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THE IMPACT OF EDUCATIONAL TECHNOLOGY INITIATIVES ON STUDENT LEARNING OUTCOMES: PERSPECTIVES OF SUB-SAHARAN AFRICA

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ABSTRACT: *Despite the numerous impact studies reported in the literature, the impact of ICT use on student learning outcomes remains difficult to measure and open to much reasonable debate especially when it is preceded with an educational technological initiative This study sought to explore the impact of an Africa Digital Schools ICT-intervention on learning outcomes of 542 students from six project participating countries in Sub-Saharan Africa. The study adopted an online survey evaluation tool in which a semi-structured questionnaire followed by a focused group discussion was used to conduct a robust evaluation of project impact on student learning outcomes. Findings revealed that the ICT initiatives and its package were well received and patronized by the student target groups and were the reasons for students improved learning outcomes demonstrated in their reported improved attitudes, developed competencies and behavioural changes in the use of computers. Nevertheless, the findings showed that essential conditions required to support the sustainability of project ideas to school levels were seemingly not adequate. The study therefore advocates the need for implementers of ICT initiatives or research projects in Sub-Saharan countries and countries of similar contexts to ensure that enabling conditions for the continuous use of innovations are provided in order to foster an effective adoption as well as support long-term goals.*

KEYWORDS: Learning outcomes; computer attitudes; computer competencies; ICT initiatives

INTRODUCTION

The integration of Information and Communication Technology (ICT) is high on the education reform agenda worldwide particularly in developed countries. Often ICT is seen as an indispensable tool to fully participate in the knowledge society (Peeraer & Van Petegem, 2011). ICTs are therefore perceived to provide a window of opportunity for educational institutions to harness and use technology to complement and support the teaching and learning process with the ultimate aim to improve the learning outcomes and achievements of learners. Although a large body of research on factors determining the integration of ICT in education emerge from developed countries, recent development indicates that developing countries are finding means to participate effectively in the global information society and to address challenges regarding ICT in education (Tilya, 2008). The emerging developing countries do not only draw on this research but are also gradually advocating for ICT use for teaching and learning to gain acceptance in education. In recent times developing countries have been engaging in educational technology initiatives/technology projects and venture funding for educational technology in these countries have been on a rise. The desire of many of such technology-related initiatives has been to encourage reform-oriented technology integration grounded in inquiry and drawing on cognitive and constructivist learning principles (Fishman & Krajcik, 2003). The widespread belief of such ICT initiatives or research projects is to transform teaching and learning processes that will result in increased learning gains for students, creating and allowing for opportunities for learners to develop their creativity, problem-solving abilities, informational reasoning skills, communication skills, and other higher-order thinking skills. Student learning outcomes are key to determining the success of educational technology initiatives; and while no single evaluation design may be appropriate, student learning outcomes should be the basis of both designing and evaluating educational technology initiatives or research projects. However, there are currently very limited, unequivocally compelling data to support this belief. This study has a focus in this direction. The study sought to explore the impact of an Africa Digital Schools ICT-project that was implemented in six-Sub-Saharan African countries. The Africa Digital Schools ICT-project was launched few years ago under the joint sponsorship of the British Council and Microsoft and in coordination with the Ministries of Education of six Sub-Saharan African partner countries: Kenya, Tanzania, Uganda, Ethiopia, Ghana and Nigeria. The ultimate goal of the project was to influence policy for ICT integration to build ICT competencies in teachers in order to enhance and transform school practices. The goal of this study was to understand how the educational technology initiative influenced the project ultimate student beneficiaries in terms of increased skills, active use of ICT and better learning outcomes.

The ICT Initiative

Under the joint sponsorship of the British Council and Microsoft and coordination with Ministries of Education of the partnering countries and other partners, the Africa Digital Schools ICT-project was launched in the six Sub-Saharan African countries as mentioned above. The focus was to build capacity for embedding ICT into the education curriculum, school practices and to serve school communities' learning and development needs. Key to the envisioned project roll-out was a network of 80 digital hubs (also referred to as digi-hubs) installed and made to operate in the six participating countries. While some of the hubs served as digi-hub host schools, others served as centres of excellence; in both scenarios hubs were to support up to 10 other (satellite) schools within the catchment area of where the hub was cited. Schools could access the digi-hubs within their normal school hours guided by a timetable while students alike could visit the hubs to learn on their own outside school hours and also with their teachers. In some instances, schools allowed students to visit the hubs during the extra school time.

Cascading from the digital hubs, digi-hub ambassadors and master trainers were supporting schools and teachers in the project participating countries with ICT professional development and ongoing support during the 18 months-long project implementation period. Several months after implementation of the digi-hub technology solution, students who participated in the programme were expected to continue accessing the digi-hubs as well as implementing the projects' ideas. What remains to be done is a follow-up study to see if the ICT initiatives yielded the desired results in the way the students currently apply their computer knowledge and skills gained in their everyday life; within school and outside school settings. Thus, the purpose of this study was to provide a better understanding on how the educational technology solution influenced achievement of learning outcomes of the student target group, the ultimate beneficiaries of the initiative. The study is a follow-up of an earlier study (See Agyei 2020). While Agyei (2020), evaluated the impact the ICT initiatives on teachers' capacity building and the extent of transfer of the programme's ideas into classroom instructional practices, this study is an extension of the evaluation to explore the impact on student learning outcomes.

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LITERATURE REVIEW

According to Australian Qualifications Framework [AQF] (2013), learning outcomes describe the knowledge, skills and the application of the knowledge and skills a person has acquired and is able to demonstrate as a result of learning (AQF, 2013, p.97). Thus, learning outcomes should reflect significant and essential learning that learners achieve, and can reliably demonstrate at the end of a programme or training initiative. In this sense, learning outcomes, as situated in the study, were defined in terms of students improved attitudes with the use of computers, developed competencies in computer use and behavioural changed in using computers after participating in the ICT initiative. The following sections discuss the various outcomes as situated within literature and the context of study.

