e-learning as a supplemental teaching tool for secondary students in Uganda: lessons from COVID-19

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Research Article

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Abstract

Introduction

Edubee, a holistic learning approach for Ugandan students is an initiative Pic-Ed. Pic-Ed is an educational company that provides digital learning materials for students, learning management systems for schools and institutions plus examination proctoring tools. The project was undertaken to determine the effectiveness of digital learning platform by Edubee in enhancing the educational level achievement of Senior three students in selected districts in Uganda.

Methods

We designed a three-armed field trial which was piloted in the Central and Eastern regions of Uganda.The pilot study was conducted among Senior Three students in 12 randomly selected schools and the content was from the Senior Biology and Physics syllabus. The topics chosen for Physics were vapour pressure and heat quantities, for Biology, the topics chosen were seed dormancy, seed germination and factors affecting seed germination.

The three study arms were; (A) Teacher and Edubee Platform; this arm involved the teacher explaining concepts to the students using the Edubee platform that would either be hosted in a school computer lab or would be pre-uploaded on the research team's tablets and MP3 players, (B) Edubee only; this arm involved the students navigating the content of the Edubee platform at their pace and doing self-teaching without the aid of the teacher to). Both rural and urban districts, the students used the Edubee platform or the MP3 players and (C) Teacher only; this consisted of the teacher using the conventional syllabus notes which are in-line with the national curriculum development centre. The sample size for the study was 360 students from 12 schools in the two regions. Thirty students were randomly sampled from each school. Each of the sampled students was subjected to both a baseline and an endline assessment which were marked by experienced Uganda National Examinations Board (UNEB) examiners). The study was carried out in two weeks (28th February to 10th March 2022).

Results

The total number of respondents of the study was 360 and of these, 41.6%were male and females were 58.4%. Those aged 15-16 years constituted the highest percentage at 49% and many identified with the Catholic religion at37%. Slightly above average of the participants were from the urban based schools at 59.3% and those who were in the boarding section constituted 71.6% of the total sample size. The enrolment for arm A was 33.2%, arm B (34.4%) and arm C was 32.4% of the total number of respondents. The results showed the mean performance at the endline assessment to be at 22.4%, standard deviation 7.26 and was higher than the baseline which was at 15.8%, standard deviation 12.53. On further analysis, it was noted that the odd ratio of passing an examination in arm B was 0.344 (0.173, 0.767, p= 0.006) compared to arm C 0.845 (0.4150, 1.719, p= 0.642). Factors that were associated with positive outcomes of using e-learning outcomes included; a school being located in an urban setting (p=0.002), a learner's

parent being a business person as the occupation (p=0.001), being located in Eastern region (p=0.000) and having a policy on e-learning was statistically significant during the multivariate logistic regression analysis.

Conclusion

The Edubee platform is a effective learning resource for learners that should be scaled up for a longer period of time to ensure that learners master and understand the concepts better. The Edubee platform should be used as a supplementary tool where the teacher uses the audio-visual components of Edubee to enhance their explanations for science subject concepts. The stakeholders should integrate digital learning as a major component for the new national education curriculum, enact laws and pass policies on digital learning at school and national levels.

Introduction

The Coronavirus Disease,2019 (COVID-19) caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV2) that ravaged the whole globe, led to a huge dent in the economy, health, transport and education systems. This study focused on the devastation COVID-19 caused to the education system and as a result, there was closure of physical school attendance as one of the public health interventions to curb the spread the spread of the virus in order to reduce the burden in the health sector. School closure affected about 80% of the education of school-going children worldwide van[1]. Beyond the direct clinical impacts of COVID-19, measures to contain the spread of disease have left nearly 1.6 billion pre-primary through post-secondary students more than 90% of those enrolled at least temporarily out of school [2]. The COVID-19 pandemic has had enormous impacts on children and families around the world. Since the start of the outbreak in 2019, more than 80 countries have implemented partial or full lockdowns with direct effects on approximately 1.4 billion school-going children, and an additional 100 countries have introduced restrictions on movement [2].

