Association Between E-learning System Usage and Medical Student Academic Performance at the Kilimanjaro Christian Medical University College in Moshi, Tanzania

by

Margaret Carroll Murray

Duke Global Health Institute
Duke University

Date:_______________________

Approved:

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John Bartlett, Supervisor

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Nathan Thielman

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Lawrence Park

Thesis submitted in partial fulfillment of
the requirements for the degree of
Master of Science in the Duke Global Health Institute
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ABSTRACT

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Abstract

Introduction: Due to Tanzania's rising population and shortage of physicians, there has been an emphasis on the expansion of medical schools in the past two decades, both in number and class size. In order to teach a growing student body, faculty adopted e-learning (electronic learning) systems to distribute materials and educate students. At Kilimanjaro Christian Medical University College (KCMUCo) faculty adopted the e-learning system called Learning Management Content System (LCMS+) in 2011. LCMS+ allowed students to access and download course materials during the year; but the association between the downloaded course materials and final grade was unknown. This study aimed to analyze the association between the downloaded materials and final grade in a course between 2011 and 2016.

Methods: To determine the association between downloaded materials and grade, a retrospective secondary analysis study studied first- and second-year medical students in seven courses from 2011-2016 at KCMUCo. The study initially measured the frequency of downloaded course material (i.e. powerpoints, readings, assignments, course outlines and discussion board posts) from LCMS+ per first and second-year student. The final course grades were then obtained. A linear regression was used to assess the association between (1) downloads and grade and (2) sociodemographic variables and grade.

Results: Of the 1,527 students and 5,205 student-course-years studied, the distributions of grades were approximately normal from 2011-2014 and in 2014-2016 there was a left shift of grade distribution. Additionally the female sex and post-service history were associated with slightly lower grades in some of the student years. There was a null association between downloaded materials and grade for each year and for different types of downloaded material

Conclusion: This study demonstrated there was no association between the number of downloads and grade. There was also no association between the type of downloaded material and grade and the number of materials did not increase the longer the e-learning system was at KCMUCo. More research on how e-learning systems can benefit students is required and may lead to better training for future generations of health care providers.

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1. Introduction

Medical schools are essential to the future health of a country's population. In 2017 World Health Organization (WHO) reported that over 44% of WHO Member States had less than 1 physician per 1000 population (1). Tanzania was likely one of them with 0.022 doctors per 1,000 population in 2014 (ibid). A sustainable health workforce is still currently crucial for a country's achievement of the 2015 Sustainable Development Goals (SDGs) and as of 2013 there were only 64,449 health workers in the Tanzania (30). Furthermore between 2005-2015 Tanzania had 0.46 skilled health professionals per 1,000 population (1). This total is far short of the required 4.45 doctors, nurses, and midwives per 1000 population, which is the minimum health workforce density to achieve the SDGs according to the WHO Global Strategy on Human Resources for Health: Workforce 2030 (2).

Medical schools in Tanzania will serve a large role in educating future medical providers to meet the health needs of the country's growing population. Typically medical schools require students to pass a national standardized entrance exam before entering. Medical schools lectures, classroom activities, and medical textbooks are the primary means to teach the basic sciences and clinical concepts in the first two years. Then in the later school years guided experience in different hospital departments provides an interactive education for students. However the criteria and structure of medical schools vary worldwide.

Currently medical schools in Africa serve an important role in meeting the area's growing health needs. The region has more than 24% of the global burden of disease, only 3% of the world's health workers, and less than 1% of the world's financial resources (2). Therefore Africa, which suffers one of the highest health burdens, has a significant shortage of providers and a high poverty rate.

1.1 Health Education in Sub-Saharan Africa

Sub-Sahara Africa has only 0.3 physicians per 1,000 people and an estimated 277,964 physicians to serve the 926,548,177 people (1). Due to the shortage of graduates from the few medical schools and the emigration of graduates to other countries, the training of medical providers does not sufficiently meet these demands (3,4). The emigration of students has cost these countries an estimated $2.17 billion in lost returns from investment in medical education for all doctors (5). For example Tanzania lost an estimated $3.49 million of investment in medical education for all the emigrated physicians before July, 2011 (5). The education and retention of medical doctors in Africa is a priority for countries, in order to provide enough physicians to deliver clinical care, make health policies, and manage hospitals in the area.

In 2008 the international spotlight focused on the shortage of physicians and the problems within the medical education system, yet the lack of African data eluded many international organizations, such as the WHO, the Institute for International and Medical Education, the Foundation for Advancement of International Medical Education and Research, and the World Federation for Medical Education. In 2010 the Sub-Saharan African Medical School Study (SAMSS) studied medical education in Sub-Saharan Africa in order to learn more about current schools and how to strengthen the capacity for the health education system (6). The SAMSS continues to oversee and visit the area's schools and provide recommendations for the schools and countries based on their annual findings. Countries began to escalate their medical education efforts in order to increase their health workforce and address national health disparities. Many medical schools suffered from variability in how secondary school prepared students, poor physical infrastructure, a lack of a coordinated effort between the ministries of health and education, faculty shortages in basic and clinical sciences, and growth of the student body (7). These problems require innovative planning focused on cost-efficient and effective medical education.

1.1.1 Medical Education in Tanzania

In 2014 The World Health Organization estimated that Tanzania had 0.022 physicians per 1,000 people, one of the lowest worldwide (Figure 1) (1). In order to meet the country's demand for a larger health workforce, the Ministry of Health and Education in Tanzania opened more medical schools and nongovernmental funds financed more private schools. However the health workforce is heavily concentrated in the urban areas, as the national urban population has increased approximately four times since 1960 (8). The uneven distribution of the health workforce may originate from the lack of available graduate medical training programs, limited exposure to rural medicine, and low incentive to practice rural medicine.

External funding provides 36.6% of the national health revenue as of 2015 (1). The country's reliance on external funding is unsustainable for future investments in medical education. Currently there are seven medical schools in Tanzania, and each school faces similar problems, while continuing to provide an education to the next generation of health providers.

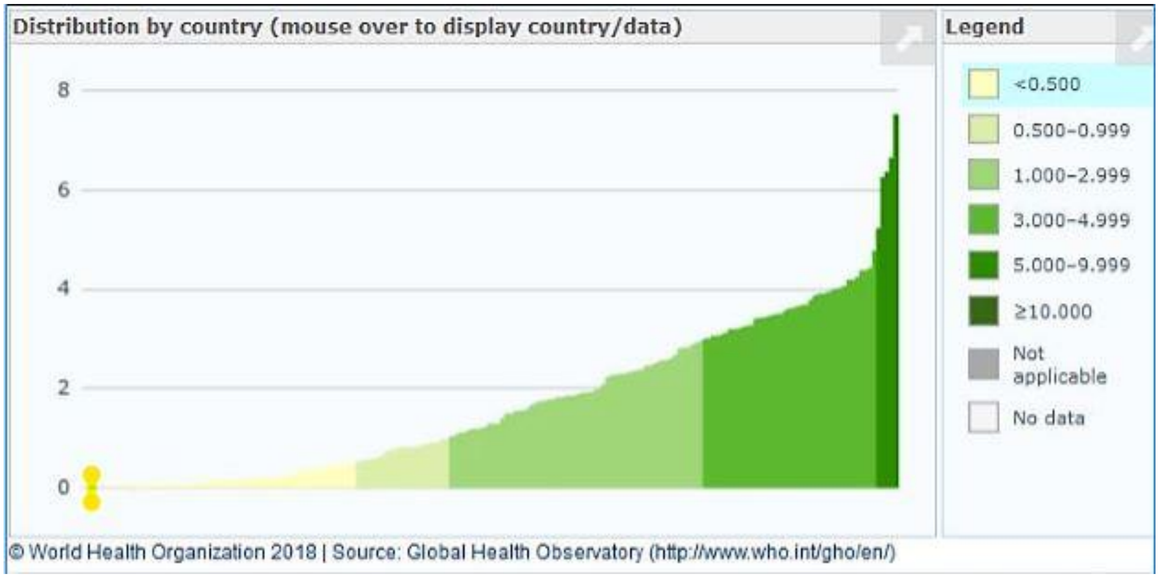

Figure 1: A distribution of the densities of physicians per 1,000 population in international countries. The yellow line indicates the relation of Tanzania's population physician density (1).

