors, however, by only focusing on one course we were able to conduct a more in-depth analysis than if we had examined multiple courses.

Because we were not able to analyze our statistical data to determine the effectiveness of incorporating ASSISTments into the tutoring center, we performed secondary analysis of our data. We analyzed results based off the lack of participation and compared the scores of students who attended classes on a regular basis to those who did not. This allowed us to get comparable data to draw conclusions and led us to our recommendations.

There is evidence to suggest that our project in Namibia with ASSISTments could have a positive impact on students' mathematical performance. Although the statistical conclusions regarding ASSISTments were insignificant, we still received positive feedback from both students and faculty regarding the program. The use of ASSISTments in classrooms and the tutoring center as well as an implemented attendance policy shows strong potential to increase the passing rate of the introductory level mathematics courses at NUST. Our project was created for the purposes of the Namibia University of Science and Technology but could be applied to many tutoring centers and classrooms attempting to integrate e-learning into their curricula. ASSISTments could be used as a powerful tool to help develop the fundamental skills that some students may be lacking. We encourage further research into this topic and encourage the Mathematics and Statistics Department at NUST to use our findings to aid the student body and facilitate learning as much as possible.

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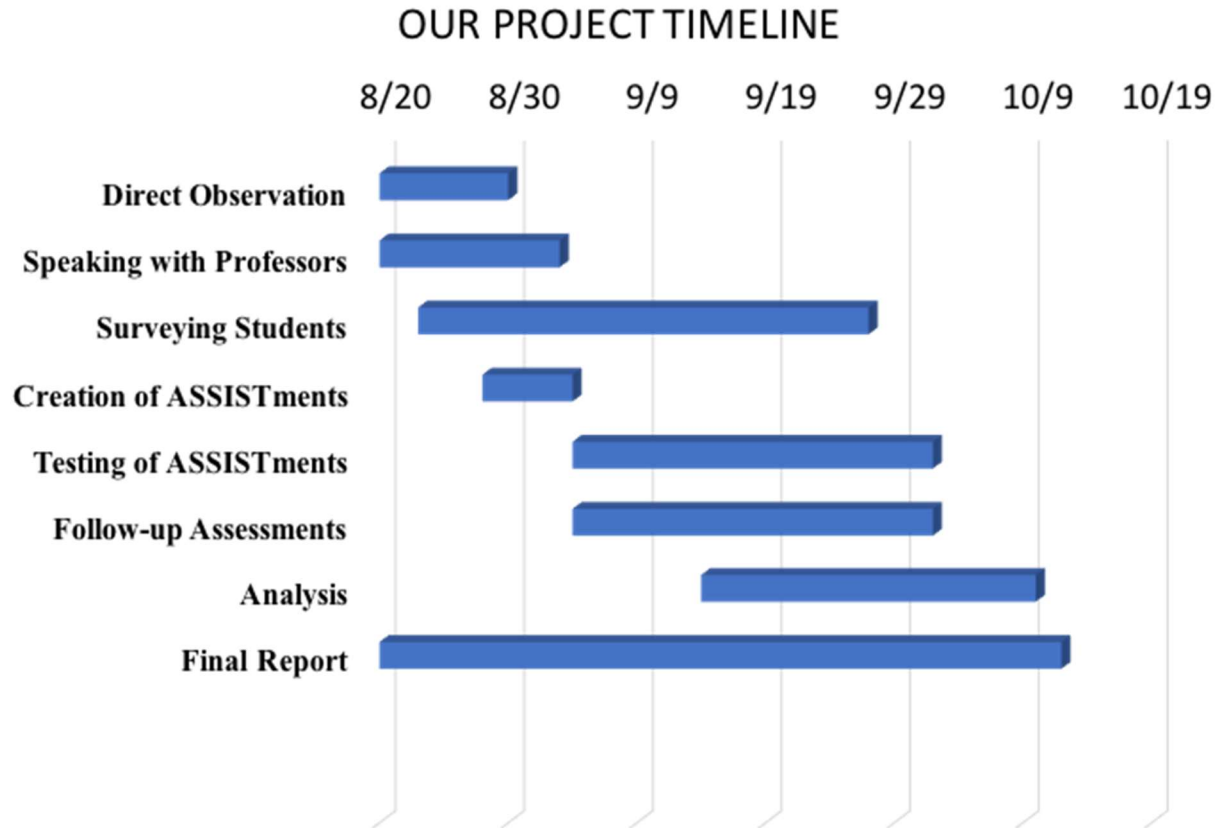
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Appendix A: GANTT CHART FOR PROJECT PLAN WHILE ON SITE IN NAMIBIA