Student Computer Attitudes

Attitudes towards computers influence students' acceptance of the usefulness of technology, and also influence whether students will use computers for different purposes. Huang and Liaw (2005) pointed out that no matter how sophisticated and powerful the state of technology is, the extent to which it is implemented depends on users having a positive attitude towards it. Many research studies confirmed that there are several factors affecting computer attitudes such as gender, socio-economic status and age. Recent studies about the effect of age on attitude towards computers have shown that younger people tend to have more positive attitudes towards the use of computers than their older peers (Christensen & Knezek, 2006; Meelissen, 2008). This gives an indication that younger students are probable to use computers for different purposes than the older ones. Alkan and Erdem (2010) indicated that students generally have positive attitudes towards technologies and further pointed out that students from the fifth grade showed more computer attitudes towards interaction than students from preliminary stages. The study also showed that students who received training on ICT also showed strong positive attitudes than those who did not receive any computer training. Other related studies that have been conducted into attitudinal and motivation/personality factors towards technology in education contained questions about fear of computers, extent of liking technology, attitudes towards using technology in school, enjoyment in using computers, productivity/utility of computer, computer use for e-mails have shown strong links between pupils' attitudes and the effect on technology use (Marshall & Cox, 2008). According to Pamuk and Peker (2009), computer anxiety is the most important dimension of attitude towards computer scale; indicating that users who are anxious about computers tend to develop negative attitudes towards computers and express opposition to their use.

Computer Competencies

Research into computer competencies, also indicated with the terms *computer performance*, *computer ability*, or *computer achievement*, is in contrast to the large attention of studies in computer attitudes (Meelissen, 2008). Numerous studies have showed that computer competencies are positively correlated with an individual's willingness to choose and participate in computer-related activities, expectations of success in such activities, and persistence or effective coping behaviours when faced with computer-related difficulties (Looney, Valacich & Akbulut, 2004; Sang, Valcke, van Braak, & Tondeur, 2010; Smarkola, 2008). A number of other studies have described computer competencies to include computer knowledge and skills (Agyei 2012; Valavicius & Babravicius, 2012; Nwezeh, 2010). Valavicius and Babravicius (2012) reported low tendencies of ICT knowledge and skill in databases, spreadsheets and major concepts in ICT for college and university students whiles knowledge and skills in computer related tasks including text processing skills, file management and making presentations were rated high. Ariffin (2005) also reported low computer knowledge in skills among college students; only 17.9% of students had the skill to send e-mail messages, 16.4% knew how to search for information on the website and 20.6% print materials or images. In the study competency was described as one's ability to perform a computer task and was measured in students' computer knowledge and skill gained as a result of ICT initiative.

Students Use of technology

The use of different ICTs has become unavoidable for doing different tasks. Literature is key on students' use of technology in Education. Students can retrieve their information in a short space of time by using modern ICTs. They can use different modern ICTs, such as wireless network, Internet, search engines, databased systems, websites and Web 2.0, to access and diffuse electronic information such as e-books, e-journals and improve their learning. This has been observed in a number of studies such as Zakaria, Watson and Edwards (2010). Their study reported that students prefer to use search engines to access online tutorials to do assignments instead of asking friends or teachers for the information. Literature also demonstrates that, students' use of ICT is not only limited to learning but also, for interaction and recreation. The use of smartphones by students in the United States amounted to 83% and the Netherlands to 90% for interaction purposes (Mohamedhoesein, 2017). In their everyday lives, students interact using different platforms: text messaging, social media posts, e-mails, and other online media (Ha, Joa, Gabay, & Kim, 2018). Primarily, students interact using smartphones and social media networks such as WhatsApp, Twitter, Telegram, SnapChat, Facebook, Instagram, among others (Ha, Joa, Gabay, & Kim, 2018; Maweu &Yudah, 2020). With these platforms, students develop their own identity as well as communicate with friends and wider groups of peers (Ahn, 2011; Chua & Chang, 2016). Several studies (Harridge-March, Dunne, Lawlor, & Rowley, 2010; Awan & Gauntlett, 2013; Anderson & Jiang, 2018) have demonstrated a significant association between students' use of social media and their desire to connect online. Apparently, anxiety about missing out or avoiding social isolation inspires students to use social media for interaction purposes (Dossey, 2014).

In the context of this study actual use of computers by students who participated in the project were measured. The intent was to access whether the ICT initiative yielded the desired results in the way the students currently apply their computer knowledge and skills gained in their everyday life; within school and outside school settings.

Conceptual Framework

In alignment with the focus of the study, Guskey (2002) evaluation framework was adopted to measure Level 5**:** Student Learning Outcomes impact of the digi-hub technology solutions. Thomas Guskey is an educationist who has been writing for some time about the importance of seeking evidence of the effectiveness of interventions, professional development models, and programmes (see Guskey 1985, 1986, 1990, 1991, 1998). According to Guskey (2002), effective evaluations require the collection and analysis of five critical levels of information: level 1: participants' reactions; level 2: participants' learning; level 3: organization support and change; level 4: participants' use of new knowledge and skills and level 5: student learning outcomes. According to Guskey, the process of gathering evaluation information gets a bit more complex with each succeeding level. The framework also explains that success at one level is usually necessary for success at higher levels because each level builds on those that come before. As already mentioned, previous study reported in Agyei (2020) evaluated the first four levels of the ICT initiative described in this study with a focus on the worth of the programme in building capacity of school teachers to support embedding ICT in schools and classroom pedagogy. This study builds on the previous 4 levels of impact assessment; It seeks to cover informational gaps realized in the earlier studies and evaluates level 5 impact of the digi-hub innovation on student learning outcomes. Thus, the additional impact question addressed in this study essentially measured the extent to which the digi -hub technology solution led to improved students' practices to produce better learning outcomes with the use of computers. The focus was to understand how the project influenced the attitudes of the project ultimate student beneficiaries toward computers, their new gained competencies (knowledge and skills) as well as their behaviour in using computers.

