# USING LEARNING ANALYTICS TO PREDICT STUDENTS' PERFORMANCE IN MOODLE LEARNING MANAGEMENT SYSTEM: A CASE OF MBEYA UNIVERSITY OF SCIENCE AND TECHNOLOGY

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**ABSTRACT**

The past decade has seen the rapid adoption and use of various Learning Management Systems (LMS) in Africa, and Tanzania in particular. Institutions have been spending thousands of dollars to implement these systems in a bid to improve the quality of education as well as increasing students' enrolments through distance and blended learning. However, the impact of these system on improving students' performance has been a popular subject of research in recent years. Studies have been relying on data from users' opinions and subjective interpretation through surveys to determine the effectiveness of LMS usage on students' learning performance. The use of such data is normally subject to the possibility of distortion or low reliability. Therefore, this study designed and developed Learning Analytics tool and used the tool to determine the causation between LMS usage and students' performance. Data from LMS log of two courses delivered at Mbeya University of Science and Technology (MUST) were extracted using developed Learning Analytics tool and subjected into linear regression analysis with students' final results. The study found that discussion posts, peer interaction, and exercises were determined to be significant factors for students' academic achievement in blended learning at MUST. Nonetheless, time spend in the LMS, number of downloads, and login frequency were found to have no significant impact on students' learning performance. The implications of these results on improving students' learning are discussed.

**Keywords**

Learning analytics, Educational Technology, LMS, Higher education, eLearning.

## 1. INTRODUCTION

The past decade has seen the rapid adoption and use of various Learning Management Systems (LMS) in higher education in Africa. The LMS are web-based systems that facilitate teaching and learning via the Internet with tools that provide interaction between students and their instructors. They also have tools that allow instructors to share learning resources with students. Some of the popular LMS in the market are LMS include Sakai, Moodle, and Atutor, and Chisimba (Unwin et al., 2010).

Many institutions tend to adopt and use these systems to improve the quality of on-campus delivery by complementing traditional face-to-face with LMS (Ssekakubo et al., 2011; Unwin et al., 2010). Other institutions use these systems to meet the growing students' population through distance and blended learning (Unwin et al., 2010). Given these advantages, the number of LMS that has been adopted by institutions in Africa, and Tanzania in particular has been increasing.

As of 2011, almost 80% of institutions had installed LMS with Modular Object-Oriented Dynamic Learning Environment (Moodle) being the most popular (Munguatosha et al., 2011). It was also revealed that half of 11 surveyed institutions had installed various LMS (Mtebe & Raisamo, 2014). This is also evident from data obtained from Moodle

website that showed 47 Moodle sites were of institutions from Tanzania (Moodle LMS sites, 2015).

Despite the continued adoption and use of various LMS throughout higher education, there is little evidence to suggest that they are actually improving students' learning performance (Phillips et al., 2011). Apparently, many studies have used data from users' perceptions and subjective interpretation through surveys to investigate the effectiveness of these system in Africa (e.g. Lwoga, 2012, 2014; Ssekakubo et al., 2011; Unwin et al., 2010). Nonetheless, the use of such data is normally subject to the possibility of distortion or low reliability (Jo et al., 2014). Moreover, data obtained from students' perceptions through surveys may not provide accurate indicators of learning as they rarely indicate the causality of effects (Phillips et al., 2011).

Ultimately this points to the need for more sophisticated methods of evaluating the effectiveness of LMS that is non-intrusive and requires no instructors' intervention. New analytical methodologies, particularly Learning Analytics, have made fulfilling this requirement possible. Since most of learners activities take place in the LMS, Learning Analytics tools can potentially utilize log data to provide crucial information on how learning processes occur throughout the login duration (Jo et al., 2014). Consequently, they can provide institutions informed decisions about possible problems related to students' learning (Kotsiantis et al., 2013; Phillips et al., 2011). Compared with subjective methods such as surveys and questionnaires, Learning Analytics can capture learners' authentic interactions in real time.

Despite these great potential benefits of Learning Analytics, there has been no reliable evidence to suggest that institutions in Tanzania have been utilizing them in a bid to improve students' performance. Although some LMS have students tracking capabilities, the majority of them are generic and they do not provide the depth of extraction and aggregation that is required for various contexts (Ferguson, 2012). To address this, this study developed Learning Analytics tool that enables instructors to examine students' activities in Moodle through utilizing data from the system log.