APPENDIX B: PRELIMINARY SURVEY AND SEMI-STRUCTURED INTERVIEW QUESTIONS

B. 1 Introduction to Vacation School

Hello everyone, we are from a university in the United States called Worcester Polytechnic Institute. My name is Quinton, and this is Jess, Jordan, and Brandon. We are here working on a project with the Department of Mathematics and Statistics and NUST. Specifically, we are working to improve the effectiveness of the tutoring center in the Health and Applied Sciences building here on campus. Right now we're just trying to gather some preliminary data on the tutoring center, so we're asking you all to take the next couple minutes to fill out our survey. If you have any questions please ask one of us, and we thank you for taking the time to do this.

B. 2 Survey for Vacation School and Tutoring Center

Introduction:

We are students from Worcester Polytechnic Institute in the USA who are aiming to assess and improve the current math tutoring system at NUST. We want to improve the student passing rate of the mathematics courses by developing new techniques for tutors to utilize at the current mathematics tutoring center. We are collecting data to see what students and professors want to see improved in the center and how we can best help these groups.

Questions:

QUESTION 1: How often do you use the tutoring center? If you don't use it regularly, why not? If you use it frequently, why?

QUESTION 2: How do you think the tutoring center could be improved?

QUESTION 3: If you utilize the tutoring center, what do you like about it?

QUESTION 4: Do you think the tutoring center helps improve your mathematics skills? Why or Why not?

B. 3 Demographic Survey for Participants

Please fill out the following demographic information. Although we ask for your name, this is for our use only. All of the information in our final report will be anonymous. We ask that you complete the form fully, however if you are uncomfortable providing any of the following data, leave the section blank.

Name: _____

Number of times attempting this class: _____

Area of Study (degree/major): _____

Mode of Study for Basic Mathematics (circle one): Full Time Part Time

Employment (circle one and provide approximate hours worked per week):

 Currently Employed Not Currently Employed Hours: _____

Number of courses currently enrolled as a full-time student: _____

Number of courses currently enrolled as a part-time student: _____

Age: _____

Lecturer: _____

Gender: _____

Highest level of math taken and passed:

B. 4 Script for Preliminary Meeting with Students from the Test Group

Hello, I believe we briefly met during your class last week, but my name is Quinton and these are my group partners, Brandon, Jess, and Jordan. We are from the United States and we are working on a project with this tutoring center and we need your help. We are determining whether the use of an online e-learning program can increase the effectiveness of the tutoring center. So right now, we are going to set you up with an account on the program, ASSISTments, and teach you how to use it. Then, each week for the next three weeks you will be assigned an online module through ASSISTments; it should only take about thirty minutes. After you complete this module, you will come in to the tutoring center for one hour. You're welcome to stay for more than one hour, but we require you spend at least one hour in the tutoring center. I have here a survey that I need you to complete, asking for your demographic information. The information will be anonymous in our report, so don't be afraid to answer any of the questions. Once you complete the survey, we will set you up with an account on ASSISTments. We thank you for your time and be on the lookout for a follow-up message from us.

B. 5 Script for Preliminary Meeting with Students from the Test Group and Control Group

TEST GROUP

We have already met with you and set you up with an account on www.assistments.org and outlined our project to you. Our project begins today, and will run for the next three weeks (until October 2nd). Each week, you will have online modules to complete in ASSISTments, and are additionally required to spend at least one hour in the tutoring center. This module must be completed before you go to the tutoring center for that week. Each set of modules should take approximately 30 minutes to complete. If you get stuck on a problem, feel free to use the “show hint” button in the bottom right corner. If the hints do not help, you will be able to click the “show answer” button and skip the problem after enough attempts.