Research Design and research question

The study employed mixed methods research design that included the collection of quantitative as well as qualitative data in conducting a robust evaluation of project impact on student learning outcomes. The design involved a field research to collect an in-depth data and information about the impact of the digi-hub technology solution on students' learning outcomes, reported in improved attitudes, developed competencies and behavioural changes in the use of computers. The main question that was addressed was: *How did the digi-hub technology solution intervention impact on the attitudes and competencies of students in the use of ICT for better learning outcomes?* The data collection design was particularly suitable in addressing the purpose and evaluation questions because of its potential to embed the qualitative analysis component of the students focused group discussions to enrich and interpret quantitative data results from the planned student survey.

METHODS

Participants

A total of 542 students from the six sub-Saharan African countries of Kenya, Tanzania, Uganda, Ethiopia, Ghana and Nigeria were involved in the study. A purposive sampling technique was employed to select 40-45 respondents who had opportunity to access digi-hubs in their schools/localities as individuals or accessed the hubs with their teachers and who had opportunities to work with technology in their schools. The respondents were selected from 2 schools (one each from the primary and secondary school levels) in each country. The highest number (163) of respondents was from Ghana constituting 30.1 % of the total number of respondents. The lowest response (43) was from Ethiopia and that constituted about 7.9 % of the total respondents. The reason accounting for the low response rate in Ethiopia, as was reported, was due to two factors: the survey was conducted during the school vacation period when most students had already gone home; the few schools left were in the final stages of the conduct of their examination and were preparing to go on vacation. Figure 1 shows an overview of the distribution of the respondents of the survey by country.

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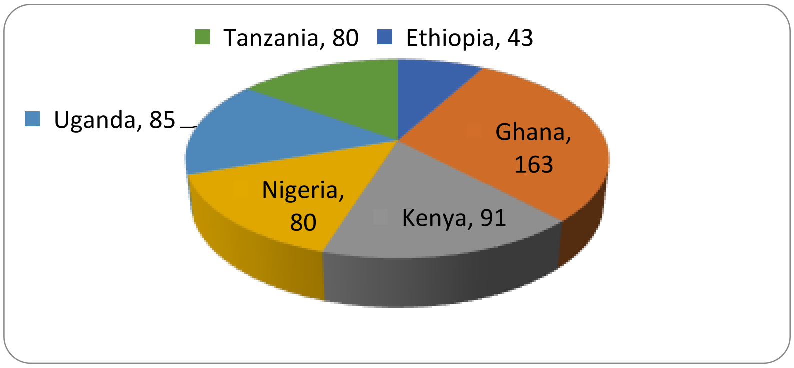

Figure 1: Distribution of Respondents by Country

The summary profile of the respondents' gender distribution showed slightly higher female to male ratio of about 52: 48. An aggregate analysis of the levels of the respondents occurred as follows: primary (39.6%) and secondary (60.4%). While the ages of respondents from the primary level ranged between 8-17 years (with the mean age nearer 12 years), ages of respondents from the secondary level ranged from 11-24 with the mean age of almost 16 years.

Research Instruments

Student questionnaire

This study adopted an online survey evaluation tool in which a semi-structured questionnaire was developed to collect data at the Level 5 of the Guskey model. The questionnaire had several sections. The first section of the questionnaire was used to collect data on demographical characteristics such as age, gender and level of study of respondents. Following were sections about students' attitudes towards computers, technology competencies (knowledge and skills) and students' experiences with computers or the digi-hub usage. The questionnaire also contained open ended questions. Details of items on the instrument are presented below.

Computer Attitude Questionnaire (CAQ)

Items from CAQ (see Knezek and Christensen (1995;1997) was adapted and modified to explore the attitude of the students that took part in the study. The CAQ is a 65-item Likert instrument designed to measure attitudes (feelings toward a person, or thing) and prevailing attitudes (dispositions), rather than achievement. Thirty-three of the items were selected as high loadings on the extracted factors after an exploratory factor analysis. In all, 5 sub-scales were used: enjoyment (student thoughts about experiences when using or talking about computers), anxiety (fear to use and talk about computers), benefit (students' perceived advantages of using computers/digi-hub to learn), interaction (willingness to use possible applications of computers for information use and dissemination) and instructional productivity (influence of teachers' use of digi-hub/computer use on the student productivity. The student respondents indicated to what extent they agreed or disagreed with items using the following four-point Likert scale: 1) strongly disagree, 2) disagree, 3) agree, and 4) strongly agree. The scores were interpreted as follows: 1 is the lowest possible score, which represents a very strong negative attitude, while 4 is the highest possible score which represent a very strong positive score. The internal consistency reliabilities for the five CAQ sub-scales are reported in Table 1.

Technology in Education Competency Survey (TECS)

Technology in education competency survey (TECS) (Knezek, Christensen, Miyashita & Ropp, 2000) is a self-report measure of technology competence. The TECS was adopted to measure the self-efficacies of the respondents on a four-point Likert scale ranging from 1 (not at all) to 4 (a lot). This instrument is a quick and reliable self-report measure for use in assessing technology competencies. Christensen and Knezek (2000) reported a Cronbach's alpha of 0.92. In this study, eight items of TECS were and slightly modified and used to measure students' confidence (technology competence) of doing a task on a computer. Two sub-scales: general purpose (confidence in using the computer to do general purpose task) and learning purpose (confidence in using computers to support students' learning) were used. The internal consistency reliabilities observed for the scales were general purpose (α =0.83) and learning purpose (α =0.79).

Open-ended Items

The survey also included an open-ended item which required student respondents to explain what they saw as good or bad in using computers or the digi-hubs as a result of participating in the programme. The main question that was addressed was: *What do you see as good about using computers in the digi-hub or in your classroom?* The focus was to explore the potential influence of the digi-hub post-training on the students' experiences and practices and thus to verify the potential enabling conditions for supporting their teachers' ICT implementations efforts.

Focus Group Discussion Guide (FGD)

The focus group discussion was meant to provide information about the extent to which the programme had improved students' practices and experiences of ICT use in the classroom and for various purposes. One focus group discussion was the target for each of the participating schools of the study (making two from each country); however, only one was possible in Ethiopia for reasons that have been explained earlier. A total of 84 students were involved in the 11 student focus group discussions from 11 schools: five were digi-hub host schools and six were satellite schools. While five of the schools were at primary level, six were at the secondary level. On average, focus discussion groups were made up of up to eight students.