The developed Learning Analytics tool was used to analyze data from the Moodle LMS at Mbeya University of Science and Technology (MUST) with 2 courses Applied Biology I and Services and Installation II. The courses were offered to 171 students via blended mode in the academic year 2014/2015. This tool will enable them to track how learners use the systems in order to find strategies that will ensure that learners use these LMS features more effectively. The study had the following objectives:

i) To establish requirements of designing and developing Learning analytic tool based on strength and weakness of analyze existing Learning analytic tools.

ii) To design and implement the LA tool based on features established in (i).

iii) To use the developed Learning Analytic tool to analyze students' activities on various features of selected courses in Moodle system at MUST.

iv) To determine the causal relationship between students' activities in Moodle and final students' results.

## 2. LITERATURE REVIEW AND RELATED WORKS

The concept of Learning Analytics has been making headlines for some years now, bringing a lot of interest amongst higher leaning institutions worldwide. Adopting online or blended mode of delivery implies that most of learners' activities will be taking place in LMS (Jo et

al., 2014). Therefore, there is a need for institutions to measure the quality and intensity of LMS usage. In fact, studies have shown that there is a correlation between LMS usage with students' performance (Filippidi et al., 2010; Jo et al., 2014; Macfadyen & Dawson, 2010; Whitmer, 2012) as well as students' satisfaction with courses offered via LMS (Naveh et al., 2012).

It should be noted that, LMS accumulate vast amounts of data on student behavior that can be used to inform and improve student engagement in LMS (Beer et al., 2010). These information include users visits, number of downloads, LMS tools accessed, messages read or posted, and content pages visited (Macfadyen & Dawson, 2010). According to Whitmer (2012), such information explain over four times the variation in final grades compared to traditional student characteristic variables, and that combining both types of variables increase the quality of predicting learning performance by more than 70%.

Therefore, through analyzing LMS usage via log data we can understand status of students' learning and even predict their possible learning achievement (Yu & Jo, 2014). In this case, we can identify struggling students in need of academic support (Macfadyen & Dawson, 2010). We can also use Learning Analytics tools to assess the quality of online postings (Nistor et al., 2015) and visualize usage behaviors in the system (Scheffel et al., 2011).

Given the benefits and opportunities offered by log data stored in LMS database, studies have developed various Learning Analytics tools to analyze such data. For instance, Yu and Jo (2014) studied factors influence students' academic achievement using log data collected from Moodle with 84 students in a university in South Korea. They found that total studying time, interaction with peers, regularity of learning interval, and number of downloads had significant effect on students' academic perfomance in online learning environment.

Jo et al. (2014) identified "candidates for proxy variables" from the log data set that could be used as factors to determine students' performances in courses offered via Moodle. The authors used the identified variables to pilot them in commercial eLearning course with a total of 200 students. It was revealed that an (ir)regularity of the learning interval showed to have correlation with learning performance.

Kotsiantis et al. (2013) used Learning Analytics tool called Moodle Parser to collect data from logs and to identify successful learners in blended learning course through students activities in Moodle. The study found that students' failures were associated with their negative attitudes and perceptions towards Moodle. On the other hand, excellent grades were associated with increased Moodle usage. The study was based on 337 students enrolled in a blended course over three years using Moodle at the University of Patras, Greece.

Mödritscher and colleagues studied relationship between LMS usage patterns and students performance using data from system log. The authors revealed that, topic views had positive influence on students' performance. They also concluded that at-risk students could be differentiated from well- performing students by their usage behavior.

Finally, a study conducted at Central Queensland University using a sample of 92,799 students, reported a statistic significant correlation between the number of page views and students final grades (Beer et al., 2010). In other words, the more 'views' or visits to the course, the higher the final grades.

These few studies and many others show that Learning Analytics tools have shown to enable institutions to analyze students' activities and eventually helping in finding strategies of helping those who are at risk. In the same way, this study developed Learning Analytics

tool that enables instructors to examine students' activities in Moodle through utilizing data from the system log.

## 3. Design and Development of Learning Analytics Tool

The design and development of the Learning Analytics tool involved gathering requirements from those who were managing the system at MUST. These included systems administrators and some instructors who were already using the system. In addition, interviews were conducted to registered students to gain an understanding how they use the system.