1.1.2 Electronic Learning Systems

Electronic learning systems (e-learning systems), which are online platforms that provide electronic access to educational materials to students, are one of the tools that medical institutions use to provide quality education to a growing student body both in high income countries (HIC) and low and middle income countries (LMIC). They have been used to provide students learning materials, such as textbook chapters and powerpoints, in addition in lectures, labs, and discussion groups. While e-learning systems remain a relatively recent addition to the medical curriculum in areas such as Sub-Saharan Africa, they have made considerable impact in medical education in more developed regions. For example, researchers in South Australia evaluated the correlation between use of e-learning systems and grades through frequency of access to the e-learning system and distance from the school (11). Another study in South Korea revealed a positive association between the regular use of e-learning management systems and student's performance in courses (12). However other studies have found that greater use and frequent visits to e-learning systems are insufficient measurements in assessing their benefit. Students who viewed more topics and accessed more features in the e-learning systems showed better academic performance (13). E-learning systems provide unlimited access to educational course materials to a growing student body, but uncertainties remain around the most effective use of the technology and the best way to measure the impact of these systems.

Unlike the schools in HIC, many of schools in Tanzania are reluctant to adopt advanced technology in delivering the medical curriculum (9). Fewer medical schools have e-learning systems due to inadequate physical infrastructure and funding within institutions. In order to encourage higher e-learning usage, five recommendations for the regions' schools are: (1) greater awareness of mobile technology, (2) increasing access to e-learning through mobile devices, (3) coupling e-learning systems with social media to increase access, (4) clarifying policies on intellectual property rights and copyrights of e-learning materials, and (5) increase internet speed within institutions to increase user access to educational technologies (10). E-learning systems can be an effective, cost-efficient way to provide medical education to the future health workforce.

1.2 Kilimanjaro Christian Medical Center

Kilimanjaro Christian Medical Center (KCMC), located in Mount Kilimanjaro, Tanzania, opened in March 1971. The Good Samaritan Foundation funded the building and equipment of the hospital, which currently houses 500-800 inpatients with 630 beds, 40 baby incubators, 1852 students, and 1300 staff (14). KCMC is one of the four zonal consultant hospitals in Tanzania and serves northern, eastern, and central zones of the country. The hospital provides health services to the 1,769,795 residents in the Kilimanjaro region (16). In 1997 the Kilimanjaro Christian Medical University College opened in collaboration with KCMC and resides adjunct to the hospital. In 2009 the Kilimanjaro Clinical Research Institute was established as an institution of the Good Samaritan Foundation, forming the third pillar in the Foundation next to health services and training.

1.3 Kilimanjaro Christian Medical University College

The Kilimanjaro Christian Medical University College (KCMUCo), was established on October 1, 1997 by the Good Samaritan Foundation and its mission was to expand medical education in the Kilimanjaro region in order to provide more Tanzanian healthcare providers (15). After 20 years KCMUCo now ranks not only as one of the largest but also one of the premier medical schools in Tanzania and offers more than 16 separate health-related degrees. Currently the college provides education for the following institutes: Faculty of Medicine, Faculty of Nursing, Faculty of Rehabilitation Medicine, Directorate of Postgraduate Studies, Directorate of Research and Consultancies, and Institute of Public Health. Additionally KCMUCo provides diplomas in Laboratory Sciences, Physiotherapy, Optometry, Occupational Therapy, Prosthetics and Orthotics, HIV and AIDS Care, and Nursing.

The KCMUCo medical education program is five years and after the completion of the program, graduates are expected to take a sixth year of apprenticeship in an approved institution before being able to practice independently. All courses are taught in English and students are expected to have earned an ordinary or advanced level Secondary School Education Certificate in the basic sciences.

1.3.1 Medical Education Partnership Initiative

In 2010 KCMUCo and Duke Global Health Institute received a five-year $10 million grant from PEPFAR, Fogarty International Center and Health Resources and Services Administration. The Medical Education Partnership Initiative (MEPI) grant provided sufficient funding for the education of future Tanzanian physicians in academics, research, and policy (17). Additionally the grant relied on and strengthened the longstanding partnership between Duke and KCMC.

This grant has allowed KCMUCo to make innovative changes to the medical curriculum. For example, in 2012 Kapanda, G. et al. began peripheral rotations for medical students during their third year of clinical training; and during these rotations, students traveled to rural areas of the country where there are the greatest number of health disparities (18, 19). Nyindo, et al. introduced team-based learning at the medical school during 2012 with an ectoparasite module for students (19). This creative style of learning was not only reviewed positively by the student body but also improved final exam grades. The grant also funded the introduction of a diagnostic teaching laboratory at KCMUCo and currently the curriculum incorporates laboratory sciences into the medical curriculum (20).

1.3.2 Learning Content Management System

Funded by the MEPI grant, KCMUCo introduced an e-learning system in 2011. Electronic technology allowed the KCMUCo faculty to deliver quality medical training efficiently to their expanding student body. KCMUCo used the Learning Content Management System+ (LCMS+), an e-learning system for health education that was developed in 2005 at Duke School of Medicine in Durham, North Carolina. Through LCMS+, course content, like textbooks and lectures, became available on a digital platform for medical students to access and download.

All KCMUCo medical students were introduced to LCMS+ in October 2011 and received tablets. The 2011 cohort kept the tablets and used it throughout their five years. As the MEPI grant continued, new tablets were distributed to incoming first-year medical student cohorts and at the conclusion of the grant in 2016, the tablets from the initial cohort were recycled for the use of future cohorts of students. The KCMUCo campus is wireless, allowing students internet access anywhere on campus. KCMUCo was one of the first medical schools to begin using a learning management system in sub-Saharan Africa to manage their curriculum (21).