In Uganda, closure of schools has indirectly affected the school curriculum where we had no intermittent school opening, but when the second wave of the pandemic hit the nation, the President ordered for the immediate closure of schools, which led to students missing out on a lot of time and content that they could have covered during this time of school exposure [3]. This did not only affect students and teachers but also had a vast impact on the parents that had cleared their children's school requirements leading to an economic loss. Efforts to ensure that the children remain engaged with educational activities using tools such as the internet, television and radio programs, zoom links, use of tablets which are all digital platforms in the making as a result of this school closure have been embraced [4].

The Ugandan Government through various media platforms has tried to keep the school-going children engaged by collaborating with various media groups to air the school content on either Television stations such as Uganda Broadcasting Cooperation (UBC), radio programs, newspaper articles with educational content, print paper with work from home yet assessment of uptake and feasibility of using these digital platforms has not been carried out. Some parents are still skeptical considering the negative

effects of internet access on the children if they are not monitored. The bigger question is if the digital learning platforms will offer a solution to students' educational needs.

Edubee,a holistic platform which offers video-based learning and online assessment tools, additionally also an offline version with an MP3 Audio guided class with print study materials for Ugandan students is an initiative by Pic-Ed. Pic-Ed is an educational company that provides digital learning materials for students, learning management systems for schools and institutions plus examination proctoring tools [5].. Edubee intends to bridge the gap between the teachers, students and learning materials through their vision of revolutionizing the way students learn and prepare for the examinations. The content of Edubee covers the educational needs of students as it is intended to be used as a supplementary medium of learning to that offered by teachers who use the Ugandan curriculum with a wider aim is to become East African leading educational platform. Due to the evidence from the benefits of some of the different e-learning platforms, and how they enhance education in Uganda and the world at large. Similarly, Edubee could be one of the solutions the country is looking for to fill the educational gap that was created as a result of the persistent lockdown due to the COVID-19 pandemic. For these reasons there was need to assess the feasibility of using Edubee as a digital education platform among secondary students in Uganda while looking at its ease of usage, uptake, and factors associated.

Methods

Study design

We designed a three-armed field trial which was piloted in the Central and Eastern regions of Uganda. The pilot study was conducted among Senior Three students in 12 randomly selected schools and the content was from the Senior Biology and Physics syllabus. The topics chosen for Physics were vapour and vapour pressure and heat quantities, for Biology, the topics chosen were seed dormancy, seed germination and factors affecting seed germination.

The three study arms were; (A) Teacher and Edubee Platform; this arm involved the teacher explaining concepts to the students using the Edubee platform that would either be hosted in a school computer lab or would be pre-uploaded on the research team's tablets and MP3 players, (B) Edubee only; this arm involved the students navigating the content of the Edubee platform at their pace and doing self-teaching without the aid of the teacher to). Both rural and urban districts, the students used the Edubee online platform or the MP3 players with audio content and printed study guides and (C) Teacher only; this consisted of the teacher using the conventional syllabus notes which are in-line with the national curriculum development centre.

Sampling and Sample Size Determination

At design stage, the sampling frame of the schools that are located in the two regions of interest was provided by Uganda Communications Commission (UCC). The schools and students that were part of the study were simple randomly selected using the computer method. The sample size for the study was 360

students from 12 schools in the two regions. Thirty students were randomly sampled from each school. Each of the sampled students was subjected to both a baseline and an endline assessment which were marked by experienced Uganda National Examinations Board (UNEB) examiners). The study was carried out in two weeks (28th February to 10th March 2022).

The schools and students were simple randomly selected from the list of schools in the selected districts that were provided by Uganda Communications Commission (UCC) computers.

The study availed informed consent (Supplementary II) and child assent forms for those between 12-17 years as well as permission from teachers to take part in this study. After the informed and assent documents were signed and received, a baseline assessment was conducted prior to students using the digital educational platform by Edubee and a later ending survey was conducted and the results compared to the endline and was used to assess the effectiveness of using the Edubee educational platform. This was conducted through the award of marks by UNEB examiners. These UNEB examiners were be outsourced, oriented and trained about the Edubee and its uses. The student and school identities were withheld by coding students' scripts from UG001 to UG360 and this was done to minimize bias from the examiners.

