Data Quality, Data Capacity, Data Culture and use of Students' data in Improving Teacher Performance: Evidence from Secondary Schools in Uganda

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Abstract

This study investigated data quality, data capacity, data culture and the way they are related to students' data use by teachers in improving teacher performance. It was conducted in Kampala Metropolitan City among secondary school teachers of Uganda. Research design was descriptive, quantitative and used cross-sectional data collected from respondents using a self-administered questionnaire. Study variables were selected through factor analysis and Cronbach testing before diagnostic tests and data analysis. Findings were that students' data use by teachers in improving teacher performance needed improvement; Culture of Leaders encouraging learning through data use and culture of leaders supporting development of data use; capacity of teachers to use ICT and capacity of functionality of ICT systems were inadequate. Use of students' data in improving teachers' performance was significant and positively correlated to culture of leaders encouraging learning through data use; culture of leaders supporting development of data use; capacity of teachers to use ICT; and capacity of functionality of ICT systems. The relationship between data quality and students' data use by teachers in improving teacher performance was mediated by culture of leaders encouraging teachers learning through data use. The relationship between culture of leaders supporting development of student data use and students' data use by teachers to improve teacher performance was mediated by culture of leaders encouraging teachers' learning through data use. A regression of students' data use by teachers to improve teacher performance was predicted by capacity of teachers in using ICT, culture of leaders supporting development of student data use and culture of leaders encouraging teachers learning through data use with a contribution of about 52 percent. These findings suggest recommendations for students' data use by teachers to improve teacher performance

Key words: Data Quality, Data Capacity, Data Culture, Students' Data Use for Teacher Performance

Introduction

High performing organisations in contemporary times make meaningful decisions using evidence from data. This strategy has been quickly adopted because of integration of computers and Information and Communication Technology (ICT) in organisational activities. In most disciplines, computer processes of data that result into information or knowledge are referred to as analytics and can broadly be descriptive analytics, predictive analytics, prescriptive analytics or analytics for taking action (Mandinach *et. al*., 2005). Analytics in education is useful in learning of students, improving teaching and consequently, a vital tool in strategic management of schools for policy formulation, programme development, student placement and practice. For data to inform decisions about these aspects, three critical factors of data use need to be in place: data quality, data capacity and data culture (Ronka, 2007) and the factors have to synergistically

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interact to create an environment where data use is powered. That is the reason Schifter and colleague (2014) assert that the of data for school improvement is no longer a choice. Thus, in this study, it is averred that a teacher is a key participant in leading to the required empowerment.

Uganda developed its initial ICT national policy in 2003 and one of its objectives was integration of ICT in mainstream educational curricula as well as other literacy programmes. On this setting, the Ministry of Education and Sports has been making her contribution to promote ICT in schools as an integrated vision (The Education Sector Annual Performance Report 2005 – 2006). The vision is supported by the Uganda Communication Commission under the Ministry of Information and Communication Technology. Many projects have been initiated to promote ICT use in schools such as SchoolNet Uganda; School-Based Telecentre (SBT) Project; VSAT project; Content Development at National Teachers Colleges, Uganda; Uconnect; I-Network Project; and CurriculumNet Uganda with each having her scope of intervention.

Secondary Education in Uganda is composed of four years (O. Level) and two years of advanced level (A. Level) education. At both levels, ICT is offered as an academic subject following a developed curriculum. ICT curriculum in Uganda has three main components, namely, ICT as an academic subject; ICT as a teaching and learning tool; and ICT for effective school management. Broadly, ICT intervention for secondary school teachers covers issues like applicability of common MS Office programs, internet usage, basic aspects of e-learning, computer maintenance, CD burning and website designing though there are variations in the scope and depth, content coverage, timing and use of the ICT resources by each school due to various reasons. Most student data accessed by teachers in schools are assessment data with the rest managed mainly by administration. Furthermore, the global adaptation of ICT has made teachers develop computer literacy on their own as a way of being highly competitive in getting entry to good schools. One could assume that one of ways to demonstrate competitiveness in schools is to use student data to improve teacher teaching. Anecdotal evidence and scholarly studies (for example, Ndawula, Kahuma, Mwebembezi and Masagazi, 2013; Kasse and Balunywa, 2013) reveal that use of data by teachers to improve teacher performance does not exist and there is no conceptual frame to evaluate its conditions for data use in Uganda. Therefore, this study was set out to investigate this knowledge gap as an education analytics. This study was intended to investigate the existing data quality, data capacity, data culture and student data use by teachers to improve teacher performance using evidence from secondary schools in Kampala Metropolitan city of Uganda.