1.4 Rationale and Study Aims

1.4.1 Gap in Knowledge of the Effectiveness of Electronic Learning Systems in Medical Academic Centers

Since the introduction of LCMS+ at KCMUCo, there have been several studies analyzing the system's effects on the students and faculty. Killewo, et al. published a report summarizing the introduction of the learning management system in 2012 at KCMUCo (22). Their study illustrated the rapid expansion of students using LCMS+ and the gradual increase in faculty use during its first-year. Furthermore they reported a high level of student satisfaction with the software, quality of content, and learning enhancement (ibid). Other Tanzanian higher learning institutions have adopted e-learning in education, including Unversity of Dar es Salaam, College of Information

Technology (CoICT). They, like KCMUCo, found acceptance varies among faculty at the college (23). In 2014 the majority of the KCMUCo medical students accessed LCMS+ on a daily basis and they took tests during the year to assess their understanding of the material (24). That year Muiruri C., Kapanda G., et al. examined the students' perception of the implementation and effectiveness of LCMS+ at KCMUCo since its start, and revealed that medical student "perceived usefulness and attitude [of LCMS+] had a significant effect on intention to use" (25). In 2016 Mtebe, et al. preformed a comprehensive review of different factors that affect teachers' acceptance and use of e-learning systems (23). The 2016 study also identified ways to help KCMUCo faculty increase the use of e-learning systems in their classrooms as well (ibid).

Class size at KCMUCo continues to increase and faculty are challenged to deliver unlimited access to educational course resources to students. With the help of LCMS+ KCMUCo faculty now are able to relay these educational resources to students. During 2011-2016 those KCMUCo medical students had access to textbooks and lectures through LCMS+ but it is unknown whether their access to those materials on the e-learning system affected their academic performance.

Medical schools in LMIC are only beginning to adopt these electronic services. Therefore there is no defined way to measure the effectiveness of these e-learning systems. The analysis of the system depends upon the system's capacity to measure student engagement with the site and its available material and different platforms. Furthermore each institution uses a different e-learning system. Determining a more precise way to measure student academic performance based on their interactions with e-learning systems would help faculty better use the system to identify students struggling with the material. It would also inform the medical education community as to the best way students can interact with these electronic systems, as more schools adopt technology in their curriculum.

1.4.2 Study Aims for the Association between E-learning Usage and Academic Performance

This retrospective analysis study was sponsored by Duke University Global Health Institute, conducted in partnership with Duke University and KCMUCo. This study was conducted between May and August of 2017, relying on documents on the LCMS+ site and final course grade. Throughout each year faculty posted documents, such as powerpoints, readings, assignments, outlines, and posts on course discussion boards. Students downloaded these documents for personal use. LCMS+ recorded the names of students who downloaded each of the resources on course webpages and we measured the frequency each student downloaded different types of documents. Documents were categorized according to powerpoints, assignments, outlines, readings, and posts to discussion board. This study analyzed five cohorts of first- and second-year

KCMUCo medical students from 2011-2016, who had access to LCMS+ and used the site for their first two years of training. We investigated the association between the number of resources available on LCMS+ used by a KCMUCo medical student in courses taken during their first- and second-year and the student's final grade in each of the respective courses. We defined "usage" as the number of resources downloaded by a student during an academic year.

One aim of the study was to investigate the association between the number of resources available on LCMS+ used by a KCMUCo medical student in courses taken during their first- and second-year and the final grade of each student in each of the respective courses. We hypothesized that the more the students downloaded the learning materials, the more they used the course educational materials. Additionally the students with the highest frequency of downloaded materials would have the higher grade since they had greater exposure to educational materials.

We collected and measured the sociodemographic variables, including sex, age, service history, and Form 6 score, per student. Service history was defined as whether or not students were a non-physician clinical officer before coming to school. The Form 6 score is the score on a national standardized pre-enrollment exam, which students take before medical school. These variables were accessed through the academic profiles of each student and were measured to account for each student's history of academic performance. The second aim of the study was to investigate the association between the various sociodemographic variables and the student's final grade. We hypothesized that younger, pre-service students with a higher pre-enrollment exam score would have higher grades than older, post-service students with a lower pre-enrollment exam score.

2. Methods

2.1 Setting

We conducted this study between May and August, 2017 at Kilimanjaro Christian Medical University College in Moshi, Tanzania. As previously mentioned, KCMUCo is part of the Kilimanjaro Christian Medical Center and resides on the same campus as the hospital and Kilimanjaro Christian Research Institute. The campus is devoted to medical, educational, and research institutes and sits approximately 6 kilometres from the urban district of Moshi.

2.1.1 Education in Moshi and the Kilimanjaro Region

Moshi is the capital of the Kilimanjaro Region in northeastern Tanzania and became a Tanzanian municipality in 2014. Moshi is made up of the Moshi Rural and Moshi Urban Districts. According to the most recent projected population, the Rural District had a population of 466,737, which was projected to be 509,431 in 2017, and the the Urban District had a population of 184,292, which was projected to be 201,150 in 2017 (26, 27). In Tanzania high literacy rates and education attainment rates are concentrated in urban centers, with Moshi and the Kilimanjaro Region being an urban island in the northwestern Tanzania. The Kilimanjaro Region had the second highest female literacy rate in the country, with 92.8% of women, and the seventh highest male literacy rate, with 87.0% of men (28). In the Kilimanjaro Region, 53.8% of women and

46.2% of men have attended primary school; and 43.3% of the men and 37.8% of the women have attended secondary school (27). Moshi has become one of the centers for higher education in the country.

2.1.2 Internet Usage in Tanzania

Internet usage within Tanzania is 8% of women and 19% of men in 2012, compared to approximately 38% of the total population in 2017 (28, 29). However, some of the primary deterrents of internet usage in Tanzania are the access to internet and electrical power.

2.2 Participants

The target population was KCMUCo first-year medical students from 2011-2016 taking courses in in biochemistry, anatomy, and physiology classes, and second-year medical students from 2012-2016 in classes covering community health, pharmacology, parasitology, and microbiology classes. The inclusion criteria were KCMUCo first- and second-year medical students from 2011-2016 in biochemistry, anatomy, physiology, biochemistry, community health, pharmacology, parasitology, and microbiology classes who had access to LCMS+ which was authorized by KCMUCo, and completed the entire first- or second-years of medical school. 6 students, who dropped out during the academic year or did not receive a grade in a course, were excluded. 73 students, who did not have one of the sociodemographic variables, including Form 6 score, birthdate, sex, or service history, were also excluded. The Form 6 exam, Advanced Certificate of Secondary Education Examination is the national standardized exam students must take before entering medical school. The exam had a maximum of 15 and encompassed the subjects: biology, chemistry, and physics.

2.3 Data Collection

Data was collected from three primary sources: LCMS+ website, academic records, and university student registry. All stages of data collection process were performed independently by Margaret Murray.

2.3.1 LCMS+ Website

The LCMS+ website is a site owned by KCMUCo and used explicitly for educational purposes. Each student and faculty member had a unique username and password for the site and could access the site on KCMUCo's wireless campus as well as off campus. Outside researchers on this study had to sign a consent form ensuring that data remain confidential and identifiable information not be shared, before they could access LCMS+ content. KCMUCo provided internet access that is protected by firewalls. Each course had a unique site and students could find the link for their courses site on the LCMS+ homepage. Faculty uploaded course materials onto the LCMS+ site during the academic year and the amount and type of material varied by year and by course. The materials that were available to students on LCMS+ were powerpoints, visual recordings, course outlines, Microsoft Word and pdf documents, assignments, and faculty member posts on the course discussion board. Microsoft Word and pdf documents were classified as readings. Microsoft powerpoint slide sets and visual recordings were recorded as powerpoints since there were so few courses that used visual recordings and visual recordings typically contained powerpoint presentations. Posts were announcements distributed on course discussion boards by faculty and students downloaded the posts in order to view it. Students could access these materials either under the course material or on their event calendar.