The variables used as input the development of the Learning Analytics tool were solicited from previous research such as in (Jo et al., 2014; Kotsiantis et al., 2013; Mödritscher et al., 2013; Yu & Jo, 2014). These variables are shown in Table 1.

Table 1: Variables used in the designing and development of Learning Analytics tool.

| No. | Variables | Description | Source |
|---|---|---|---|
| 1. | Total login frequency in LMS | Adding up the number of individual student's login time into the LMS | (Mödritscher et al., 2013; Yu & Jo, 2014) |
| 2. | Time spent in the system | Calculating the total amount of time spent between login and logout | (Davies & Graff, 2005; Mödritscher et al., 2013; Yu & Jo, 2014) |
| 3. | Number of downloads | Adding up the numbers of course materials downloaded | (Yu & Jo, 2014) |
| 4. | Interactions with peers | Counting the total number of student's postings responding to peers | (Mödritscher et al., 2013; Yu & Jo, 2014) |
| 5. | Number of exercise performed | Counting number of exercise a student has done | (Yu & Jo, 2014) |
| 6. | Number of forum posts | Counting a number of posts a student has contributed in the discussion forums | (Davies & Graff, 2005; Kotsiantis et al., 2013; Yu & Jo, 2014) |

With variables in Table 1, the Learning Analytics tool was linked with the LMS database so that real time information can be generated. The user interface was designed so that user can run the system with minimal computer knowledge. In addition, to allow the system to be accessed anywhere, a web based interface was designed. The screenshot of the system is shown in Figure 1.

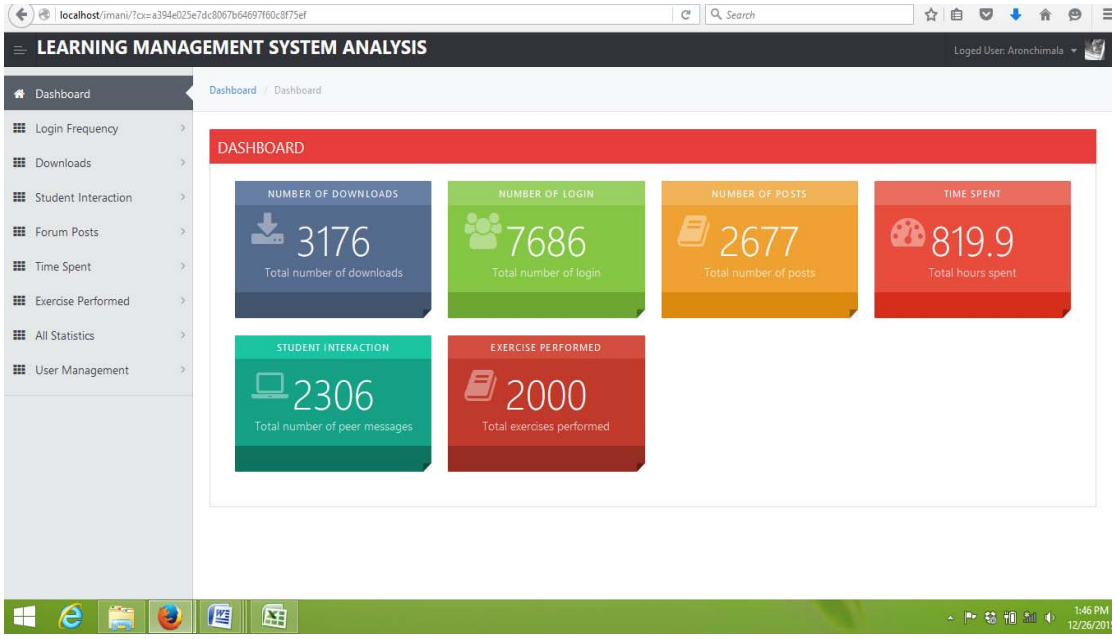


Figure 1: Screenshot of the system showing extracted data

The Learning Analytics tool database was automatically updated with information from Moodle logs and forum when students' interacted with the system. Figure 2 shows the sample of number of downloads extracted from the developed Learning Analytics tool.