Purpose:
The study investigated the status of data capacity, data quality, data culture and student data use by teachers in improving teacher performance. It also considered their relationship and the mediating effect of data culture between each of the data quality, data capacity and students' data use by teachers in improving teacher performance. The study was carried out in Kampala Metropolitan City of Uganda among secondary school teachers. The study does not provide knowledge on different types of student data, data analysis carried out or areas of teaching improvements gained by teachers by use of student data in secondary schools of Kampala Metropolitan City of Uganda

Literature Review
Data Capacity
Data capacity is the engine that converts data into information and eventually, assists in knowledge generation. According to Long and Siemens (2011), data capacity includes organizational factors such as team structures, collaborative norms and clearly defined roles as well as responsibilities. The concept includes also existing technology used for data accessibility like allowing multiple users and formats that are easy to interpret. Schifter and colleagues (2014) add data capacity issues like need for balance between volume, velocity and variety of data with abilities to utilise the data.

Soft aspects of data capacity a*re* personnel characteristics such as knowledge, skills and attitude towards data use, which require diverse forms of regular capacity building (Schifter *et. al*., 2014). However, Ronka, Geier and Marciniak, (2010) as well as Wayman (2005) found that most teachers lack training in how to use the data system, lack time to engage in data exploration and reflection, while Mandinach, Honey and Light (2006) indicated that capacities that were lacking covered aspects like information comprehensibility and information flexibility. These inadequacies are reconfirmed by Schifter and colleagues (2014) that teachers often do not know how to make use of extensive data despite importance of teachers in student data use in schools.

Data Culture
A data culture is the belief that good data are an integral part of teaching, learning and managing a school enterprise (Ronka, 2007). Therefore, this covers roles of administrators, teachers and students as a minimum. A strong data culture results when an organisation believes in continuous improvement and regularly puts that belief into practice (Ronka, 2007). Aspects that reveal a good data culture include commitment from all stakeholder groups to make better use of data; a clearly articulated vision for data use (Hamilton *et. al*., 2009); beliefs about efficacy of teaching; and the value of data in improving teaching and learning(Wayman, 2009). Data culture considers also accountability for results and empowering teachers to make instructional changes, collaboration at all levels, setting aside time for administrative teams to meet as well as discuss data and establishing processes including procedures for data management (Ronka *et. al*., 2010). At school level, Bichsel (2012) as well as Wayman and co-authors (2007) reveal that allocation of resources, establishment of infrastructure and processes are also critical. Mandinach and colleagues (2006) summarise that data culture should originate from leadership in terms of the message administrators communicate to their staff and support staff receive.

Data Quality
Educators collectively understand data to be words, numbers and observations constituting of both quantitative as well as qualitative facts and data quality, therefore, is "fitness for use" of the data (Ronka, 2007). Different scholars give varying dimensions of data quality. However, they all agree that it should include aspects like using multiple measures to ensure relevance and triangulation of data; making sure data are well organized for any use, easy to interpret; and using accurate data that have been standardized and cleansed (Vaziri and Mohsenzadeh, 2012). Consequently, these dimensions increase faith in stakeholders who use the data (Ronka *et. al*, 2010). Specificities of data quality are given by Ronka and colleagues (2010) to include consistency, accuracy, completeness or timeliness. These dimensions confirm that data quality is a measurable concept at all phases of data management like data capture, data manipulation, digitisation, storage, presentation (Chapman, 2005).