In order for faculty to upload a document to a course website, they had to follow a link on the course's homepage that took them to the course level documents control site. Faculty and staff could view the names of the students who have downloaded the materials. The names of students who downloaded each document were recorded during the study and saved as excel files.

2.3.2 Academic Records

The final course grades of students were recorded in the academic records office at KCMUCo. Outside researchers on this study had to sign a consent form ensuring that data remained confidential before they could access content from the academic records. The final course grades were obtained and analyzed after the names of students who downloaded course materials were recorded. The grades were available in electronic copy and the names of the students were converted to match the spelling, order, and format of the names in LCMS+ files.

The Form 6 exam scores were also obtained from the academic records office and were stored on hard copy. They had to be transcribed into an electronic version by hand. The transcribed scores were double-checked by an outside source and the transcription of the Form 6 scores had less than a 10% error rate.

2.3.3 University Student Registry

The sociodemographic variables, including sex, age, and service history, were obtained from the university student registry. This registry could only be accessed by KCMUCo faculty and the data were stored electronically. Sex of the students was categorized as either male or female. Age was calculated from the student's birthdate as of the year the student was enrolled in the course (i.e. student born in 1990 and enrolled in 2011 was 21 years old at the time of the course).

2.3.4 Ethical Review Board

All study procedures were approved by the ethical review boards at the Tanzania National Institute of Medical Research, the KCMUCo Research Ethics Committee, and Duke University Medical School.

2.4 Measures

The primary measure was the frequency of downloaded material per student. Frequency of downloaded material per student was defined as the number of times a student downloaded material in a certain course. Available course materials that students could download were: powerpoints, readings, course outlines, assignments, and faculty posts on course discussion boards. All materials were treated equally throughout the research.The numbers of downloaded materials per student were calculated through several steps. Initially the names of students who downloaded powerpoints in a first-year course were recorded. Then the number of downloaded powerpoints was calculated for each student in that respective first-year course. The frequency of downloaded powerpoints for a student represented the number of times the student downloaded a powerpoint during the first-year course. The frequencies of downloaded powerpoints in each first-year couse were added together. The total frequency of downloaded powerpoints for one student represented the total number of powerpoints the student downloaded during their first-year. The frequencies of the other materials (readings, course outlines, assignments, and faculty posts on course discussion boards) were measured and summarized similarly. These calculations were done identically for both first- and second-year students.

2.5 Data Management

Data was collected and stored on a secure laptop computer. This laptop was encrypted through Wake Forest University School of Medicine and had password entry points prior to being able to access the data. During the data entry and analysis, the data were backed up on a one terabyte, encrypted external hard drive. In addition, the study and analysis data were backed up on a password-protected an online Box storage account that was protected by Duke University firewalls. Data entry occurred in a private, locked room at KCMUCo. Internet access occurred behind KCMUCo firewalls and Duke University's virtual private network.

2.6 Analysis

The frequencies of the various downloaded materials, such as readings, powerpoints, assignments, course outlines, and discussion board posts, were calculated against student name in each course. The frequencies of the different downloaded materials in a course were matched with final grade in that respective grade by student name. The frequencies of the different materials were summed together to generate total downloads in a course in a given year. Linear regression models were fit to assess the association between the total course downloads and the course grade. To analyze the association between sociodemographic variables and grade, the mean grade was calculated according to first sex and then service history per year.

A Wilcoxon rank sum was used to assess differences between sociodemographic variables and grade. Statistical significance was determined at p-values at <0.05. Data analysis for this study was generated using SAS software 9.4 [SAS Institute Inc. 2016. *SAS System for Windows, Fifth Edition*. Cary, NC, USA: SAS Institute Inc.] and Microsoft Excel 2010.

3. Results

From 2011-2016, 899 first-year students were enrolled at KCMUCo [Table 1]. Incoming first-year students had a mean age of approximately 22 years old. The majority of these incoming students were male and did not participate in service before medical school. From 2011-2016 the mean form 6 score increased from 6.26 to 10.54, suggesting that KCMUCo was enrolling medical students with higher scores on the national standardized exam. Also the percentage of class that was female increased from 2011-2016, signifying that more females were enrolling at KCMUCo.

Based on the inclusion of the first- and second-year medical students in those seven respective classes from 2011-2016, the sample size was 1,527 students and comprised of approximately 5,205 student-course-years. Each student was treated as a separate entity in each different course, in which they received a grade. From 2011-2016 the total number of first-year students was 899 and the total number of second-year students was 627. Since each first-year student completed three courses, each student received three distinct grades and downloaded materials for three different courses. Each second-year completed four courses, and therefore each student received four distinct grades and downloaded materials for four different courses. After totaling the number of students in each course in a year, 5,205 students per course per year was calculated.

Table 2: Basic sociodemographic variables of first-year medical students from 2011 to 2016.

Variable		2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	Sum
Age	N	113	138	147	131	269	798
	Mean	23.23	21.47	21.14	21.50	22.94	22.16
	Std Dev	4.65	3.19	2.32	3.40	3.07	3.40
	Min.	18	17	19	18.00	20.00	17.00
	Max.	37	35	33	36.00	46.00	46.00
	Missing	32	18	10	38	3	101
Form 6 score (0-15)	N	144	152	142	151	253	842
	Mean	6.26	6.58	6.57	9.51	10.54	8.24
	Std Dev	2.1	1.64	1.71	1.90	3.16	2.99
	Min.	2	2	0	2.50	0	0
	Max.	14	15	14	13.00	15.00	15.00
	Missing	1	4	15	18	19	57
Sex (Missing=16)							
Male	N	87	103	101	85	160	536
	Percent (%)	67.44	70.07	67.33	55.92	58.82	63.06
Female	N	42	44	49	67	112	314
	Percent (%)	32.56	29.93	32.67	44.08	41.18	36.94
	Missing	16	9	7	17	0	49
Service History (Missing=16)							
No	N	111	137	147	143	259	797
	Percent (%)	86.05	93.20	98.00	94.08	95.22	93.76
Yes	N	18	10	3	9	13	53
	Percent	13.95	6.80	2.00	5.92	4.78	6.24
	Missing	16	9	7	17	0	49
Total Students		145	156	157	169	272	899

3.1 Distribution of the Grades

The mean grade in both first and second-year cohorts decreased from 2011-2016 [Table 2]. The distributions of the grades were approximately normal between 2011 and 2014 but the distribution of the grades began to shift to the left between 2014-2016 [Figure 2]. The left shift of the grade distribution between 2014 and 2016 might explain the decrease in mean grade from 2011-2016, suggesting the presence of the outlier grades in the 2014, 2015, and 2016 grade distributions.

Table 2: Mean Grades of the first and second-year grade distributions between 2011 and 2016.