Data Collection and Analysis

Data were collected using semi-structured questionnaires that were uploaded on the Mwater application to assess factors associated with embracing digital learning and the independent variables that were considered included; access to computers and internet, stability of internet, knowledge of use of ICT facilities at the respective schools, availability of school policies, among others. Using Mwater application, data were exported to STATA version 140.0 software for analysis. At univariate level, we used descriptive analyses like proportions and percentages and presented the data outcomes using tables and figures. For the associated factors with the outcome variable which was utilization of e-learning platform, and logistic regression was performed to understand the statistically significant variables.

The outcome variable was the performance in the end line assessment. Mean performance was done for Physics and Biology. The pass mark for the subjects was guided by UNEB examiners and it was 25%, this is always decided on after assessment of all learners and a range is determined for all learners to be graded. The students who scored 25% and above were coded 1 and those who scored below 25% were regarded as having failed and were coded 0. Factors with a P-value less than 0.05 were considered to be statistically significant at multivariate analysis but for bivariate analysis, factors with a P-value of 0.2 were accepted and transferred to contribute to the final model. The raw data had a password only accessed by the statistician and project investigators for data protection efforts.

For purposes of quality assurance, the Investigation Team was trained by the Pic-ED Team on how to navigate the Edubee platform. The study arm that utilized only teachers and their notes as a source of education was used as the control arm of the study. Pretesting of the tools was done in Mukono district

at Bishops SS Mukono, Mt. St. Henry's High School Mukono and Mukono High School. The data collection team was trained about this study protocol and the tools. Experienced research assistants and supervisors were employed in the project to ensure credibility of the data collected.

Results

a) Socio-demographics of the participants

The study was conducted in Eastern and Central regions of Uganda among Senior Three Students from 12 Secondary Schools. Out of 360 respondents, 145 (41.6%) were male and 204 (58.4%) were females. Students aged 15–16 years constituted the highest percentage and were 171 (49%) and many identified with the Catholic religion at 129 (37%). Students whose score was slightly above average were from the urban based schools (59.3%) and were in the boarding section (71.6%). The enrolment for arm A was 116 (33.2%) then arm B 120 (34.4%) and lastly arm C 113 (32.4%) (Table 1).

Table 1
Socio-demographics for study participants

Characteristic	Category	Frequency (n)	Percentage (%)
Arm of Enrollment	A	116	33.2
	B	120	34.4
	C	113	32.4
Gender	Female	204	58.4
	Male	145	41.6
Age	< 15	5	1.4
	15–16	171	49.0
	17–18	147	42.1
	> 18	26	7.5
Religion	Anglican	95	27.2
	Catholic	129	37.0
	Moslem	43	12.3
	Pentacostal	79	22.6
	SDA	3	0.9
Category of school	Rural	142	40.7
	Urban	207	59.3
Status of respondent	Boarding	250	71.6
	Day scholar	99	28.4
Education level of parent/guardian	No formal Education	11	3.2
	Primary	39	11.2
	Secondary	185	53.0
	Tertiary /college	23	6.6
	University	91	26.1
Occupation of parent	Accountant	02	0.6
	Business	151	43.3
	Civil servant	107	30.7
	Doctor	1	0.3

Characteristic	Category	Frequency (n)	Percentage (%)
	Driver	2	0.6
	Engineer	9	2.6
	Nurse	2	0.6
	Peasant	73	20.9
	others	2	0.6
Region/location	Central	169	48.4
	Eastern	180	51.6
District	Butebo	60	17.2
	Iganga	60	17.2
	Kawempe Division	56	16.1
	Lubaga Division	55	15.3
	Tororo	59	16.9
	Mpigi	59	16.9

b) Effectiveness of Edubee platform

The results showed that the mean performance of the students at Endline (22.4%, standard deviation 7.26) is higher than baseline (15.8%, standard deviation 12.53) (Fig. 1). On further analysis, it was noted that the odd ratio of passing an examination in arm B was 0.344 (0.173, 0.767, p = 0.006) compared to arm C 0.845 (0.4150, 1.719, p = 0.642) (Fig. 2).

c) Factors associated with Edubee learning platform

From the study, being in arm B was strongly associated with better learning outcomes among students although it was not statistically significant (p = 0.006) and different factors were found to be positively associated with better e-learning outcomes included; a school being located in an urban setting (p = 0.002), being a business person as occupation of parent (p = 0.001), being located in the Eastern region (p = 0.000) and having a school policy on e-learning (p < 0.001) (Table 2).