Data Use

According to Long and Siemens (2011) and Chen, Hermitage and Lee (2005), most school teachers use student data for reporting purposes such as enrolment management, student progress, budgeting and attendance. However, many schools still struggle with data-driven decision-making (Schifter *et. al.*, 2014). While student data use has many benefits to teachers, Mandinach and co-workers (2005) found that it is also used to punish educators, to justify a *status quo* or to make critical decisions based on single data points. The same authors (*ibid.*) reveal that student data use also affected extent of coverage and time for teaching thereby making teachers over stressed by accountability

Data Quality, Data culture, Data Capacity and Data Use

The aforementioned literature reveals an integrated configuration of variables (data quality, data culture, data capacity) in supporting data use. For example, Anderson and co-authors (2010) emphasise on importance of top management in establishing data use purposes, expectations, opportunities, training, access to expertise and follow-up actions. They (*ibid.*) also reveal that issues like accessibility, timeliness, quality of data and human resource capacity are important to make good use of data. The same authors (*ibid.*) aver that all organisations have practices, technology and other resources that influence on data use. On the other hand, Coburn and Turner (2011) assert that data use implicates a number of processes, conditions and contexts. The following hypotheses, therefore, were formulated from the collected literature.

Hypothesis Formulation

Using the availed literature, the following hypotheses were formulated:

H_{01}: Student data use by teachers to improve teacher performance needs improvement, student data quality is lacking, student data culture is inappropriate and student data capacity is unsatisfactory in metropolitan secondary schools of Kampala city.

H_2: Data quality, data culture as well as data capacity have a significant and positive relationship with student data use by teachers to improve teacher performance.

H_3: Data culture mediates between data quality and student data use by teachers; data capacity and student data use by teachers to improve teacher performance.

Materials and Methods

The research was exploratory, quantitative and descriptive and was carried out using cross-sectional data. Study variables were adapted from Mandinach and co-workers (2005); Anderson and colleagues (2010); Ronka and co-workers (2010); Bichsel (2012); Ronka (2007); and Wayman (2005). Variables were identified through factor analysis using Principal Axis and Varimax rotation at a loading of at least 0.500. Each variable exceeded Cronbach Alpha coefficient of 0.70 (Neuman, 2006) and the following categorisations were found as shown in Table 1:

Table 1 Factor analysis of study variables

Study variable	Cronbach Alpha	items
Data culture of Leaders encouraging learning through Data Use	0.787	3
Data culture of Leaders supporting development of data use	0.710	4
Data quality	0.854	4
Capacity of ease of use of ICT systems	0.876	7
Capacity of staff using ICT	0.873	6
Data Use by teachers to Improve teacher performance	0.885	7

All study variables on data capacity, data quality, data culture and student data use by teachers were measured as extent of frequency of actions taken on a 5 point Likert Scale ranked as Never (1), Rarely (2), Sometimes(3), Often (4) and Always (5). Data collection tools were pretested for validity before data collection.

Sample size
The sample size was computed using Smith (2004) as well as Noordzij and colleagues (2010) expressed by a formula as:

$$Sample\ size\ (n) = \frac{(z+x)^2}{pq(logK)^2}$$

Where n is estimated sample size

z is the value of $Z_{\alpha/2}$ for significance level of 0.025 one-tailed test (z = 1.96)
x is the value of Z_{β} for a sample power of 90 percent (x =1.282)
Assuming equal allocation, that is, heterogeneity of the population, p and q are each 0.5
LogK is the reciprocal of natural logarithm of the size effect and taken to be 0.5 as a moderate effect. The sample size using the formula was n = 169.

Data collection
A questionnaire was used to collect data from respondents through simple random sampling. Respondents were identified through their school heads and their completed questionnaires were collected directly from them. Respondents indicated by a tick the extent of frequency on each action item, while ordinal scale was used for collecting most of the personal characteristics of the respondents. Data were cleaned and coded before analysis in Statistical Package for Social Sciences (SPSS) Version 21.

Normality Test
Normality test is used for confirmation whether or not the sample used is from a normally distributed population (Ghasemi and Zahediasl, 2012). A P-P plot of normality was used.