	MD1					**MD2**				
	N	**Mean**	**Std Dev**	**Min.**	**Max.**	**N**	**Mean**	**Std Dev**	**Min.**	**Max.**
2011	438	64.534	6.370	48.000	81.000	[redacted]				
2012	469	60.094	6.605	41.000	81.000	596	67.159	7.404	41.000	85.000
2013	480	61.583	6.4963	45.000	80.000	624	67.227	8.251	31.000	89.000
2014	537	60.355	9.8129	0	83.883	612	63.009	8.072	41.500	80.500
2015	544	57.696	7.3661	0	78.916	696	62.248	8.706	42.417	85.000

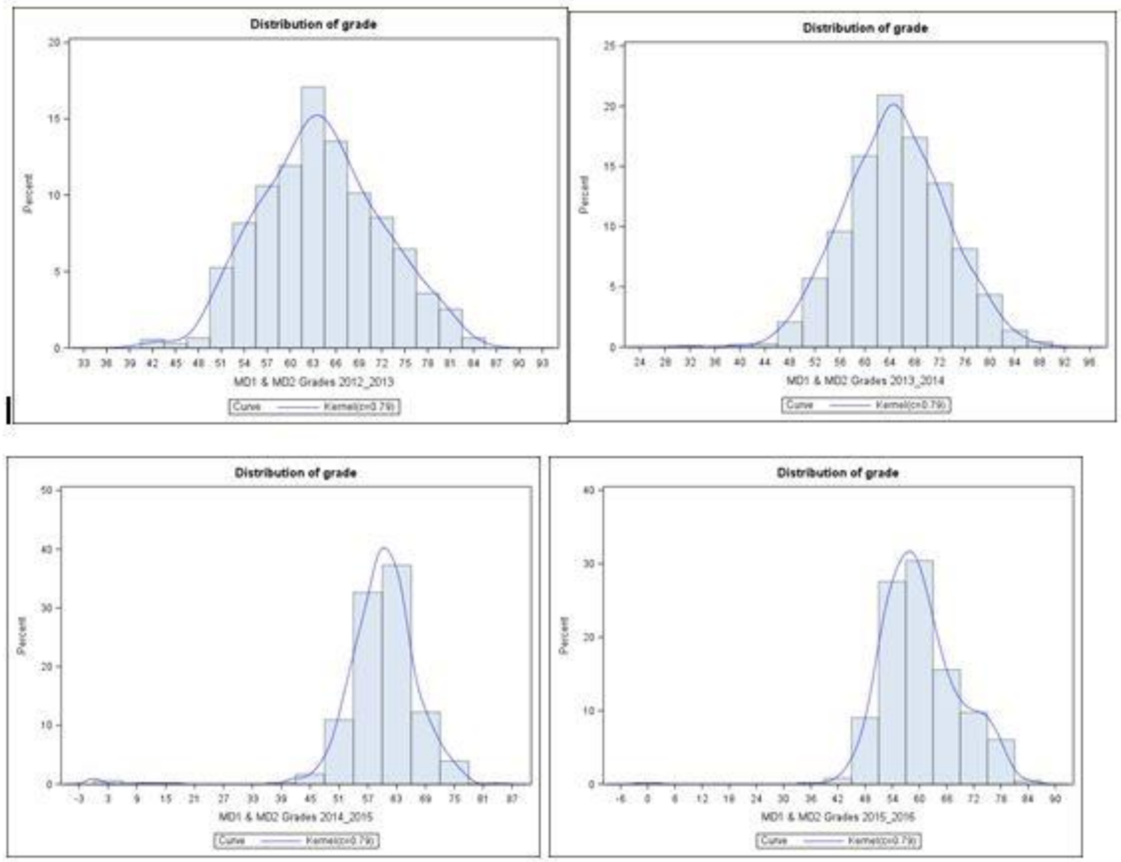

Figure 2: Distribution of combined first and second-year grades from 2011-2016.

3.2 Association between Downloads and Grade

3.2.1 Association between Downloads and Grade by Type of Downloaded Materials

The linear regressions between the different types of downloaded materials (i.e. powerpoints, assignments, readings, outlines, and posts) and final grade from 2011-2016 did not signify a strong direct association [Figure 3]. The regression coefficients ranged from 195E-7 to 0.0552, suggesting no strong association between all of the different downloaded material types and final grade in the total first and second-years from 2011-

2016 [Table 3]. Outlines had the highest regression coefficients in both the first and second-years.

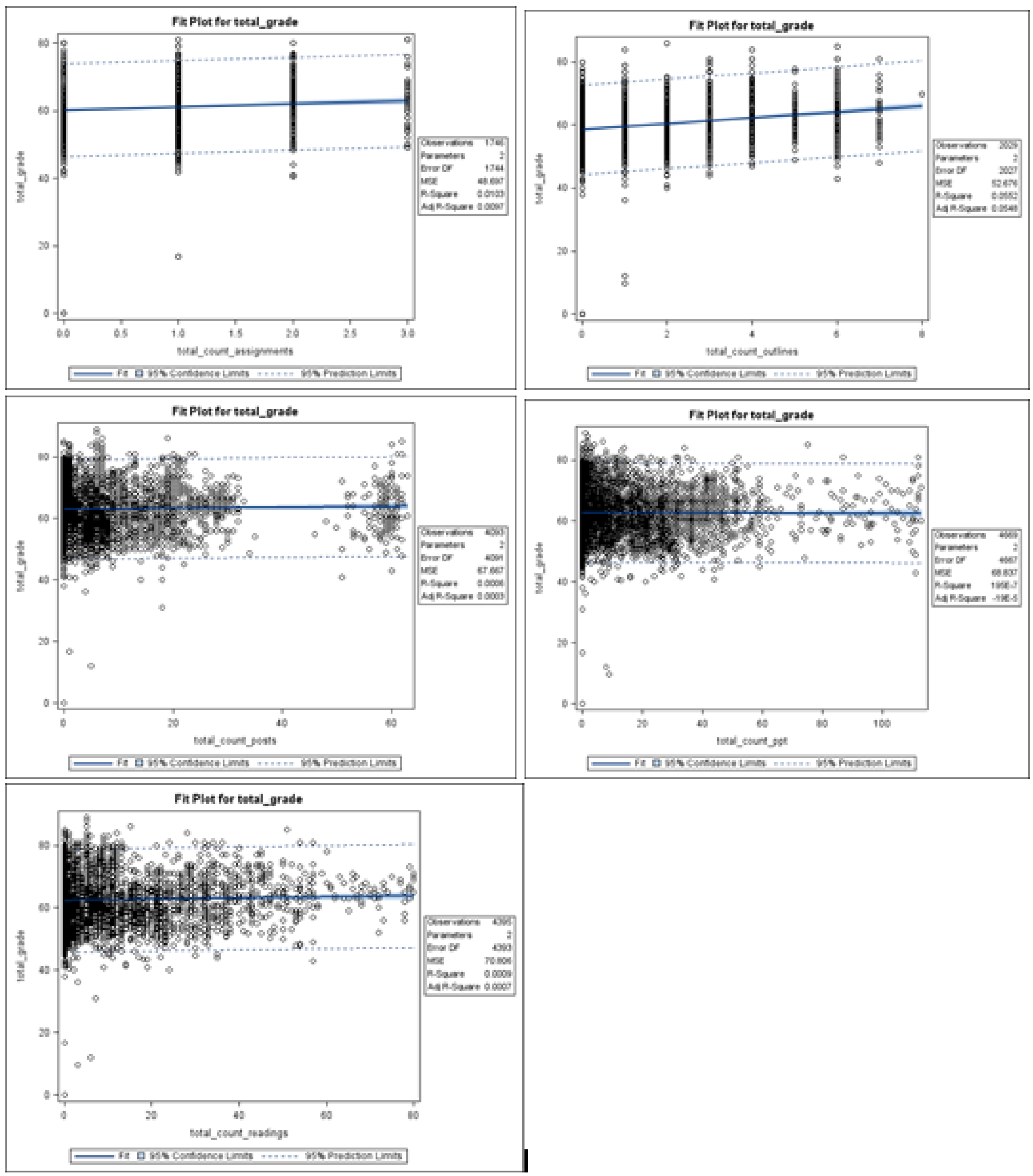

Figure 3: Linear regressions of the types of downloaded materials and grade from 2011 to 2016 in the first and second-years. From top left to right: Assignments, Outlines, Posts, Powerpoints, and Readings.