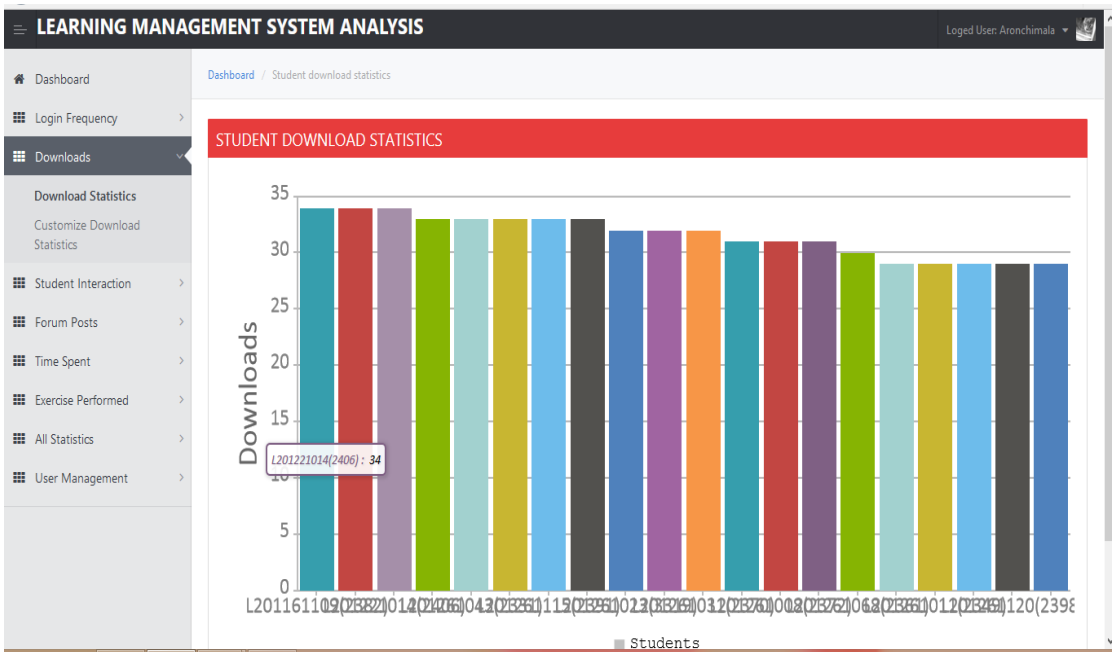


Figure 2: Sample of number of downloads extracted from the developed Learning Analytics tool.

## 4. METHODOLOGY

The research was based on quantitative research design with data gathered from LMS log using the developed Learning Analytics tool. The variables used in the developed Learning Analytics tool included the number of downloads, number of forum posts, number of peer interactions, the time spent in the system, the number of logins performed, and number of exercises performed by students. The study used the data obtained from the Learning

Analytics tool to compare with students scores in the final exam through linear regression analysis. The aim was to determine if there was any causal relationship between students' activities in the Moodle and final students' final grade.

A total of 111 NTA 6 students taking Applied Biology I, and 60 NTA 7 students taking Services and Installation II course in the academic year 2014/2015 participated in the study. The variables from LMS log was subjected to linear regression with final scores of exams of the same academic year. These students were enrolled in two courses offered via Moodle LMS in blended mode of delivery at MUST. The data collection was undertaken between November to December 2015. The data was analyzed using Statistical Packages for Social Science (SPSS) version 20.

## 5. FINDINGS

The regression analysis was conducted separately for each course. Before conducting regression analysis, multicollinearity test and Pearson correlation were conducted.

### 5.1 Multicollinearity Test

Multicollinearity refers to when variables are measuring the same thing, meaning that those variable are highly correlated. The presence of multicollinearity shows that 'R' which is correlation coefficient, is a joint influence and hence prevents to perform multiple linear regressions. A tolerance error of less than 0.2 or 0.1 and/ or VIF (Variance Inflation Factor) of 5 or 10 and above indicates the presence of multicollinearity problem among the factors (Tabachnick & Fidell, 2007). Table 2 shows the tolerance value that is above 0.2 and VIF value of less than 5 indicating the absence of joint influence (multicollinearity). The absence of multicollinearity justifies the performance of multiple linear regressions.