This week you have three modules to complete, two of them are questions about Set Theory which should take about 30 minutes for you to complete both. The third is a quick survey which we ask you to complete as fully as possible. Each week resets on Tuesday, meaning that you have until your Tuesday class to complete both the online modules and the tutoring center hour. We also ask that you attend all classes during this time so that you can learn as much as possible.

During your hour in the tutoring center, you will be working with Gabriel Mbokoma - the head of the tutoring center. Because of this, we need you to schedule your one hour each week to make sure that Gabriel can take the time to meet with you. Please reply with a time that will work for you each week so that we can confirm it with Gabriel.

We would like to thank you for taking the time to help us with our project, and we hope that we are not taking up too much of your time. Once again, all of the work you do will be anonymous in our final report, and none of the assignments will affect your grade in the class. If you have any questions or problems, feel free to contact any of us with the information listed below.

Best Regards,
NUST Math Tutoring Team 2018

Brandon Navarro - bmnavarro@wpi.edu - WhatsApp: +264815492990
Quinton Schimmel - qwschimmel@wpi.edu - WhatsApp: +1 7327353737
Jessica Brewster - jlbrewster@wpi.edu - WhatsApp: +1 6035400866
Jordan Myers - jlmyers@wpi.edu - WhatsApp: +1 6035027447

CONTROL GROUP

We had briefly met you in class and explained our project to you, but would like to take the time to explain it more and outline what we need your help with. We are testing an e-learning program called ASSISTments with your class to see if it can aid the learning process. We have two groups of students: one group will be using this program, and the other group (the one you are in) will not be. At the end of our study we will meet with all participants and determine if the students who used ASSISTments had a better, worse, or similar experience than those that did not.

Our project begins today, and will continue for the next three weeks (until October 2nd). During this time, we ask that you spend at least one hour in the tutoring center each week learning the material you are being taught in your Basic Mathematics class. You are welcome to spend more than one hour in the tutoring center, however it is not required. We also ask that you attend all classes during this time so that you can learn as much as possible.

We would like to thank you for taking the time to help us with our project, and we hope that we are not taking up too much of your time. If you have any questions or problems, feel free to contact any of us with the information listed below.

Best Regards,
NUST Math Tutoring Team 2018

Brandon Navarro - bmnavarro@wpi.edu - WhatsApp: +264815492990
Quinton Schimmel - qwschimmel@wpi.edu - WhatsApp: +1 7327353737
Jessica Brewster - jlbrewster@wpi.edu - WhatsApp: +1 6035400866
Jordan Myers - jlmyers@wpi.edu - WhatsApp: +1 6035027447

B. 6 Rubric for Assessing Feedback of Vacation School and Tutoring Center Surveys

| Category | 1 | 2 | 3 | 4 |
|--|---|--|---|---|
| 1. Knowledge of the tutoring center and frequency of use | Limited knowledge, never uses the center | Some knowledge, rarely uses the center | Good knowledge, uses the center frequently | Uses the center on a regular basis |
| 2. Constructive feedback | Improvement suggestions aren't relevant | Improvement suggestions are somewhat relevant but rarely mentioned by other surveys | Improvement suggestions have a common theme with others | Improvement suggestions are very relevant and frequently brought up among surveys |
| 3. Satisfaction with the tutoring center | Student does not utilize the tutoring center | Student utilizes the tutoring center but doesn't find it helpful | Student utilizes the tutoring center and lists one or zero liked items | Student utilizes the tutoring center and lists two or more liked items |
| 4. Helpfulness of Tutoring Center | Student does not think the tutoring center is improving math skills and gives no relevant reasons why | Student does not think the tutoring center is improving math skills and gives relevant explanation | Student thinks the tutoring center is improving math skills and gives one or no reasons why | Student thinks the tutoring center is improving math skills and gives two or more reasons why |

B. 7 Survey after First ASSISTments Module

Introduction:

We are students from Worcester Polytechnic Institute in the USA who are aiming to assess and improve the current math tutoring system at NUST. We want to help improve the student passing rate of the mathematics courses by developing new techniques for tutors to utilize at the current mathematics tutoring center. We are collecting data to see what students and professors want to see improved in the center and how we can best help these groups.