The FGD guide was informed by Intel Guide to Monitoring eLearning Programmes (INTEL, 2010), an educational toolkit which provides suggestions and stakeholder protocols for evaluation of e-learning activities.

Data collection and analysis procedures

The questionnaire was uploaded in the survey monkey for the targeted students. Students recorded their perceptions on the items of the various instruments on their own or in some cases under the supervision of a teacher in the classroom environment, or a parent at home. Focused group discussions were led by skilled moderators to elicit responses and generate discussions among participants normally after school sessions and normally between a period of 45 minutes to one hour. All the discussions were recorded. To analyze the quantitative data, scale construction was done on responses from the CAQ (after the exploratory factor analysis) to capture the underlying constructs needed in ascertaining the target group perspectives of the digital programme and its impact on students' learning outcomes. Rescaling of some items was done to ensure both negatively and positively worded items were in one direction. In particular, rescaling of the anxiety scale was done so that a high score on some negative constructs about computer anxiety could be interpreted as lack of anxiety. Similar analysis was done for the TEC items. Descriptive statistics were further used to analyse the data set to determine the pattern of the respondents' experiences with computer use. Following that, t-test or analysis of variance was conducted to explore differences in the groups of participants of the study. Effect size was calculated, using Cohen's d (Cohen, 1969). Cohen

(1969) provided tentative benchmarks for the interpretation of effect sizes. He considers d= 0.2 a small, d= 0.5 a medium and d = 0.8 a large effect size.

Open ended items of the questionnaire and focused group data were analysed qualitatively using data reduction techniques in which major themes were identified and clustered (Miles & Huberman, 1994). This was followed by a systematic quantitative analysis of the occurrence of particular categories/themes. Afterwards, interpretative inferences were drawn from the patterns and frequencies generated in the content analysis. The themes and descriptions generated from the responses of the students in the open-ended item on the questionnaire are presented in Table 2 and Table 8 and Figure 2 in the results section. Those themes generated in the students focused group discussion are also reported in various areas under the results section

RESULTS

The study placed emphasis on relevant progress achieved and the effectiveness of a digital programme implementation in respect to student learning outcomes. The findings were reported from the perspectives of three target data sources, namely, students' questionnaire, open ended questions and students' focused group discussions. Furthermore, the results have been organized to embed a qualitative analysis component of students' views and understandings of the impact of the digital programme to enrich and interpret quantitative data results from the planned student survey.

Respondents' reported computer attitudes

The first level of the survey instrument focused on student respondents' views that illustrate the impact of the digital technology solution on students' attitudes towards using computers having had the opportunity to access digi–hubs in their localities/schools as individuals or with their teachers. The results showed overall positive high attitudes (M=3.57, SD= 0.241) (i.e., approximately 'strongly agree') towards the use of computers/digi-hubs for all participating students of the programme.

Table 1: Attitudes of students of all participating countries based on CAQ scores (n=542)

Subscale	**Cronbach's Alpha**	**Mean**	**SD**
Enjoyment	0.78	3.64	0.303
Benefit	0.80	3.53	0.235
Lack of anxiety	0.77	3.65	0.329
Interaction	0.72	3.44	0.624
Instructional Productivity	0.78	3.58	0.331
Overall attitude	-	3.57	0.241

Note: 4= strongly agree, 3=agree, 2= disagree, 1=strongly disagree

Table 1 shows a mean value of almost 4.00 (i.e., approximately 'strongly agree') for all the subscales suggesting that the innovation seemed to have impacted positively on all the various attitudinal variables. The students' *lack of anxiety* (M=3.65, SD=0.329) subscale, however, recorded the highest mean value. Thus, the findings indicate that students who were involved in the study had become less anxious and subsequently gained more confidence to use and talk about computers after participating in the programme. *Enjoyment* (M=3.64, SD= 0.303), respondents' thoughts about experiences when using or talking about computers, recorded the second highest mean value and *instructional productivity* (M=3.58, SD= 0.331), the influence the digi-

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hub/computer use have on students' learning productivity when their teachers use them in lessons reported the third highest mean value. Major themes that were identified, clustered and aligned from the open-ended item provided in-depth elaborations to the specific thematic issues or constructs developed for the closed-ended items of the questionnaire. Table 2 shows a close relationship between the scores generated from the themes for the open-ended questions and that of the closed items of the students' survey. The patterns evolving in the number of occurrences of themes were similar to the results of student's attitudes that was based on the CAQ scores. The highest percentages were reported on themes that had to do with students' *enjoyment* (30.3%) (e.g., providing recreation for students, games, videos etc.) and lack of anxiety (29.79 %), the confidence one can develop in the use of computers. The theme that recorded the least percentage (1.76%) had to do with the influence of teachers' instructional use of digi-hub/computer use on student learning productivity.

Table 1: Perceptions of the digi-hub/computer usage based on open-ended item

Subscale (CA)	Themes (from open ended responses)	% Response
Enjoyment	-serves recreational purposes fun and relaxation/playing games/ watching videos	30.3
Benefit	-save time/fast/easy/simplifies work -helps in students' research -provides rich information for students 'learning	24.87
Interaction	-aids in communication and interactions with friends and family -exposure to the whole wide world (e.g., participating in different chats groups internationally, finding scholarships, participating in projects etc.)	14.27
Lack of Anxiety	-builds one's confidence in computer usage	29.79
Instructional Productivity	-provides rich information for teachers' teaching	1.76

An analysis comparing student's computer attitudes of the partner countries was also conducted. The country by country analysis showed a similar overall trend as shown in Table 3. The highest reported attitudes of respondents in most countries were *enjoyment* and *lack of anxiety* subscales whereas *interaction* was the lowest computer attitude reported.