Table 2: Multicollinearity Statistics Test

| Model | Downloads | Exercises | Peer interaction | Forum posts | Time spent | Login frequency |
|---|---|---|---|---|---|---|
| Tolerance | 0.693 | 0.550 | 0.233 | 0.208 | 0.788 | 0.720 |
| VIF | 1.44 | 1.817 | 4.290 | 4.798 | 1.270 | 1.388 |

### 5.2 Pearson Correlation

The following were the Pearson correlation test for independent and dependent variables as shown in table 3. The independent variables used were DOWNLOADS, EXERCISES, PEERINTERACTIONS, FORUM_POSTS, TIME_SPENT and LOGIN_FREQUENCY while the dependent variable used was SCORE

Table 3: Pearson Correlation

| | | DOWNLOADS | EXERCISES | PEER INTERACTION | FORUM_POSTS | TIME_SPENT | LOGIN_FREQUENCY | SCORE |
|---|---|---|---|---|---|---|---|---|
| DOWNLOADS | Pearson Correlation | 1 | .491 | .436 | .437 | .200 | .054 | .466 |
| | Sig. (2-tailed) | | .000 | .000 | .000 | .035 | .576 | .000 |
| | N | 111 | 111 | 111 | 111 | 111 | 111 | 111 |
| EXERCISES | Pearson Correlation | .491 | 1 | .518 | .585 | .059 | -.046 | .606 |
| | Sig. (2-tailed) | .000 | | .000 | .000 | .539 | .635 | .000 |
| | N | 111 | 111 | 111 | 111 | 111 | 111 | 111 |
| PEER INTERACTION | Pearson Correlation | .436 | .518 | 1 | .873 | .203 | .277 | .896 |
| | Sig. (2-tailed) | .000 | .000 | | .000 | .032 | .003 | .000 |
| | N | 111 | 111 | 111 | 111 | 111 | 111 | 111 |
| FORUM_POSTS | Pearson Correlation | .437 | .585 | .873 | 1 | .191 | .278 | .972 |
| | Sig. (2-tailed) | .000 | .000 | .000 | | .045 | .003 | .000 |
| | N | 111 | 111 | 111 | 111 | 111 | 111 | 111 |
| TIME_SPENT | Pearson Correlation | .200 | .059 | .203 | .191 | 1 | .424 | .178 |
| | Sig. (2-tailed) | .035 | .539 | .032 | .045 | | .000 | .062 |
| | N | 111 | 111 | 111 | 111 | 111 | 111 | 111 |
| LOGIN_FREQUENCY | Pearson Correlation | .054 | -.046 | .277 | .278 | .424 | 1 | .251 |
| | Sig. (2-tailed) | .576 | .635 | .003 | .003 | .000 | | .008 |
| | N | 111 | 111 | 111 | 111 | 111 | 111 | 111 |
| SCORE | Pearson Correlation | .466 | .606 | .896 | .972 | .178 | .251 | 1 |
| | Sig. (2-tailed) | .000 | .000 | .000 | .000 | .062 | .008 | |
| | N | 111 | 111 | 111 | 111 | 111 | 111 | 111 |

The association of independent and dependent variables is evident from the Table 3 as it shows that most of the values ranges from 0.4 to 0.7. This provides a room of performing regression analysis. Therefore, the data of each course was analyzed separately and are shown hereunder.

### 5.3 Regression Analysis for Applied Biology I

Six factors were subjected to linear regression analysis to measure the success of the model and predict causal relationship between factors and exam scores. The factors are downloads, number exercise, peer interaction, forum posts, time spent, and login frequency. Using enter method, a significant model emerged: $F(6,104)= 382.616$, $p<.0005$.

The model explains 95.4% of the variance (Adjusted R Square = 0.954) in the impact of LMS usage on the students' learning performance. Table 4 shows a summary of the research model.

Table 4: Regression Analysis Model Summary

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | df1 | df2 | Sig. F Change |
| 1 | .978[a] | .957 | .954 | 1.423 | .957 | 382.619 | 6 | 104 | .000 |

a. Predictors: (Constant), LOGIN_FREQUENCY, EXERCISES, TIME_SPENT, DOWNLOADS, PEER INTERACTION, FORUM_POSTS

Table 5 shows a summary of predictive factors in terms of beta values for each variable obtained from regression analysis. The results show that Peer Interaction (beta value = 19.6%), and Forum Posts (beta value = 77.1%) have shown to have positive significant effect on students' performance with forum post being the strongest predictor.