Mediation
Mediators explain how external events take on internal psychological significance in explaining a relation between two variables (MacKinnon, Fairchild and Fritz, 2007; Kenny, 1986; Preacher

& Hayes, 2004). In this study, exploration of significant bivariate correlations coefficients and corresponding significant hierarchical regression coefficients were used to test for mediation effects of particular variables.

Findings
Characteristics of Respondents
Of the 169 sampled respondents through simple random sampling, 114 completed forms were returned and found usable, giving a 67 percent response rate. Of the 114 respondents, 75 percent were males and the rest were females. Though female respondents were reasonably fewer, the study reflects a gender representation of teachers. Majority (96.5%) of the respondents had an education level of at least a first degree and the rest had a diploma. Such education levels show that most respondents were able to teach at both levels of secondary education and academically competent to integrate teaching with data use. Respondents were asked for their age range. Majority (92.9%) were below 45 years and thus, showing that respondents were reasonably young to learn and apply the gained for a long time in the education system. Only 16.1 percent of respondents were in their current schools for less than one year and this shows that majority of respondents must have gained an understanding of the school culture on data use, aspects of data quality and data capacity. Respondents were almost equally distributed in terms of their subject areas taught with. It was revealed that 47.7 percent were teaching science subjects and the rest were teaching arts subjects. A good number (59.6%) of teachers owned personal computers and majority (79.5%) of them had undergone some ICT training sessions. Respondents indicated that on average, they taught 15 hours a week with a standard deviation of 7 hours, while the average number of students they taught in a week was 343 with a standard deviation of 922.

Normality test
Normality test using P-P plot of normalised data showed that the data tended to a normal distribution as shown in Figure 1 of a sample of the independent variables; data quality; and data did not need any transformation before analysis.
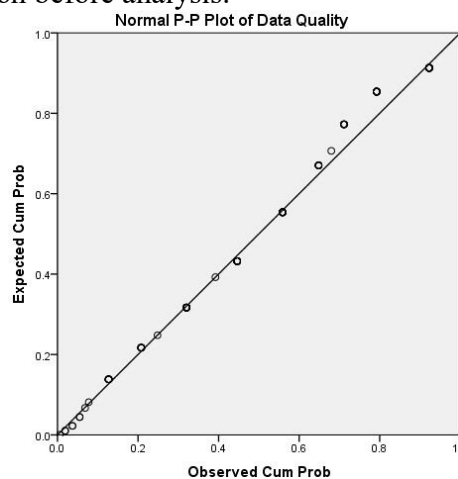

Figure 1

Using a 5-Likert scale of Never (1), Rarely (2), Sometimes (3), Often (4) and Always (5), the study revealed that student data use by teachers to improve teacher performance could be improved (Mean 4.15; SD=0.726); Staff Capacity was unsatisfactory (Mean 3.73; SD=0.960); Capacity of functionality of ICT systems was unsatisfactory (Mean 3.63; SD=0.817); Data

quality was lacking (Mean 3.89; SD=0.817); Culture of school leaders supporting development through student data use was weak (Mean 3.28; SD=0.970); and culture of school leaders encouraging learning through student data use by teachers was weak (Mean 3.48; SD=1.053). These findings confirm Hypothesis one (H_1)

Correlations
Bivariate correlation of variables is shown in Table 3.