Table 2
Factors Associated with e-learning platforms

Covariate	Categories	Frequency (n)	Odds ratio	95% CI	p-value
Arm	A	116	Ref		
	B	120	0.344	0.173,0.767	0.006*
	C	113	0.845	0.4150,1.719	0.642
Religion	Anglican	95	Ref		
	Catholic	129	0.600	0.317,1.135	0.117
	Moslem	43	0.419	0.176,1.143	0.076
	Pentacostal	79	0.527	0.252,1.102	0.089
	SDA	3			
School category	Rural	153	Ref		
	Urban	207	0.308	0.148,0.646	0.002*
Respondent status	Boarding	250	Ref		
	Day	99	0.535	0.262,1.086	0.084
Education level of parent/guardian	No formal education	11	Ref		
	Primary	39	1.158	0.221,6.087	0.862
	Secondary	185	1.453	0.330,6.410	0.621
	Tertiary	23	2.500	0.450,13.880	0.295
	University	91	1.565	0.325,7.530	0.577
Occupation of the parent	Accountant	2	Ref		
	Business	151	1	0.100,0.496	0.001*
	Civil Servant	107	0.223	0.36,0.835	0.015
	Doctor/Nurse	3	0.337	0.024,5.35	0.595
	Driver	2	0.702	0.035,13.23	0.804
	Engineer	9	0.086	0.013,1.24	0.076
	Others	2	1		
	Peasants	73	1		
Region	Central	169	Ref		

Covariate	Categories	Frequency (n)	Odds ratio	95% CI	p-value
	Eastern	180	19.491	8.090,49.96	< 0.001*
Utilization of e-learning platform	No	182	Ref		
	Yes	167	1.227	0.683,2.204	0.492
Presence of Electricity	No	34	Ref		
	Yes	315	4.705	1.251,17.695	0.022
Presence of Solar back-up	No	155	Ref		
	Yes	194	0.831	0.466,1.482	0.531
Presence of ICT teacher	No	152	Ref		
	Yes	197	0.86	0.299,2.475	0.781
Presence of policy on e-learning	No	192	Ref		
	Yes	157	2.644	1.500,4.659	0.001*
Exposure of e-learning materials/content	No	140	Ref		
	Yes	208	0.71	0.390,1.322	0.288

*Suggests statistically significant p value < 0.05

Discussion

Our study was conducted in Eastern and Central regions of Uganda among both males (41.6%) and females (58.4%). Those aged 15–16 years constituted the highest percentage (49%) and many identified with the catholic religion (37%). Slightly above average was from the urban based schools (59.3%) and majority were in the boarding section (71.6%). The enrolment for arm A was 33.2% then arm B (34.4%) and lastly arm C (32.4%). The results showed the mean performance at Endline (22.4%, standard deviation 7.26) higher than baseline (15.8%, standard deviation 12.53). On further analysis, it was noted that the odd ratio of passing an examination in arm B was 0.344 (0.173, 0.767, p = 0.006) compared to arm C 0.845 (0.4150, 1.719, p = 0.642). Being in arm B was strongly associated with better learning outcomes among students although it was not statistically significant (p = 0.006) and different factors were found to be positively associated with better e-learning outcomes including; a school being located in an urban setting (p = 0.002), being a business person as occupation of parent (p = 0.001), being located in Eastern region (p = 0.000) and having a policy on e-learning (p = 0.001). These results are very critical

for Ministry of Education and Sports to integrate digital learning as a key driver for new curriculum, enact and make a policy on digital learning in secondary schools, conduct a national-wide assessment on functionality of school computers, guide all school leadership to ensure electricity and solar provision as a key resource in this area and design a curriculum for blended learning for secondary school level; teacher and digital learning platform.

Our study found out that there were more females than the males. This is in agreement with the current Country socio-demographic where there are more females than males. This too is the gender categorization in most schools where female learners are more than their male counterparts. Having a relatively equal attendance would better inform the design of the e-learning interventions for example, previous studies have shown that females have preferences on the color of the website, tools, but also have peculiar needs including some periods when they may be absent due to menstrual cycle needs [5]. Our study results are in agreement with other studies done in Uganda and Croatia by Meyer et al and Corluka et al respectively that showed more females than males [6, 7], however, it differs from another study in Turkey by Karaca et al which showed more boys than girls in their study [8]. This calls for deliberate considerations to the issue of gender in designing and implementing e-learning platforms.