Table 3: Regression coefficients of the types of downloaded materials and grade from 2011 to 2016.

	Assignments	Outlines	Powerpoints	Readings	Posts
1st year	0.016	0.037	0.0069	0.00090	0.0096
2nd year	0.0025	0.079	0.028	0.0033	0.0042
Total	0.010	0.055	19E-7	0.00090	0.00060

3.2.2 Association between Downloads and Grade by Year

The linear regressions between the total downloads and final grade per year in first and second-year classes did not signify a strong direct association [Figure 4]. The total regression coefficients ranged from 0.00020 to 0.014, suggesting a weak association between downloads and final grade in both first and second-years each year. [Table 4]. In both the first and second-years the association between downloads and final grades also suggested a weak association. Between the first and second-years there was no agreement on year with the highest association of downloads and grade.

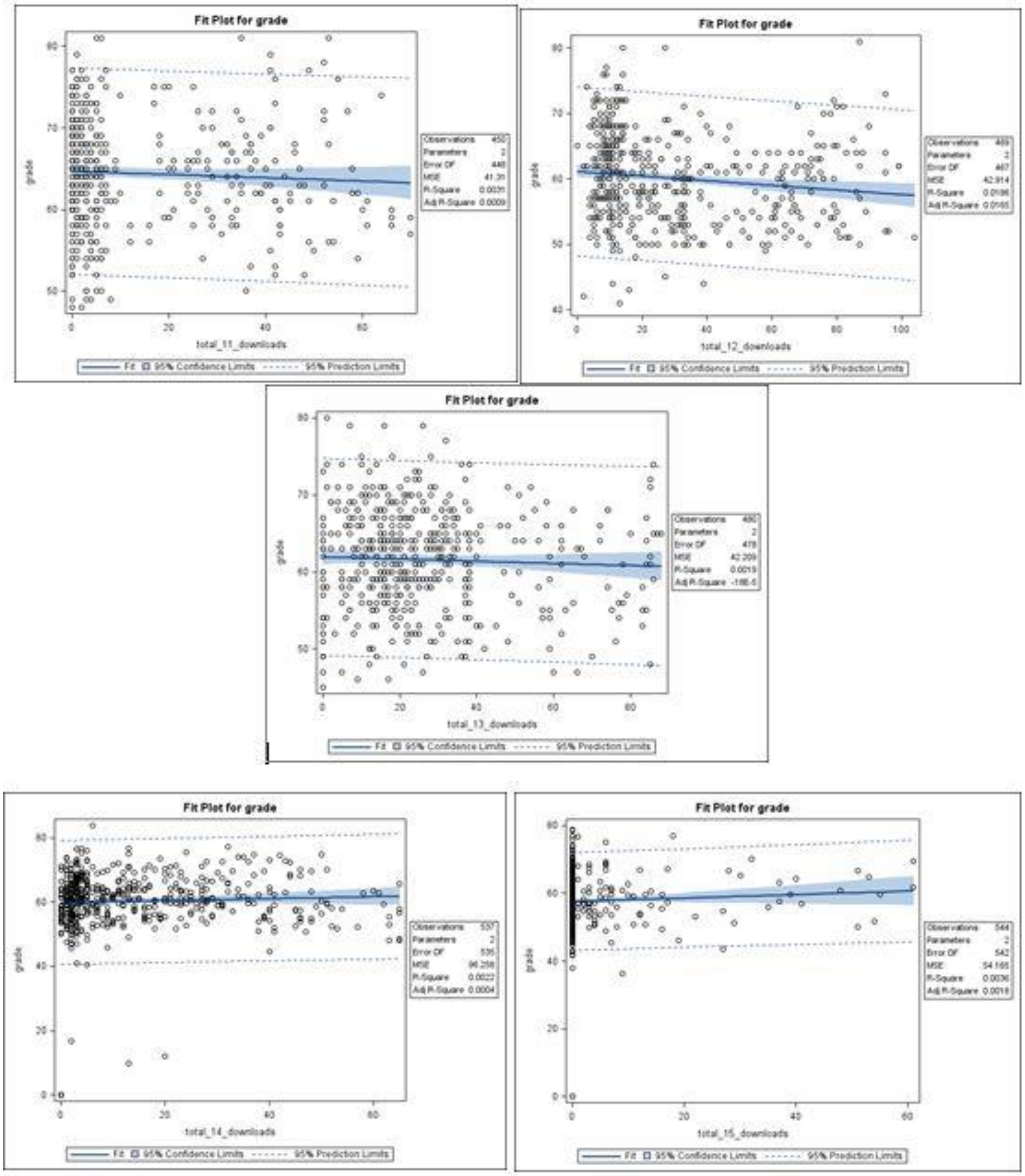

Figure 4: Linear regressions of the total downloaded materials and grade from 2011 to 2016 in the first and second-years.

Table 4: Regression coefficients of the total downloaded materials and grade from 2011 to 2016 in the first and second-years.

	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2011-2016
1st year	0.0031	0.019	0.0019	0.0022	0.0036	
2nd year		0.17	0.080	0.0018	0.17	
Total		0.018	0.01	0.00020	0.014	0.0011

3.3 Association between Grade and Sociodemographic Variables

Age was weakly associated with grade, although in 2012 grades decreased as students got older [Figure 5]. Age was not associated with downloads per year, as demonstrated by the regression coefficients [Table 5]. Aggregating the data together over the years, the younger students appeared to download more than older students; however, the difference in downloads between younger and older students was small [Figure 6]. Males and students who did not serve had higher grades than females and students who served [Table 6]. Males received higher grades than females four out of the five years, and males accounted for the majority of first-year class. The difference between grades of first-year males and females from 2011-2015 was significant, with a p value of 0.0023. First-year students, who did not serve, received higher final grades than students who served except for the 2015 to 2016. However, the difference between the total first-year students who did not serve and those students who did serve was not significant, with a p value of 0.206.