Questions:

For questions 1-4, 1 is the least and 5 is the most (select one response for each question)

QUESTION 1: On a scale of 1-5, how easy was ASSISTments to use?

1 2 3 4 5

QUESTION 2: How often do you use the computers in the tutoring center?

1 2 3 4 5

QUESTION 3: How much do you think ASSISTments would increase your usage of the computers in the center?

1 2 3 4 5

QUESTION 4: How likely are you to use this program again to help you with your mathematics class?

1 2 3 4 5

QUESTION 5: Please provide a brief explanation of why you would or would not use this program again.

B. 8 Rubric for Question 5 of the Survey after the First ASSISTments Module

| Category | 1 | 2 | 3 | 4 |
|---------------------------------------|---|---|------------------------------------|--------------------------------------|
| 1. Desired use of the tutoring center | Students would not use this program again | Student will probably not use the tutoring center again | Student may use this program again | Student would use this program again |

APPENDIX C: TERMS AND DEFINITIONS

1. Non-response Bias: not obtaining a representative sample of the general population as a result of lack of participation
2. Response Bias: a certain demographic of students only participates
3. Single Blind: a situation in which only the test subjects of the clinical trial are unaware of the goal and methods of the study
4. Type-I Error: rejecting a true null hypothesis
5. Type-II Error: accepting a false null hypothesis
6. Null Hypothesis: there is no distinction between the test and control groups
7. Treatment-related Selection Bias: placing participants in either the test or control groups based on prior knowledge of the participants
8. Treatment-related Feedback Bias: bias in observation and the recording of data
9. General Population: the entire group of students currently taking *Basic Mathematics*
10. Sample Population: the students that are participating in the test and control groups

APPENDIX D: CLASS SCHEDULE FOR *BASIC MATHEMATICS* COURSE

| Day | Tuesday | Wednesday | Thursday |
|------------------|--------------------|------------------|--------------------|
| Part Time | 17:15-18:25 | | 20:00-21:25 |
| Full Time | 8:30-9:30 | 8:30-9:30 | 9:30-11:30 |

APPENDIX E: PRE-ASSESSMENT

E. 1 Pre and Post Assessment questions

Question 1: Set Theory

A. Consider the following sets (2 points)

$$\Omega = \{1, 2, 3, 4, 5, 8, 13, a, b, c, d, e, f\}$$

- $A = \{3, 5, 8, 13, e\}$
- $B = \{1, 2, 3, a, b, c\}$
- $C = \{8, 13, e, f\}$
- $D = \{3, a, b, c, d, e, f\}$

I. $A \cup C$

II. $(A \cup B)^c$

B. Represent sets A & B in the form of a Venn Diagram

C. Write out the power set for $A \cap C$

Question 2: Matrices

For the parts A-C, refer to the 2x2 matrices shown below.

$$W = \begin{bmatrix} 3 & 2 \\ 5 & -1 \end{bmatrix} \quad L = \begin{bmatrix} -2 & 9 \\ 1 & 2 \end{bmatrix}$$

A. Calculate $3L-W$

B. Calculate WL

C. Calculate $\det(W)$

D. Find the value of x , y and z in the following matrix equation.

$$\begin{bmatrix} 4 & x \\ y & 3 \end{bmatrix} + \begin{bmatrix} 2 & y \\ 4 & 2 \end{bmatrix} = \begin{bmatrix} x & 12 \\ z & 5 \end{bmatrix}$$

Question 3: Percentages, Ratios and Proportions

- A. Convert the following fractions to percentages, and percentages to fractions
- a. $\frac{5}{7}$
 - b. $3\frac{1}{2}$
 - c. 0,541
 - d. 76,21%
 - e. 23%
- B. Increase 164 by 21%
- C. 2 months ago, a TV sold for N\$5,180. Now, the price has gone down by 32%. What is the price now?
- D. Find the value of x in the following ratio:
- a. $\frac{1}{3} : 4 = x : 36$
- E. It is expected to share N\$5,012 between three people in the ratio 16:40:56. How much will each person get?