We also found that there were more Catholics and Protestant than other religious affiliations. This could be linked to the regions/districts that had more people in this religious background. In some districts in Uganda, some schools are religious founded and it is possible that most of the schools that were randomly selected were Christian founded as opposed to the Moslem faith. This study results are in agreement with another study conducted across the African region by Wodon et al that showed that many Catholic and Protestant founded schools serve many students in the region [9].

For age, most of the study participants were aged between 16–17 years. This could be attributed to the fact that most students in Uganda begin nursery section at the age of three years making many of them to finish ordinary level at age of 18 years. This age range does not differ from the usual expected age for students in secondary level three in Uganda. These results are in agreement with a study conducted in the US on predicting the learning outcomes which showed many students are in senior three around the age of 15 years of slightly above [10]. Socio-demographic factors are very critical in designing e-learning platforms and the stakeholders in education sector should consider these facts in planning and designing.

Our study also showed that the Edubee learning platform is an effective supplemental tool. The evidence relates to better performance in the post assessment (after five days of intervention in Arm A and B but also the same five days for teaching the content using the conventional way for the control Arm;C) than the pre-assessment although the difference was narrow and narrowly missed the statistical significance ($p = 0.006$). The examiners of the study assessments attributed this small margin in improvement in performance to the short time allocated for the intervention but also disruptions in many schools due to lack of internet connection and competing school activities. Most of the schools had computer laboratories but did not have internet. Furthermore, the students had just returned from a long holiday of

two years without full interaction with educational content. This improvement in performance could be attributed to the fact that learners had chance to watch content from the materials that we offered on the Edubee Platform and read content on their own. This solution allows for students to learn at their own pace and makes them more responsible for their learning outcomes, following the new pedagogy of the National Curriculum Development Center. Our study is consistent with the previous studies done in this area and have reported that digital learning is very critical for academic achievement and very interestingly for the contribution of performance in science and mathematics at schools and universities [11, 12]. Therefore, there is need to execute this intervention for a longer period of term like a full term or a year for better assessment of the outcome. However, the results for phase 1 field trial have showed that the Edubee platform innovation is a great innovation to be used by science teachers in Uganda in a bid to contribute to improvement in scientific performance.

We also found out that for any e-learning platform to succeed and work effectively, there are factors that facilitate positive outcomes; the study found out that a school being located in urban setting, having e-learning policy at all levels, parents' occupation being a businessperson and being located in Eastern Uganda were statistically significant with good e-learning outcomes in Uganda. Schools in Urban settings are likely to have access to electricity, solar backups, stable wifi/internet which are key variables for successful e-learning platforms across the world. This is likely to improve since many districts are currently being upgraded to urban areas in that some have gained municipality and city status. Policies in place can dictate the vote creation at all levels ranging from school level, district, ministry levels. Policies could also encourage many partners to support and invest in the area of e-learning in Uganda. Having e-learning policies across board is pivotal not only in resource allocation but also in enhancing access and utilization of e-learning platforms by all stakeholders. Therefore, having an enabling policy environment would help to address all these likely hinderances to e-learning in secondary schools. Our study findings are in agreement with other findings from other studies including one in Ireland, South Korea and USA that showed that national policies, school leaders' attitude to technology and resource allocation is very important for success of e-learning. The same report also noted that rural based schools are negatively affected as regards to e-learning access and utilization [13–15]. There is need for deliberate efforts by the Ministry of Education and Sports to have such enabling factors in rural schools in a bid to standardize learning across the country since the final year assessment at ordinary level are standardized.