Table 3: Country by country analysis on computer attitudes of students based on the CAQ scores (n=542)

Subscale	Ghana	Kenya	Nigeria	Tanzania	Uganda	Ethiopia
Instructional Productivity	3.53	3.64	3.61	3.70	3.66	3.11
Interaction	3.35	3.55	3.64	3.66	3.58	2.46
Benefit	3.51	3.59	3.53	3.59	3.58	3.32
Lack of Anxiety	3.62	3.62	3.74	3.70	3.67	3.47
Enjoyment	3.64	375	3.60	3.82	3.50	3.42
Overall (SD)	3.53 (0.198)	3.63 (0.182)	3.62 (0.192)	3.69 (0.169)	3.59 (0.194)	3.16 (0.179)

Note: 4= strongly agree, 3=agree, 2= disagree, 1=strongly disagree

Table 3 shows to a large extent that the participating countries reported fairly high and nearly equal impact of the digi-hubs use on the attitudes except for respondents from Ethiopia. Ethiopia reported a relatively lower overall mean score of (M=3.16, SD= 0.179). A one-way ANOVA test was conducted to evaluate to what extent differences existed between the overall attitudinal subscale for all the respondent from the various participating countries. The ANOVA was significant (F (5, 536) = 43.604, p = 0.000) for the overall attitudinal scale. In particular, the differences were pronounced between the overall attitudinal score of Ethiopia and all the other countries respectively; while the other countries did not identify significant differences across their various attitudinal scale scores. It is not too clear why this observation was made particularly with respondents from Ethiopia; but as reported earlier, there were challenges regarding data collection from Ethiopia. Getting the right schools as well as the participants for the study was a great challenge; most students had already gone home for holidays and the remaining few were just completing the final examinations since all schools in Ethiopia were preparing to go down on vacations. This resulted in a significant limitation to the data collection and explains why 43 constituting only 7.9 % of the 542 total respondents came from Ethiopia. This study also sought to explore differences in attitudes between the two groups of participants (primary and secondary). The overall computer attitudes (secondary M =3.53, primary M = 3.63) as depicted by Table 4 shows higher positive attitudes reported by primary school respondents towards computers or digi-hub use compared to their counterparts from the secondary school levels.

Table 4: Differences in attitudes of primary and secondary students

Subscale	Primary (n=215)		Secondary (n=327)		Sig	Effect size
	M	SD	M	SD		
Lack of anxiety	3.65	0.342	3.64	0.320	0.641	-
Interaction	3.51	0.513	3.39	0.682	0.034[a]	0.20
Enjoyment	3.77	0.231	3.55	0.312	0.000[a]	0.80
Instructional productivity	3.62	0.310	3.54	0.340	0.003[a]	0.25
Benefit	3.57	0.229	3.51	0.238	0.009[a]	0.26
Overall attitude	3.63	0.214	3.53	0.250	0.000[a]	0.43

[a] *P< .05- analyzed with t-test. Note: 4= strongly agree, 3=agree, 2= disagree, 1=strongly disagree*

The t-test results showed a significant difference (p=000, d=0.43) with a small effect between the two groups. Similar trends were observed in all the subscales, *benefit* (secondary M =3.51, primary M = 3.57; p=0.009, d=0.26), *instructional productivity* (secondary M =3.54, primary M = 3.62; p=0.003, d=0.25), *Interaction* (secondary M =3.39, primary M = 3.51; p= 0.034, d=0.20) demonstrating that respondents from the primary level reported more positive attitudes than respondents from the secondary levels. However, the *enjoyment* (secondary M =3.55, primary M = 3.77) attitudinal subscale reported a more pronounced difference (d=0.80) with a large effect size in favour of respondents from primary school level. Interestingly, the score for *lack of anxiety* (secondary M =3.64, primary M = 3.65; p >0.05) subscale, was approximately equal and the highest reported indicating that students from both levels reported less anxiety to use and talk about computers after their involvement in the digital programme.

Respondents' competencies (knowledge and skills) in using computers/digi-hubs

Eight *technology in education competency (TEC)* items were used to measure the student's technology competency of doing a task on a computer or using the digi-hub. The results (Table 5) showed fairly high mean values (i.e., approximately 3.00) for all the items used to measure the students' technology competency.

Table 5: Students technology competencies based on TEC scores

Item	Mean	SD
Produce a letter using a word processing programme	3.33	0.968
E-mail to friends or teacher	2.92	1.208
Draw pictures or work with photos on the computer	3.37	0.980
Do research for school work with the computer	3.38	1.055
Chat with friends on the computer	3.07	1.213
Play games with the computer	3.47	0.933
Use the Internet (e.g., select suitable websites) to do my assignments	3.14	1.130
Find useful information for my lessons or my subjects on the internet	3.33	1.012

Note: 4= a lot, 3=somewhat, 2= a little, 1=not at all

Table 5 shows that the respondents seemed to be more competent or skillful in playing computer games (M =3.47, SD = 0.933) than any other skill required to perform various tasks on the computer. Competency in sending E-mails (M =2.92, SD = 1.208) with the computer was the least reported by the respondents.

Further analysis on the eight items extracted two sub-scales: *general purpose* (confidence in using the computer to do a general purpose task) and *learning purpose* (confidence in using computers to support students' learning). In general respondents seemed to be more competent or skillful in the use of computers for learning purposes (M =3.28, SD = 0.60) than for general purposes (M =3.23, SD = 612). This trend was also observed in the country by country analysis. Table 6 shows that apart from participants from Nigeria and Uganda, respondents from all other participating countries purported more competencies in using the digi-hubs/computers for the purpose of learning (such as finding useful information for their lessons on the internet or using the internet for assignments and doing research for school work with the computer) than using the digi-hubs/computers for general purposes (such as chatting with friends on the computer, sending emails to friends, producing letters and downloading or producing photos).