Table 2 **Bivariate Correlations**

		1	2	3	4	5	6	7	8	9	10	11	12	13
Gender of Respondent	1	1												
Education Level of Respondent	2	-.063	1											
Age Range of respondent	3	**-.188***	.132	1										
Years of Service at School	4	-.111	.183	.560**	1									
Arts or Science Teacher?	5	**.443****	.004	-.061	-.012	1								
Do you own a computer	6	-.074	**-.200***	.061	-.051	**-.262****	1							
Number of hours taught in a week	7	-.046	.031	.082	.109	.112	-.104	1						
Culture of Leaders encouraging learning through Data Use	8	.029	.002	**-.203***	-.022	-.155	-.002	.025	1					
Culture of Leaders supporting development of data use	9	.015	-.047	-.088	-.036	-.048	.070	-.095	**.234***	1				
Data Quality	10	-.049	-.088	**-.229***	-.106	-.005	-.091	**.198***	**.495****	.137	1			
Capacity of Functionality of ICT systems	11	-.002	.025	.098	.137	-.028	-.002	.144	**.494****	**.244****	.517**	1		
Capacity of teachers	12	-.035	-.015	-.087	-.068	-.182	.034	.063	.569**	**.188***	.545**	.738**	1	
Student Data Use by teachers for Teacher Improvement	13	.035	-.062	-.163	-.008	-.084	-.016	-.073	.625**	**.462****	**.443****	.501**	.554**	1
*. Correlation is significant at the 0.05 level (2-tailed). AND **. Correlation is significant at the 0.01 level (2-tailed).														

The bivariate correction shown in Table 2 reveals a significant and negative correction between male teachers and age of teachers (r =-0.188, p < 0.05) and significant as well as positive

correction with science teachers (r =443, p < 0.01). There is a significant and negative correlation between teachers' education level and a staff owning a personal computer (r =-.200[*], p < 0.05). The age of teachers was found to be negative and significantly correlated to culture of leaders encouraging learning through data use (r =-.203[*], p < 0.05) and quality of data (r =-.229[*], p < 0.05). Teaching an Arts subject was found to be negatively related to owning a personal computer (r =-.262[**], p < 0.01). Number of hours taught in a week by teachers was significant and positively correlated to data to quality of student data (r =.198[*], p < 0.05). Culture of leaders encouraging learning through data use was found to be significant and positively correlated to culture of leaders supporting development of data use (r =.234[*], p < 0.05); data quality (r= 495[**], p < 0.01) and capacity of functionality of ICT systems(r= 494[**], p < 0.01). Culture of leaders encouraging learning through Data Use was found to be significant and positively correlated to capacity of functionality of ICT systems (r =.244[**], p < 0.01); capacity of teachers (r= 188[*], p < 0.05) and student data use by teachers for teacher improvement (r= 462[**], p < 0.01). Data quality was significant and positively correlated to student data use by teachers for teacher Improvement (r= 443[**], p < 0.01). These findings confirm Hypothesis two (H$_2$).

Mediation

The study revealed that Data Quality was significant and positively correlated to culture of leaders encouraging learning through data use (r= .495[**], p < 0.01) and culture of leaders encouraging teachers learning through data use was significant and positively correlated to student data use by teachers to improve teacher performance (r= .443[***], p < 0.01. The same study results revealed that culture of leaders supporting development of student data use by teachers was significant and positively correlated to Culture of Leaders encouraging teachers learning through student data use (r= .234[*], p < 0.05). In addition, culture of leaders encouraging teachers learning through student Data Use was significant and positively correlated to student data use by teachers to improve teacher performance (r.462[**], p < 0.01).

Hierarchical regression for predicting student data use by teachers to improve teacher performance was carried out according to established relationships of the variables aforementioned and the outputs are summarised as follows: Regression using data quality alone was significant (β_1= 0.443**, p < 0.01) and when culture of leaders encouraging teachers learning through data use was introduced it yielded β_2 = 0.174*, p < 0.05 and β_3 = 0.543**, p < 0.01. The indirect effect was β_2* β_3 = 0.095. Similarly, regression using culture of leaders supporting development of student data use by teachers alone was significant (β_1= 0.462**, p < 0.01) and when culture of leaders encouraging teachers learning through data use was introduced it yielded β_2 = 0.334**, p <0.01 and β_3 =0.547**, p < 0.01. The indirect effect was β_2* β_3 = 0.183. These outputs reveal a partial mediation (see also MacKinnon *et. al*., 2007) by culture of leaders encouraging teachers learning through data use in both cases. These findings partially confirm Hypothesis two (H$_3$).

Regression

A single model regression of variables yielded an output summarised in Table 3.