The study further provided evidence that parents' occupation plays a key role in accessing and utilization of the e-learning services for their children. For this study, parents' occupation was used as a proxy for the socio-economic status of the parents. Economic status is important in a sense that in the event that the Edubee platform is scaled up, parents will have to foot the bills and buy gadgets for their children to use. It is therefore important to factor parents' occupation and socio-economic status if the project is to succeed. The price environment should be friendly if the tenet of affordability is to be achieved. Additionally, working-class parents also tend to be busy at work and may not have time to guide their children on navigating the system. Therefore, making a learner friendly system is critical for the success of such a product. A learner friendly system is equally advantageous to parents who have time to support learners but may not be knowledgeable in the e-learning. The study also noted that a by a learner hailing

from Eastern region, it was statistically significant for positive e-learning outcomes. It should be noted that Eastern Uganda is among the regions which are known for chronic poor performance in both science and arts subjects [16, 17]. Our study results are in agreement with other studies done that showed that parents should proactively support their children in bid for them to achieve their academic goals [18, 19]. Therefore, this product would greatly be welcomed and appreciated as a great innovation to address this continued gap. Therefore, there is need to work on the schools and stakeholders like parents in Eastern Uganda in scaling up this innovation.

Our study had a number of strengths for example, this is the first randomized study on e-learning in these regions and gives evidence that e-learning intervention works more so that we are in the fourth industrial revolution were digital and use of technology fosters business. This project was implemented the time when the country (Uganda) had multiple debates on whether government's intervention to supply e-learning materials on televisions and radios was a good idea or not and this provides answers to this important question. This was a randomized field trial and this could help us to deduce causation. We used a computer based simple random sampling technique in identifying the schools and students and this helped us to eliminate selection bias that could have affected our study. We were able to work with students across regions (Eastern and Central), status (boarding and day) and location (urban and rural). This helped us to seek how the educational product could perform across regions. We also worked with experienced national examiners trained and empowered by UNEB and this helped us our project to provide with a honest and authentic pre and post assessment. We pretested the data collection tools before going to the field and this helped us to minimize data errors. However, we also have limitations; (1) The project was done just after COVID-19 pandemic and learners had forgotten many readings, listening skills. This could have negatively impacted on memorizing of the concepts and could explain the improvement in performance at post assessment. (2) The research project was conducted when schools were struggling to finish the syllabus and so did not give much time on the school time table for the research. This could have limited the interaction of students with the content thus affecting the outcomes of the project. (3) The study period (5 days per subject) was not sufficient enough for the students to fully grasp the concepts of the content. This was a short time for concepts of physics and biology to be appreciated by these learners. (4) Most of school computers did not connect to the internet and 2/3rd of the participants in Arm A and B participants used MP3 players. This impediment denied students time and exercise with the Edubee platform. This therefore could have contributed to a good number of unsatisfied participants during the survey. (5) The assessment period was short; it is possible that the concepts have not yet been understood. This could explain the poor performance.

Conclusion

The Edubee platform is a helpful resource to learners and using Edubee platform as a supplementary tool for learning is helpful. Having electricity, solar, computers that connect to the internet aid digital learning. The offline based learning of Edubee with an MP3 player and print study guides could be adopted in more rural locations where internet connectivity remains a challenge. There is an urgent need to have an e-learning policy for secondary schools learning in Uganda as these are very key in content access, creation

and having an interactive platform where issues about the platform are identified and critically attended to in real time. We recommend further studies on (1) the feasibility of scaling up for a longer period than the study period like 1–2 years preferably for different subjects. (2) possibility of engaging business experts to guide on the investment models and scalability of this innovation.

Abbreviations

COVID-19: Corona Virus disease 2019

ICT: Information, Communication and Technology

UNEB: Uganda National Examinations Board

NCDC: National Curriculum Development Centre

Declarations

Ethical considerations

This study did not seek Institutional Review Board approval given the COVID-19 pandemic which had made students sit home for two years and there was urgent need to understand the effectiveness of this intervention before rolling out. However, permission and consent was sought from Commissioner Basic Education, Ministry of Education and sports, Uganda before the study was rolled out. There was a letter introducing the study team from Science, Technology and Innovation Secretariat-office of the President detailing the benefits and risks of this study. Both Informed consent and assent for child (between 12-17 years) was sought from teachers to take part in this study. After the informed and assent documents were signed and received, a baseline assessment was conducted prior to students using the digital educational platform by Edubee and a later ending survey was conducted and the results compared to the endline and was used to assess the effectiveness of using the Edubee educational platform. Permission was sought and obtained from the districts and divisions that were targeted through the office of the Chief Administrative Officers and District Education Officers and town clerks and division education officers respectively to carry out the study in various schools across the country. For the sampled students, a code was given to each student to uniquely identify them and unique identifier given to the schools as well. To better answer the feasibility of it's effectiveness, blinding was done to prevent bias from the different examiners who are carrying out this process. The students constituted a huge majority of minors therefore assents were availed to them but informed consent obtained from their teachers. Students who were below 18 years of age signed assent forms then have their teachers sign on their behalf the consent forms.