E. 2 Pre and Post Assessment Answer Key

Answer Key

Question 1: Set Theory

A. Consider the following sets (2 points)

$$\Omega = \{1, 2, 3, 4, 5, 8, 13, a, b, c, d, e, f\}$$

- $A = \{3, 5, 8, 13, e\}$
- $B = \{1, 2, 3, a, b, c\}$
- $C = \{8, 13, e, f\}$
- $D = \{3, a, b, c, d, e, f\}$

I. $A \cup C$

$$A \cup C = \{3, 5, 8, 13, e, f\}$$

II. $(A \cup B)^c$

$$(A \cup B) = \{1, 2, 3, 5, 8, 13, a, b, c, e\}$$

$$(A \cup B)^c = \{d, f\}$$

B. Represent sets A & B in the form of a Venn Diagram (1 point)

2 SET VENN DIAGRAM

Jordan Myers | September 10, 2018



C. Write out the power set for $A \cap C$ (1 point)

$$A \cap C = \{8, 13, e\}$$

$$P(A \cap C) = \{2^3\} = \{8\}$$

Question 2: Matrices

For the parts A-C, refer to the 2x2 matrices shown below.

$$W = \begin{bmatrix} 3 & 2 \\ 5 & -1 \end{bmatrix} \quad L = \begin{bmatrix} -2 & 9 \\ 1 & 2 \end{bmatrix}$$

A. Calculate $3L-W$

$$3L-W = 3[-2,9; 1,2]-[3,2; 5,-1]$$

$$3L-W = [-6,27; 3,6]-[3,2; 5,-1]$$

$$3L-W = [-9,25; -2, 7]$$

B. Calculate WL

$$WL = [3,2; 5,-1][-2,9; 1,2]$$

$$WL = [(3)(-2) + (2)(1), (3)(9) + (2)(2); (5)(-2) + (-1)(1), (5)(9) + (-1)(2)]$$

$$WL = [(-6) + (2), (27) + (4); (-10) + (-1), (45) + (-2)]$$

$$WL = [-4,31; -11,43]$$

C. Calculate $\det(W)$

$$\det(W) = \det([3,2; 5,-1])$$

$$\det(W) = (3)(-1)-(2)(5)$$

$$\det(W) = (-3) - (10)$$

$$\det(W) = -13$$

D. Find the value of x , y and z in the following matrix equation.

$$[4,x; y,3] + [2,y; 4,2] = [x,12; z,5]$$

$$[6,x+y; 4+y,5] = [x,12; z,5]$$

$$6=x \quad x+y=12 \quad 4+y=z \quad 5=5$$

$$x=6 \quad 6+y=12 \quad 4+y=z$$

$$x=6 \quad y=6 \quad 4+6=z$$

$$x=6 \quad y=6 \quad z=10$$

Question 3: Percentages, Ratios and Proportions

A. Convert the following fractions to percentages, and percentages to fractions

a. $\frac{5}{7}$

1. $(\frac{5}{7}) = (x/100)$
2. $X = 71.4\%$

b. $3\frac{1}{2}$

1. $3\frac{1}{2} = \frac{7}{2}$
2. $(\frac{7}{2}) = (x/100)$
3. $X = 350\%$

c. 0,541

1. $(0,541/1) = (x/100)$
2. $X = 54.1\%$

d. 76,21%

1. $(76,21/100) = (x/1)$
2. 0,7621
3. OR just move the decimal over two places

e. 23%

1. 0,23

B. Increase 164 by 21%

1. $(21/100) = (x/164)$
2. $X = 34,44$
3. $164+34,44 = 198,44$

C. 2 months ago, a TV sold for N\$5,180. Now, the price has gone down by 32%. What is the price now?

1. Solution: $32/100 = x/5,180$
2. Solution a: $(5,180/100)*32 = \$1,657.6$
3. Or b: $(32*5,180)/100 = \$1,657.6$
4. $N\$5,180 - N\$1,657.6 = N\$3,522.4$
5. Current price = N\$3,522.4