**Table 3 Summary of regression on student data use by teachers to improve teacher performance**

	β	t	Sig.
(Constant)		3.391	**.001****

Gender of Respondent	.015	.185	.854
Education Level of Respondent	-.063	-.865	.389
Age Range of respondent	-.081	-.849	.398
Years of Service at School	.114	1.255	.213
Arts or Science Teacher?	..030	.341	.734
Do you own a computer	-.083	-1.109	.270
Number of hours taught in a week	-.086	-1.159	.250
Culture Leaders encouraging learning through Data Use	**.377**	4.031	**.000****
Culture Leaders supporting development of data use	**.294**	4.009	**.000****
Data Quality	.073	.774	.441
Capacity of Functionality of ICT systems	-.064	-.509	.612
Capacity of teachers in ICT	**.325**	2.502	**.014***
**. Regression significant at 0.01 level AND *. Regression is significant at 0.05 level			

The out values were R = 0.760, R^2 = 0.578, Adjusted R^2 = 0.519, Durbin Watson = 1.966. So the model contribution to student data use by teachers to improve teacher performance is about 52 percent and predicted by **Leaders encouraging learning through Data Use, Culture Leaders supporting development of data use and Capacity of teachers in ICT giving a model equation**

$$Y = C + \beta_1 X_1 + \beta_2 X_{2+} \beta_3 X_3$$

Student data use by teachers to improve teacher performance = *Culture Leaders encouraging learning through Data Use + 0.294* Culture Leaders supporting development of data use + 0.325* Capacity of teachers in ICT*

Conceptual Framework
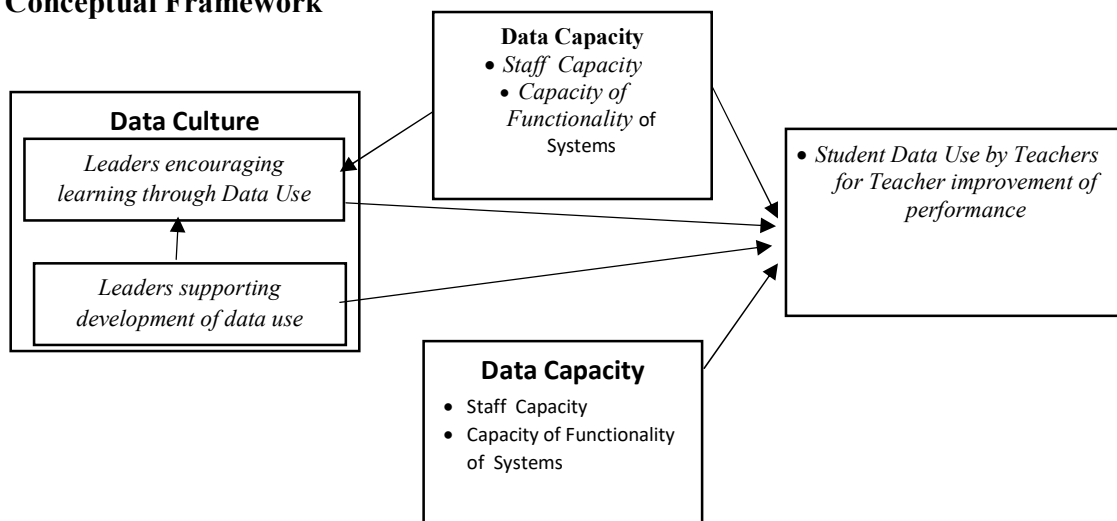
Discussion of Findings

The study showed that student data use by teachers to improve teacher performance needs improvement. This is because teachers may not have clear guidelines on the way to use students' data and its benefits to improve their performance. Some challenges they may face could be need for more effective data analysis packages and diversity of analyses like reporting, querying and data mining. In agreement with Aduwa-Ogiegbaen and Iyamu (2005), the data, culture of leaders supporting development of data use could be inadequate because of high costs of computer hardware and software; weak infrastructure; and other ICT services. Other lacking leadership issues could be absence of appropriate vision, communication and support to teachers. These limitations could eventually affect culture of leaders encouraging learning through data use. When school leaders have no clear vision of data use, they cannot communicate what is required and provide all different forms of support and thus, their role will be lacking.