Consent for publication

Not applicable

Availability of data and materials

The data collected for this study is readily available and can be accessed by sending a request to Mr. Abel Wilson Walekhwa, Science, Technology and Innovation Secretariat -Office of the President, awalekhwa@berkeley.edu

Competing interests

All other authors declare no competing interests

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Authors' contributions

AWW,MMM,BN,SJ,MN; Conceptualized, designed and implemented the study, AWW drafted the first version of the manuscript, CDO and AWW analyzed the data, SK gave technical insights in the manuscript, SJ mobilized resources for implementing the project.

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Figures

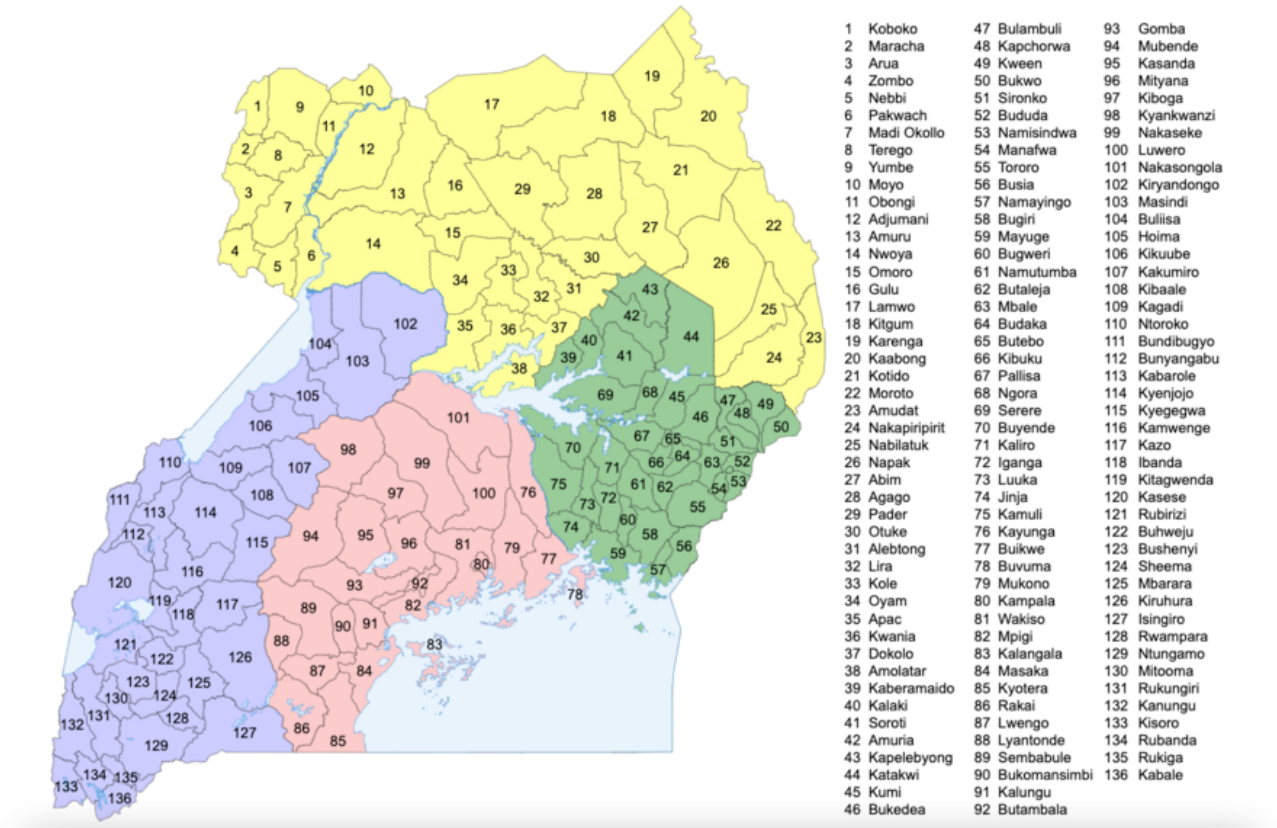

Figure 1

Map of Uganda showing districts of study

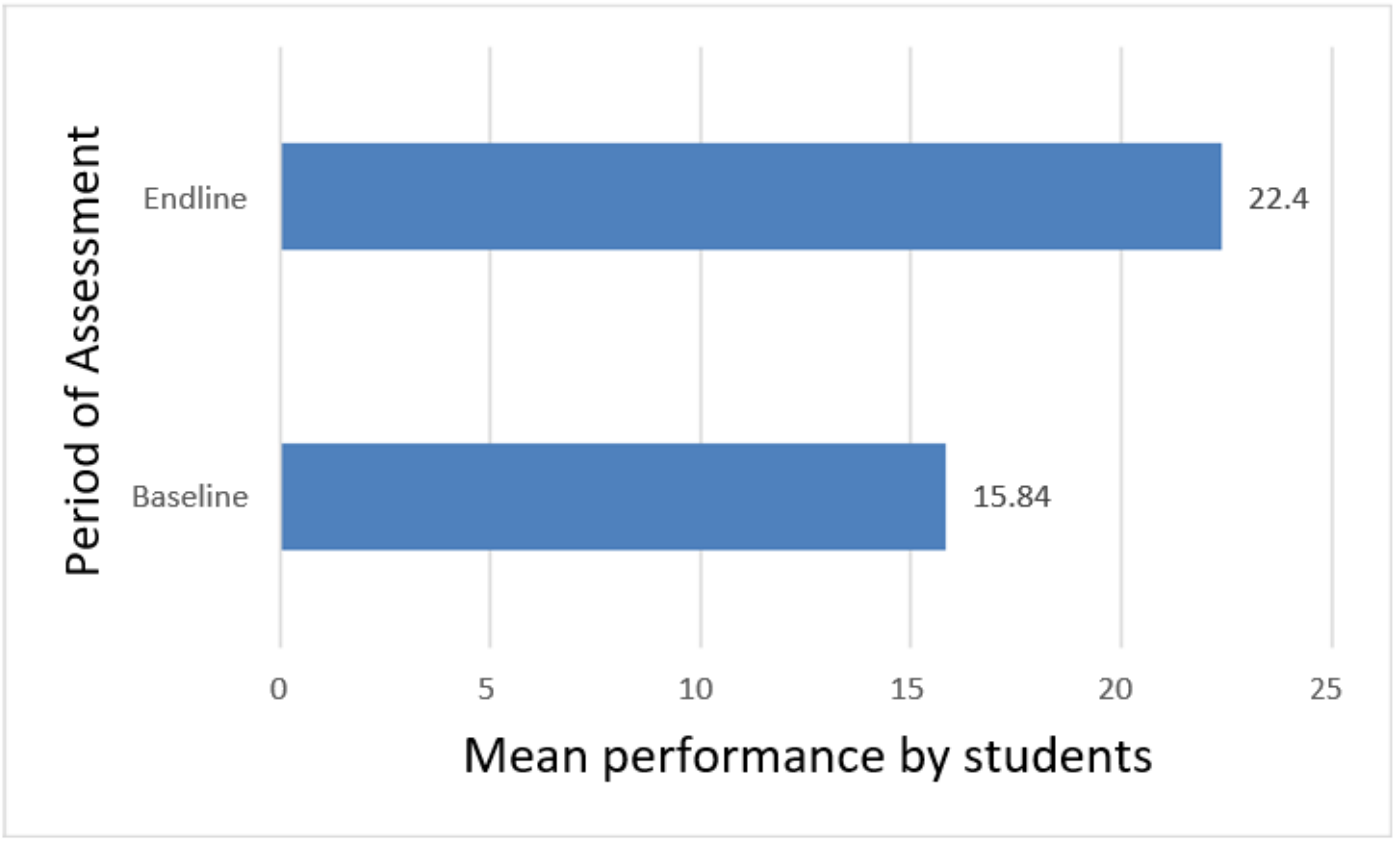

Figure 2

Mean performance by students