Table 6: Country by country technology competencies based on TEC scores

	Learning Purpose		General Purpose			Effect Size
Country	Mean	SD	Mean	SD	Sig	(d)
Ghana	3.44	0.465	3.34	0.642	0.037*	0.18
Kenya	3.29	0.503	3.13	0.626	0.050*	0.28
Nigeria	3.04	0.596	3.30	0.508	0.002*	-0.47
Tanzania	3.16	0.713	3.08	0.649	0.455	-
Uganda	3.24	0.740	3.26	0.598	0.767	-
Ethiopia	3.45	0.482	3.11	0.510	0.000*	0.69

In countries such as Ghana (p=0.037, d= 0.18), Kenya (p=0.050, d= 0.28), and Ethiopia (p=0.000, d= 0.69), the differences were pronounced between the two usage types with trivial, small and large effect sizes respectively; while Tanzania did not show any significant difference. Respondents in Nigeria (p=0.002, d= -0.47) just as in Uganda (p=0.767), however, reported more higher scores in using the digi-hubs/computers for general purposes rather for learning purpose but it was only in Nigeria that respondents differed significantly between the two usage types.

It was interesting also to explore the computer usage types among the two levels of students that participated in the study. The overall score for the general purpose (secondary M =3.28, primary M = 3.14) and learning purpose (secondary M =3.30, primary M = 3.26) suggest that the secondary students in general seemed to be more competent or skillful towards computers or digi-hub use than their counterparts from the primary school levels.

Table 7: Differences in TEC of primary and secondary students

TEC	Primary (n=214)		Secondary (n=331)		Sig	Effect size
	M	SD	M	SD		
General purpose	3.14	0.667	3.28	0.569	0.009[b]	0.48
Learning purpose	3.26	0.622	3.30	0.586	0.412	1.02

Scale: 1= not at all, 2 = a little, 3 = somewhat, 4 = a lot; [b]*p*< .05

The difference was particularly observed with the sub-scale on general purpose (p=0.009, d=0.48) suggesting that the secondary school participants in general developed their confidence in using computers to do general purpose task more than the primary counterparts.

Respondents' actual computer/ digi-hub use

A major question dealt with in the study was whether participants of the study were able to transfer their competencies (knowledge and skills) gained in the programme in the way they currently use computers in their everyday life. Thus, the different ways students actually use computers in the digi-hub or classrooms after the programme were explored and reported as shown in Table 8. Playing games (15.27%) was the highest ranked task students used the computers /digi-hubs for. This was followed by drawing pictures or working with photos (13.89%) and then doing research work (12.18%). The least reported was chatting with friends or teachers (5.29%).

Table 8: Students' reported use of digi-hub/computers

Usage of digi-hub/computers	% Response
Do research for schoolwork	12.18
Type your assignments	11.00
Prepare for a test	8.69
Send email to friends or teachers	5.77
Chat with friends or teachers	5.29
Create presentations and projects	10.10
Collaborate with others	9.31
Draw pictures or work with photos	13.89
Write stories or blogs or wiki or publications	8.50
Play games	15.27

Data gathered from students FGD from the respective countries also gave a better description about students' digi-hub or computer use. What was commonly reported among the student's groups was using the digi-hub or computers to play games. Nine out of the eleven (representing 81.82%) focused group discussions reiterated this. This was followed by the digi-hub use for research and academic purposes (72.72%) and the least reported in blogging (9.09) similar to what has been reported in Table 8.

The study also attempted to explore if differences existed between different ways the student groups actually use computers in the digi-hub or classrooms. Results from the open-ended items seem to put secondary school students higher when it comes to use computers/ dig-hubs in doing tasks that are more inclined to intellect or cognitive skills than their primary school counterparts (see figure 2). The evidence as shown in Figure 2 indicates that a higher proportion of secondary school students respondent reported on computer related task (e.g do research for school work and type school work) that are inclined to school work or academics and communication related tasks (sending emails to friends or teachers and chatting with friends or teachers) than the primary counterparts, while tasks (play games, draw pictures or work with photos, write stories or blogs or wiki or publications) that focus on motor skills or actions that require physical coordination (i.e. psychomotor skills) in the use of the digi-hubs seemed to be more the practice of the primary school respondents than their secondary counterparts

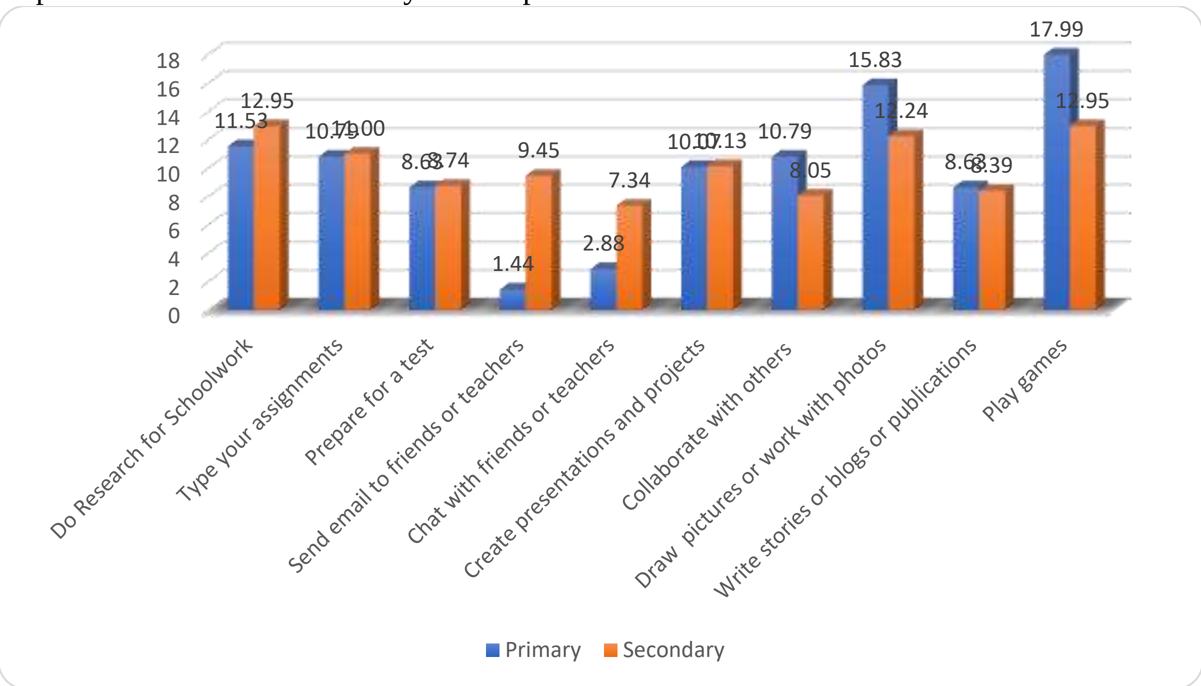

Figure 2: Comparison of usage of computers/digi hubs by student levels

Results of the FGD reiterated these findings. For example, in Ghana, one of the focused group discussions conducted among secondary level students reported:

> *Our favourite things are searching for different reading materials, searching for different information like news, and doing some practical work on the computer. In most times, we search for different materials to do our exercises and read from the tutorial videos. We learn the importance of using computer for reading and sharing*

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> *ideas with colleagues in other places. We don't like to use computers without internet connection.*

Another from the primary level group reported:

> *The most favourite things we do are using the computer to read, playing games and acquiring some practical skill on the computer.*

In Tanzania, one secondary focus group reported:

> *We use the computers for browsing to do our assignments, learning and communication. We also use computers most of the time during the lessons especially in computer subject, chemistry, biology, physics, geography and mathematics.*

The primary focus group also reported:

> *We learn how to move the mouse, keyboard, do typing, playing games and communication. Another interesting thing is how we can use computers to draw pictures and watch movies. Since the computers are not enough there is always a struggle over who should take control over keyboard and mouse.*

Thus, although the results present similar various tasks of the use the digi-hub computer resources, primary and secondary level groups differ slightly in the various tasks to a little extent as explained earlier.

Challenges to digi-hub use in facilitating students Learning Outcomes

There was a dichotomy among participants' comments in the students' survey and their focus group discussions. On the one hand, students expressed general satisfaction with use and impact of the digi-hub on their learning, but, on the other hand, they expressed dissatisfaction with existing facilities and their conditions (see figure 2) In particular, inadequate computers and projectors (32.1%) were reported by the student participants to be a real challenge faced in most of the hubs. The students explained in their FGDs that the computers in the hub centres were few compared to the rising number of students enrolled in the schools. As reported, some hubs resorted to group use of computers and sometimes queuing of students to have their time to use the computers.

Moreover, there were a number of issues relating to students' addiction (17.8%) to computers in the digi-hubs. As highlighted in some of the comments, some students waste much time surfing the internet, playing games and watching videos at the expense of their studies. In some cases, students spend the time playing games and chatting with friends while classes were on-going in the hubs. Others also absent themselves from class and spend more hours in the hubs doing same. What was more startling was that for some students, the long hours spent in the hubs were not used effectively to enhance their learning but rather indulging in the surfing of illicit materials such as pornographic pictures and films. The quality of the internet connectivity (10.7%) was also critiqued.

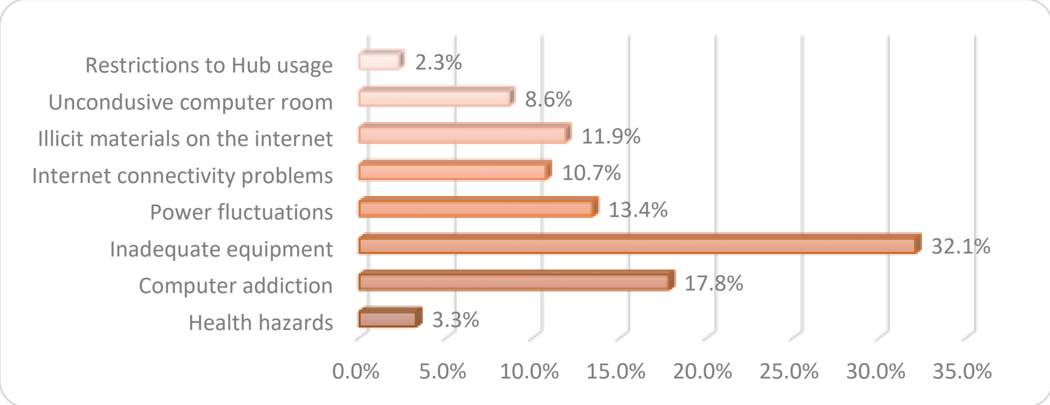

Figure 2: Student participants views on problems associated with digi-hub use

As some participants reiterated, '*the internet connectivity is very slow and not regular', s*ome complained that not all the computers were networked. The student participants also cited poor ventilation, dusty rooms and frequent power outages damaging computers; and limited and overheated work space as well as continuous breakdown of computers and internet services as detrimental to the overall quality of some digi-hub centres. Some student participants reported that there was not enough time for practice – some indicated that they have to follow strict time tables which do not allow them sufficient access to the hubs.

Others claimed they were denied access because lessons in the hubs required payment. Participants also expressed concerns about issues of health associated with the use of the hubs. Although these were not their conditions, some participants were of the view that, continuous use of the hub could lead to sight defects, spinal cord problems, stress and fatigue if care was not taken. This seems to suggest that various hubs need to organize regular training for its users to create the awareness on remedial measures to reduce or control the associated health hazards that come with the use of the hubs. The use of screen filter and movable chairs could also be recommended for use in such hubs. In spite of the enumerated challenges, the study seems to show that, exposing the students to the digi-hubs was a good way to help them gain their self-awareness and confidence, increase their understanding and develop new skills to use computer tools in their school studies and for other useful social purposes.

DISCUSSION

The study aimed at evaluating evel 5 impact of a digi-hub solution programme on student learning outcomes. The impact question that was addressed was: *How did the digi-hub technology solution intervention impact on the attitudes and competencies of students in the use of ICT for better learning outcomes?* Hence, the study focused on the impact of the digi-hub solution programme on students' performance measured in their improved learning outcomes. Learning outcomes were measured and reported in the form of improved students' attitudes, competencies (knowledge and skills) and their reported actual use of computers for different tasks in their learning in schools and outside school settings as a result of making use of the digi-hubs.