D. Find the value of x in the following ratio:

f. $\frac{1}{3} : 4 = x : 36$

1. Solution a: $(36/4) = 9$
2. $9 * \frac{1}{3} = 3$
3. $x=3$
4. Solution b: $(\frac{1}{3} * 12) = 4$
5. So $x * 12 = 36$
6. $X = 3$

E. It is expected to share N\$5,012 between three people in the ratio 16:40:56. How much will each person get?

1. Solution: 16:40:56 can be simplified to 2:5:7
2. $2+5+7 = 14$
3. $5,012/14 = 358$
4. $2x358 = 716$ $5x358 = 1,790$ $7x358 = 2,506$
5. So amounts are N\$716, N\$1,790, and N\$2,506

E. 3 Midway Quiz

Question 1: Consider the following sets

$$A = \{1, 2, 3, 4, a, b, c, d\}$$

$$B = \{2, 4, 6, 8, e, f\}$$

$$C = \{5, 6, 7, 8, b, d, f\}$$

$$D = \{3, 5, 7, a, c, e, f\}$$

a.) What is $B \cup D$?

b.) What is $(A \cap C)$ (could also be written as $(A \cap C)'$)

c.) Represent sets A and B in a Venn diagram and then shade the union.

Question 2: Complete the following matrix operations utilizing the below matrices

$$A = \begin{bmatrix} 1 & 5 \\ -5 & 2 \end{bmatrix} \quad B = \begin{bmatrix} -3 & 0 \\ 1 & 0 \end{bmatrix}$$

a.) $A - B$

b.) $B + 2A$

c.) $A * B$

E. 4 Midway Quiz Answer Key

Question 1: Consider the following sets

$A = \{1, 2, 3, 4, a, b, c, d\}$

$B = \{2, 4, 6, 8, e, f\}$

$C = \{5, 6, 7, 8, b, d, f\}$

$D = \{3, 5, 7, a, c, e, f\}$

a.) What is $B \cup D$?

$B \cup D = \{2, 3, 4, 5, 6, 7, 8, a, c, e, f\}$

b.) What is $(A \cap C)^c$ (could also be written as $(A \cap C)'$)

$A \cap C = \{b, d\}$

$(A \cap C)^c = \{1, 2, 3, 4, 5, 6, 7, 8, a, c, e, f\}$

c.) Represent sets A and B in a venn diagram.

COPY OF 2 SET VENN DIAGRAM

Jordan Myers | September 24, 2018



Question 2: Complete the following matrix operations utilizing the below matrices

$$A = \begin{bmatrix} 1 & 5 \\ -5 & 2 \end{bmatrix} \quad B = \begin{bmatrix} -3 & 0 \\ 1 & 0 \end{bmatrix}$$

a.) $A - B$

$$A - B = [4, 5; -6, 2]$$

b.) $B + 2A$

$$B + 2A = [-3, 0; 1, 0] + [2, 10; -10, 2]$$

$$B + 2A = [-1, 10; -9, 2]$$

c.) $A * B$

$$A * B = [(-3) + (5), (0) + (0); (-15) + (2), (0) + (0)]$$

$$A * B = [2, 0; -13, 0]$$

E. 5 Grading Rubric for Pre/Post Assessment and Midway Quiz

| | 0 | 1 | 2 | 3 | 4 |
|----------------------|--------------------------------------|---|---|---|---|
| Question being asked | Student does not attempt the problem | Student attempts but shows no understanding | Student shows some understanding but has major errors | Student uses the right methods and has minor errors | Student performs the problem with no errors |

APPENDIX F: GOOGLE SURVEY FOLLOWING ASSISTments WORKSHOP

QUESTION 1: On a scale of 1-5, how comfortable are you with using ASSISTments?
(With 5 being 'very comfortable')

QUESTION 2: On a scale of 1-5, how likely are you to use ASSISTments in your class?
(With 5 being 'very likely')

QUESTION 3: On a scale of 1-5, how much do you like ASSISTments?
(With 5 being 'a lot')