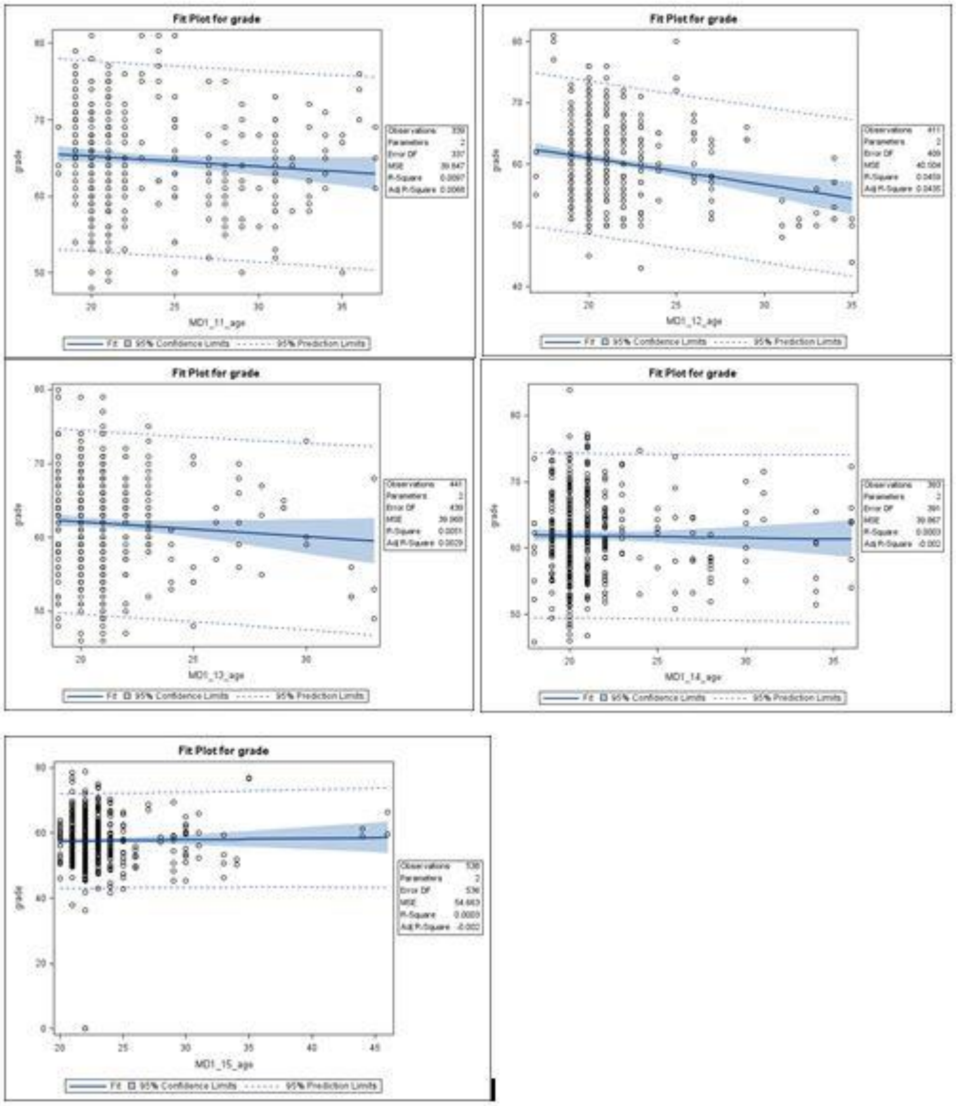

Figure 5: Linear regressions of the age and grade from 2011 to 2016 in first-year students.

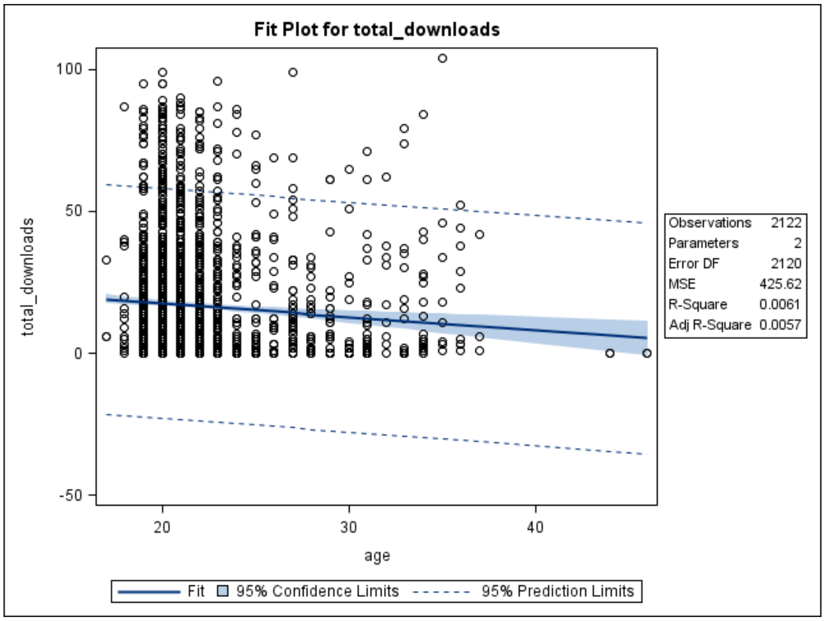

Figure 6: Linear regression of the age and total downloads from 2011 to 2016 in first-year students.

Table 5: Regression coefficients of associations between (1) age and grade and (2) age and downloads from 2011-2016.

	2011-2012	**2012-2013**	**2013-2014**	**2014-2015**	**2015-2016**
Grade	0.0097	0.0460	0.0029	0.0003	0.0003
Downloads	5.10E-8	0.0015	0.0001	0.0028	0.0004

Table 6: Academic performance of first-year students by (1) sex and (2) service history from 2011 to 2016.

			Grade					
			2011-2012	**2012-2013**	**2013-2014**	**2014-2015**	**2015-2016**	**Total**
Sex	Male	N	261	305	303	225	320	1444
		Mean	64.75	60.24	61.97	61.96	58.10	61.25
		Std Dev	6.23	6.16	6.03	6.09	8.35	7.03
	Female	N	126	132	147	201	224	830
		Mean	64.37	60.59	61.61	61.46	57.12	60.62
		Std Dev	6.44	7.07	6.85	6.72	5.63	6.90
Service History	No Service	N	333	408	441	429	518	2129
		Mean	64.86	60.59	61.89	61.82	57.66	61.06
		Std Dev	6.30	6.41	6.313	6.44	7.36	7.01
	Service	N	54	29	9	27	26	145
		Mean	63.19	57	58.89	60.45	58.42	60.37
		Std Dev	6.13	6.07	5.88	5.22	7.55	6.61

3.3.1 Association between Total Downloads and Sociodemographic Variables

Total downloads differed between sexes and employment history from 2011-2105 in first-year students. Males downloaded an average of 17.89 documents in comparison to females who downloaded 14.18 documents. This difference in number of downloads between males and females was significant, with a p value of <0.0001. Additionally, students who did not serve downloaded 15.84 documents and those who served downloaded 16.58 documents. The difference in the number of downloads between those students who served and did not serve was not significant, with a p value of 0.4155.

Males in the first-year classes from 2011-2015 were older with an average age of 22.57 years old in comparison to females who were 21.19 years old on average. Also students, who served, had a mean age of 29.93 years old, in comparison to students, who did not serve, whose mean age was 21.51 years old.

4. Discussion

4.1 Association between Downloads and Grades

The different types of downloaded materials (i.e. powerpoints, assignments, readings, outlines, and posts) and final grade from 2011-2016 were not associated with each other. The association between final grade and downloaded assignments had a regression coefficient of 0.010, whereas the association between final grade and downloaded outlines had a regression coefficient of 0.055. There was no association between grade and downloaded powerpoints with a regression coefficient of 19E-7. There was no association between final grade and downloaded readings and posts, with regression coefficients of 0.00090 and 0.00060 respectively. Based on the extremely low regression coefficients of the associations between all of the different types of materials and grade, there proved to be no relationship between the downloaded materials and grade.