Table 5: Unstandardized and Standardized Regression Coefficients for the Constructs Entered in the Model

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Tolerance | VIF |
| 1 | (Constant) | 57.443 | 1.463 | | 39.264 | .000 | | |
| | DOWNLOADS | .026 | .025 | .026 | 1.065 | .289 | .693 | 1.442 |
| | EXERCISES | .052 | .036 | .040 | 1.455 | .149 | .550 | 1.817 |
| | PEER INTERACTION | .162 | .035 | .196 | 4.640 | .000 | .233 | 4.290 |
| | FORUM_POSTS | .525 | .030 | .771 | 17.251 | .000 | .208 | 4.798 |
| | TIME_SPENT | -.002 | .004 | -.012 | -.520 | .604 | .788 | 1.270 |
| | LOGIN_FREQUENCY | -.010 | .020 | -.012 | -.496 | .621 | .720 | 1.388 |

From Table 5, the regression analysis coefficients table which produces the following model *equation*:
SCORE=Y, DOWNLOADS=A, EXERCISES=B, PEERINTERACTIONS=C, FORUM_POSTS=D, TIME_SPENT=E and LOGIN_FREQUENCY=F

Y=0.196C+0.771D+57.443

### 5.4 Regression Analysis for Service and Installation IIT

The same the six variables namely downloads, number exercise, peer interaction, forum posts, time spent and login frequency were also subjected to linear regression analysis in the second course. Using enter method, a significant model also emerged: F(6,53)= 162.500, p<.0005. The model explains 94.3% of the variance (Adjusted R Square = 0.943) in the impact of LMS usage on the students' performance. Table 6 shows a summary of the research model.

Table 6: Regression Analysis Model Summary

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | df1 | df2 | Sig. F Change |
| 1 | .974[a] | .948 | .943 | 1.799 | .948 | 162.500 | 6 | 53 | .000 |

a. Predictors: (Constant), LOGIN_FREQUENCY, FORUM_POSTS, TIME_SPENT, DOWNLOADS, PEER INTERACTION, EXERCISES

Table 6 shows a summary of predictive factors in terms of beta values for each variable obtained from regression analysis. The results show that Forum Posts (beta value=48.5%), and Exercise (beta value=51.5%) have shown to have positive significant effect on students' performance.

Table 7: Unstandardized and Standardized Regression Coefficients for the Constructs Entered in the Model

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 8.622 | 2.027 | | 4.253 | .000 |
| | LOGIN_FREQUENCY | .015 | .020 | .024 | .770 | .445 |
| | TIME_SPENT | .004 | .006 | .024 | .747 | .458 |
| | FORUM_POSTS | 1.562 | .194 | .485 | 8.066 | .000 |
| | PEER INTERACTION | .127 | .142 | .039 | .896 | .374 |
| | EXERCISES | 5.026 | .544 | .515 | 9.233 | .000 |
| | DOWNLOADS | .029 | .069 | .015 | .426 | .672 |

a. Dependent Variable: SCORE

From Table 5, the regression analysis coefficients table which produces the following model *equation:* SCORE=Y, DOWNLOADS=A, EXERCISES=B, PEERINTERACTIONS=C, FORUM_POSTS=D, TIME_SPENT=E and LOGIN_FREQUENCY=F

Y=0.515B+0.485D+8.622

## 6. DISCUSSION

The present study was aimed to design and develop the Learning Analytics tool and use it determine the causation between LMS usage and students' learning performance. The study was conducted at MUST with two courses having a total of 171 students. Given the penetration and continue adoption of LMS throughout higher education in Tanzania, it was necessary to find out if these systems have impact on students' performance. Therefore, the use of Learning Analytics tool which extracts data from LMS database files provide a lot of information about students activities in the system and such information can be used to provide informed decisions about possible problems and suitable ways to address them more effectively (Kotsiantis et al., 2013).

In this study, variables were solicited from the literature that were used to design and develop the Learning Analytics tool. The developed tool was used to extract data from two courses namely Analysis for Applied Biology and Service and Installation IIT offered in blended mode at MUST in academic year 2004/2015. Data obtained from LMS usage via Learning Analytics tool was then subject to linear regression in order to determine the effect of LMS usage on students' performance.