Data quality lacking concurs with Chapman (2005) and Ronka (2007) that this could be a result of being untimely for use, being presented in different formats and possibly with challenges of compatibility of sources of data, incomplete or having contradictions. A number of times data may also not be organized according to needs of the user without some reorganization first. Data capacity was unsatisfactory in terms of teachers' capacity and capacity of functionality of ICT systems. Ndayambaje and Aluko Orodho (2014) also found that some challenges of ICT capacity include improper maintenance and poor service delivery reported against ICT technical staff, lack of advanced ICT literacy as well as zeal to change the old practices for some lecturers and large use of the internet connectivity for non-academic purposes. While teachers may be good in utilizing common Microsoft Office packages, such packages may be limited in providing more useful analysed student data as found by Aduwa-Ogiegbaen and Iyamu (2005). Some aspects of analysed data could be comparative analysis, trends, prescriptive analysis and outlier analysis. Capacities could also be inadequate partly because many implementations of ICT policies in schools are centrally developed by the Ministry of Education without input from the affected schools. One challenge of such approach is absence of contextual factors from schools to ensure success of implementing the project and consequently, its sustainability without understanding fully by teachers how the new activity can be integrated in their existing workloads.

The study showed significant and positive bivariate correlations between most study variables and also with student data use by teachers to improve teacher performance. The relationships confirm an integrated contribution of the condition for data use by these variables as suggested by Norris and Baer (2013). For example, when the culture of leaders supporting development of data use is developed, it will lead to the culture of leaders encouraging learning through data use, a pattern, which calls for data capacity empowerment. Eventually, teachers will be expected to use student data to develop highly flexible teaching approaches and understanding of patterns in student data as part of their accountability to school leaders. These integrated relationships explain also situations of mediation effects in the model. In the prediction model, variables that predict student data use by teacher to improve teacher performance cover capacities of staff and culture of schools. These two conditions are dynamic and active variables in the model and so any change in data use is dependent on them.

Conclusion

Student data use by teachers to improve teacher teaching performance is an important aspect of Education Analytics. In this study, it was investigated using data of secondary school teachers of

Kampala Metropolitan City in Uganda. The extent of student data use was found that it can be improved. Aspects of conditions for student data use: data culture and data capacity were inadequate while data quality was lacking. Each of individual conditions for student data use were found to be positive and significantly correlated to student data use by teachers to improve teacher performance. The three conditions were also found to be significant and positively correlated to each other. Data culture, data capacity and data quality were found to be integrated in contributing to student data use by teachers to improve teacher performance as confirmed by Ronka (2007). The study revealed also that culture of leaders encouraging learning through data use partially mediated between data quality and student data use by teachers to improve teacher performance. Partial mediation of culture of leaders encouraging learning through data use was also found between Culture of Leaders supporting development of data use and student data use by teachers to improve teacher performance. Prediction of student data use by teachers to improve teacher performance was found to be by culture of leaders supporting development of data use, culture of leaders encouraging learning through data use and capacity of teachers in ICT with a prediction level of 52 percent because these are dynamic variables in the model.

Recommendations

Findings from this study reveal possible areas for increasing student data use by teachers to improve teacher performance in secondary schools of Kampala Metropolitan city of Uganda. Recommendations include increasing culture of leaders supporting development of data use through more infrastructural development, clear vision and communication about benefits of student data use even beyond improvement of teacher performance. This could eventually also increase the culture of leaders encouraging learning through data use and capacity of staff in use of ICT. These efforts could also increase innovativeness of teachers and sharing data use vertically as well as horizontally.

Limitations and Future Research

The study gives an insight of initial conditions that must be in place to enable data use as shown in this case of student data use by teachers to improve teacher performance. The study did not investigate issues like types of data used, level, scope and level of analysis by teachers. The study also used cross-sectional data by focusing on geographical area of Kampala Metropolitan City in Uganda. Thus, it was not a countrywide study. These boundaries reveal possible areas for further studies.

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