Initially this suggests that the type of materials that students downloaded had no association with their grade, but the findings might be a result of the distribution of the data. For example, a large number of students downloaded zero or less than twenty materials during the academic year, whereas some students downloaded close to sixty materials. This skewed distribution towards the null suggests that students were not using the majority of the available materials on LCMS+ or that faculty were not using

LCMS+ effectively to teach students. Also the faculty decided the amount and types of materials to upload onto LCMS+. The majority of faculty provided powerpoints, readings, and discussion board posts on LCMS+, suggesting that powerpoints and readings were the primary materials used to teach students. However, many of these students did not grow up with access to computers or e-learning systems at school; and perhaps the null association between grade and downloads was due to the student's inexperience with technology in an educational setting.

There was no association between total downloads and grade each year, as evidenced by the null slopes of each regression [Figure 3]. Furthermore the association between the total downloads and final grades summed from 2011-2016 had a regression coefficient of 0.0011.

The null association might be due to the large distribution of students who did not download materials, as evidenced by the cluster of students with less than 10 downloads each year. Another reason for the lack of an association might be that faculty were uploading materials that were identical in content to didactic teachings. Several studies in Tanzania have found that faculty at higher-learning-institutions have been resistant to adoption of e-learning systems due to a perception that e-learning systems are an additional workload, lack of computer knowledge, and fear of adopting new technologies (31, 32). Another reason for the null association between grade and total downloads might be that students were unaccustomed to technology in an educational setting. However, students at higher learning institutions believe that electronic learning is useful and will help them learn materials more efficiently (33). These uncertainties call for more analysis of the data and other studies looking at the effects of e-learning systems on student academic performance.

4.2 Distribution of Grades

The distributions of the grades from 2011 to 2016 in both the first and second-years were normally distributed except for 2014-2016. The left deviation of the grades in the later years might have been due to a change in grading with 0 as the minimum scores in both 2014 and 2015. Students who received a 0 had to retake the course the following year and pass it in order to proceed. Future studies could be conducted to look at the LCMS+ activity of the students who received a 0 in a class. Then based on those students' LCMS+ activity, faculty would be able to predict which students are in danger of failing a class in the future.

4.3 Association between Grades, Downloads and Sociodemographic Variables

The association between age and downloads was weakly associated since most of the graphs shows a null slope between the two variables. This finding might have been due to the concentration of younger students in each class. The range of grade within the younger students makes it difficult to parse out an association between age and grade.

Male students who had not served had higher grades on average in comparison to female students and students who had served. These observations likely were due to the fact that the majority of students in the study were male (63.06%) and had not served (93.76%). The discrepancy between number of male and female students is an example of how women are underrepresented in the scientific professions (34). Also female students had 14.18 downloads on average in comparison to male students who averaged 17.89 downloads. Studies have demonstrated that female students less experience with e-learning systems (35). Also students who served were older (29.93 years old) in comparison to students who did not serve (21.51 years old). Those students who served might have been less familiar with technology as their primary means of learning, as evidenced by their lower download frequency (15.84) in comparison to the download frequency of students who did not serve (16.58).

4.4 Limitations

Some of the limitations of this study were that grades could measure a student's ability but not their understanding or retention of LCMS+ materials. We did not know how much students used and understood the materials once they downloaded them. We also do not know when or where the students downloaded the materials. Another limitation is that we do not know how the students utilized the materials. We also did not evaluate if students or professors viewed LCMS+ positively or negatively. However, Killewo, et al. found that faculty and students were supportive of LCMS+ use for online testing in 2012 (17). This study also found that 50% of faculty feared adapting to LCMS+, 40% of them did not believe that the system could work at KCMUCo, and only 10% of faculty were eager to learn about the new systemin 2012 (ibid). This judgment might have influenced their use of LCMS+.

We did not know if the LCMS+ material reflected the information that was emphasized and delivered by the professor during a class. We did not know whether faculty made the tests and if those tests were changed on an annual basis to reflect the current LCMS+ material that year. Also we did not know how the final course grade was calculated each year, who determined the final grade, and which factors influenced the grades. For some classes professors did not provide any materials on the LCMS+ website. This absence of materials might have deterred students from seeking other materials. Student's socioeconomic background might have influenced their Form 6 score or final grade because students from wealthier backgrounds could afford access to outside educational materials, such as tutoring or private textbooks.

Although students were granted access to tablets from the school, it was unknown whether all students had access to an electronic platform with internet access to download these materials off campus. The power went off occasionally in the school and area; and even though the school had backup generators that turn on when the power goes off, these generators might have not been working. Another limitation was the lack of internet outside of campus, which could affect the student's ability to download when away from campus.

Limitations pertaining to the methods of the study were that the data for the Form 6 score was entered manually and an error in transcription from hard to electronic version might have occurred. Data from some of the sociodemographic variables, such as Form 6 score, service history, and sex, were missing. Also the records of the students who downloaded each material from LCMS+ were transferred to excel storage files by one study member and an error might have occurred during that transfer process.

4.4 Implications for Future Policy in Medical Education

Since e-learning systems offer a way to educate a large number of students with a small number of faculty and unlimited access to resources, they offer a way to provide medical education effectively and cost-efficiently. Hower the installation of these e-learning systems is expensive and many schools do not have the money to afford them. Since African countries, like Tanzania, lose revenue due to the emigration of African physicians, policymakers might consider implementing the use of e-learning systems in medical schools, in order to educate students less expensively with fewer faculty.

However, first medical schools must study how to most effectively use e-learning systems to advance the student's academic understanding and performance. Additionally, the incomplete and inadequate internet coverage limits medical student usage of e-learning systems in countries like Tanzania. Internet coverage must increase in the region before e-learning systems can be effective outside of a wireless classroom setting. More research is necessary to understand how large of an impact e-learning systems can have on medical education.

4.5 Implications for Future Research

The lack of an association between downloads and grade should not deter future research at KCMUCo or the field. We might not be correctly analyzing how these e-learning systems are impacting student academic performance. Within this KCMUCo study the next step could be to analyze the datasets, which are heavily weighted towards the null, in a different way. One analysis approach could be to perform log transformations of the data, which would spread out the distributions of the data, to see if there was a stronger association between grade and downloads.

E-learning systems are just beginning to appear in schools in LMIC. Since they could offer greater access to course materials to more students, they stand to be a vital tool in delivery of medical education. Usage defined as downloaded materials is just one way to analyze how students use an e-learning system. The definition of use depends on the e-learning platform and what measures it is able to track, such as number of site visits, number of downloads, number of posts, etc. Each measure or a combination of variables could be analyzed to see which one is most directly associated with grade. The goal of future research on e-learning systems in medical education should be to benefit the next generation of providers.

5. Conclusions

In conclusion this study analyzed the association between the total downloaded materials and the final grade of first and second-year medical students at KCMUCo in Moshi, Tanzania. Based on the initial analysis, the association between downloaded materials and grade was null or weak. Therefore a different analytical approach may be necessary to better understand how LCMS+ can impact the student's academic performance.

E-learning systems are beginning to emerge at professional schools in LMIC. They are capable of delivering educational materials to a greater number of students, which is important in countries where there is an emphasis on training more providers. More research is necessary to discover the best way to incorporate e-learning systems into the medical curriculum because they have the potential to impact future generations of providers.

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