The results showed that the digi-hub/computers use impacted positively on all dimensions of attitudes measured in the study but *computer anxiety* and enjoyment were identified as the most important two which were impacted most by the digi-hub solution intervention. Thus, apart from the respondents in this study reporting less anxiety and being more confident to use or talk about computers, their *thoughts about computer enjoyment to use computers for various tasks were ranked high compared to the other subscales.* The results align with findings of Agyei and Voogt (2011) which reiterate "lack of anxiety" and "enjoyment" as the most important dimensions of attitudes on users' intention to use technology. Several other research studies (e.g. Bozionelos, 2001; Durndell & Haag, 2002) have evaluated computer anxiety as a separate construct and found a high relationship between attitudes towards computers and computer anxiety. Few researches have also supported the view that computer enjoyment (see Bagozzi, Davis &Warshaw, 1992) has a positive effect on the intention to use technology in classrooms.

In spite of the fairly high positive attitudes reported; the study further showed that computer attitudes of the primary school students' group were higher than that of the secondary school group counterpart. This assertion has been revealed in a number of other studies (Christensen & Knezek, 2006; Meelissen, 2008) that younger people tend to have more positive attitudes towards the use of computers than their older peers. This observation was made in all the various attitudinal subscales but was pronounced in the subscale for enjoyment; as younger students and novices, the joy of being exposed to computers for the first time might have influenced their thoughts in relation to experiences in using or talking about computers. Interestingly, the subscale on *lack of anxiety*, did not show any difference among the groups suggesting that the digi-hub programme promoted equal levels of self-awareness and confidence among the two groups of respondents to use and talk about computers after their involvement in the digital programme.The study also showed evidence that respondents developed their technology competencies. This was as a result of exposing them to the digi-hubs/computers initiative. Ozoemelem (2010) confirmed that exposing students to ICT training or initiatives are central for students to develop their knowledge and abilities. The most commonly reported skill was reported in the students' ability to use the digi-hub or computers to play games while the least was in using the hub/computer to send emails to friends. Undoubtedly, the students reported knowledge and skills more for computer related tasks that promote their learning (using computers to do research for school work, using suitable websites to do assignments and finding useful information for lessons or subjects on the internet) than tasks that are general purpose-related (e.g. producing letter using a word processing programme with computers, emailing to friends or teachers, playing games with the computer, drawing pictures or working with photos on the computer and chatting with friends on the computer). Furthermore, the study showed that respondents from the secondary level reported more competencies than their counterparts at the primary; especially, with regards to the general-purpose tasks with computers. This is consistent with studies conducted at the elementary school level and findings from earlier studies using the same scales (Knezek & Christensen, 2000; Knezek, Christensen, Miyashita & Ropp, 2000).

The relatively high ratings on skills for general purpose computer-related tasks might have been reported not because the secondary students were being exposed to computers for the first time; rather, the digital innovation intervention might have provided them with opportunities to develop their competencies in this respect much further (having been exposed to computers in their earlier ages) than their younger colleagues at the primary school level who were apparently having their first time experiences with computers in such a manner. Thus, this study asserts that competencies for doing general-purpose computer-related tasks are normally the first skills-set students develop when they start to work with computers at early ages; subsequently, they develop competencies for other computer-related tasks.

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The study also showed the extent participants were able to transfer their competencies gained as reported in the different ways they use computers to do different tasks in the digi-hubs or classrooms or everyday life. The most popular usage types of the hub as reported were for playing games, drawing pictures or working with photos and doing research/academic work. The best ideas and learning with the digi-hubs most participants associated with was the potential of the computers to enhance their understanding of various subjects in relation to projects or assignments given in which they were required to search for their own information to complete their task (cf. Zakaria, Watson & Edwards, 2010). There were not remarkable differences between the primary school and the secondary school levels of impact. However, the secondary school students reported more on computer-related tasks that were associated to schoolwork that needed them to apply more of cognitive skills, while the primary school students reported more of the tasks that focused on motor skills or actions that require physical coordination (i.e. psychomotor skills) in the use. Another critical area that showed differences among the levels had to do with task related to communication (sending emails to friends or teachers and chatting with friends or teachers). This was more the practice of the secondary school participants than their primary counterparts. It appears the concept of exchanging digital messages on the internet from one author to another, either instantly or at a later time was a difficult one to grasp and primary level respondents' group could have experienced some challenges practising such tasks.

While the evaluation results identified many potential improvements in the students' learning outcomes, the study showed that essential conditions to continue to support the use of the digi-hubs were seemingly not adequate. These resulted from a complex interaction of several variables that pose some threats to the continuous effective use of the digi-hubs. The underpinning factor had to do with an overwhelming number of students and the difficulty schools go through in accessing the digi-hubs. The results showed that computers in the hub centres were few compared to the rising number of students enrolled in the schools. As a result, some hubs had resulted to group use of computers and sometimes queuing of students to have their time to use the computers. Other problems that were observed included: internet connectivity problems in some hubs, inadequate equipment such as projectors, unconducive computer rooms and unfavourable time-tabling that guided the usage of the hubs by various schools in the same catchment area. The obvious and most critical issue that needs to be addressed is the question of sustainability in that the essence and utmost importance of ICT initiatives or research project must be to foster effective adoption that will support the long-term goals of the education policy (Niederhauser et al. 2018).

CONCLUSION

The findings of the study indicated that the digi-hub and its packages were well received and patronized by students from the participating countries. They were the reason for students' improved attitudes, developed competencies and positive behavioural changes in the use of computers. Nonetheless, the study showed that, essential conditions to support sustainability of the project ideas to school levels were seemingly not adequate. The study therefore asserts that for Sub-Saharan countries and countries of similar context, there is need for implementers of the ICT initiatives or research projects to put in place enabling conditions that foster continuous use of the programmes' ideas for effective adoption and support of long-term goals. These conditions should include institutional and systematic whole school approach for ICT use that cover domains of ICT vision and planning, school culture, ICT infrastructure and resources in order to sustain the initiative to achieve its overall aim.

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