Generally, this study found that Peer Interaction (beta value=19.6%), and Forum Posts (beta value=77.1%) had significant effect on students' performance on Applied Biology course while Forum Posts (beta value=48.5%), and Exercise (beta value=51.5%) had an impact on students' performance on Service and Installation IIT course.

Interestingly, Forum Posts has shown to have significant effect on students' learning performance in both courses. This means, students who were active in the discussion forums during course delivery performed better that those who were less active. These findings imply that MUST should find strategies that will increase students' participation in discussion forums in order to increase students' performance. This can be done by grading quality and quantity students' posts in discussion forums.

This finding seems to be consistent with studies conducted elsewhere LMS forums posts had impact on students' final grade. For instance, participation frequency in online

activities was significantly associated with their grades in a study conducted at University of Glamorgan, UK with 122 students (Davies & Graff, 2005). Similar findings were obtained in studies conducted in various institutions (e.g. Agudo-Peregrina et al., 2012; Beer et al., 2010).

This study also found that Peer Interaction had impact on students' performance in Analysis for Applied Biology course. This finding in accord with recent studies which found that student-student interaction had a significant impact on students' academic performance (Agudo-Peregrina et al., 2012; Yu & Jo, 2014). This implies that, institutions should promote for peer interactions amongst students in in order to increase students' performance in courses offered via the LMS.

Finally, Exercises was found to be the contributing factor in students' final scores in the Service and Installation II course. The result implies that instructors at MUST should consider giving their students more exercises in order to improve their final scores. This finding is similar to a study conducted by Dietz-Uhler and Hurn (2013) who found that the performance on course assignments predicted students' final grades in an online course.

In conclusion, the study has shown that LMS usage have impact in students' performance in courses offered via LMS. Surprisingly, number of downloads, login frequency, time spend in the LMS were found to have no significant impact on students' performance in both courses.

## 7. SUGGESTION FOR THE FUTURE

Despite these promising results that emerged from this study, some limitations are worth noting. The study was based on quantitative results obtained using data stored in LMS database. However, logs simply record learners' behavior in LMS, but they do not explain why some of the factors were significant and some were not significant. Further research should be undertaken to determine why other factors were significant while others were not using qualitative research design. This can be done by conducting interviews or focus group discussions with students who were using the LMS or with instructors who used the LMS to facilitate these courses.

In addition, the two courses used in this study were not delivered entirely online. They were delivered in blended mode with some face-to-face activities taking place. As a result, there are many offline activities such as reading course-related books, lectures, and offline students' peer interactions could not tracked in the LMS. To develop a full picture of the LMS features and activities that contributed towards students' performance future studies should select courses that are offered entirely online via the LMS.

Finally, the study examined only two courses in one academic year 2014/2015. Further research could expand to many courses that are offered in a given semester or for selected courses offered in some semesters.

Despite these limitations, the findings from this study provide a new understanding on effect of LMS usage on students' performance especially in blended learning courses. Some of the contributions of this research are:

- The study has shown that Learning Analytics tools can be used to analyze how students use LMS and find ways find strategies that can be used to maximize LMS usage. The majority of LMS adopted in higher education in Africa tend to fail partially or totally (Ssekakubo et al., 2011) due to the fact that relatively few features are normally used. The use of Learning Analytics tool can be used to identify unused features and in turn, institutions can find ways of maximizing usage.

- Customizing developing new or customizing existing Learning Analytics tools to suit the context of Africa. Many existing Learning Analytics tools in the literature are generic and aimed to be developed in enrolment where the courses are offered purely online. This study has shown that developing context based Learning Analytic tools important especially in contexts where LMS are used for blended learning.

## 8. CONCLUSION

This study was set to design and develop Learning Analytics tool and use the tool to determine the factors that have impact on student performance. Using two course delivered in 2014/2015 at MUST, the study found that Forum Posts, Peer Interactions, and Exercises had an impact on student learning performance. However, the study found that number of downloads, login frequency, time spent in the LMS had no impact on students' performance.

The results generally imply that students who obtained better grades were those who were active in the discussion forums and interacted more with peer students. Moreover, students who completed exercises obtained better grades compared to those who did not. Several studies have determined that a strong relationship exists between students' LMS usage and academic performance. Our findings on the causation between students' activities in the LMS and students' final grades is in line with experiences and results from the literature.

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