The Level of ICT-Driven Collaboration during the Teaching and Learning Process in Rwandan Secondary Schools

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Abstract
Regardless of the investment that has been made in terms of Information and Communication Technology (ICT) in education in Rwanda secondary schools, poor performance in science subjects is still an issue. Therefore, this study examined teachers' perceptions on ICT-driven collaboration during teaching and learning. It investigated the collaborative tools used by students and the challenges they encounter. The study primarily utilized a descriptive survey with structured questionnaires. The data were collected from a sample of 10 Deputy Head Teachers, 40 science teachers, and 354 ordinary level high school students across the 10 selected schools in Rwanda. The study revealed that over 60% of science and basic computing teachers use online platforms for knowledge sharing and professional development. However, the findings revealed limited collaboration in designing ICT-led learning activities and using cloud storage for sharing teaching materials. Limited ICT skills, a lack of ICT gadgets, and unreliable internet connectivity contribute to students rarely or never using ICT collaborative tools.

Keywords: Active learning, Collaborative learning, Collaboration, ICT, Teachers, Schools.

Introduction

The teaching and learning process involves acquiring new knowledge, skills and attitudes that positively impact personal and societal development. In this vein, Information and Communication Technology (ICT) is gradually taking the stage, providing alternative and renovated approaches to support the teaching and learning process (Oduma & Ile, 2014).

According to Foutsitzi & Caridakis (2019), using ICT for teaching and learning has evident benefits. These range from cognitive, pedagogical, and affective domains of learning. It is also evidenced that ICT facilitates the teaching and learning process in the sense that it creates a conducive environment for learning and helps learners develop creative thinking and self-confidence-related attributes (Das, 2019). Also important is the fact that ICT supports students' collaboration and helps teachers provide feedback about students' work (Lomos et al., 2023).

Nonetheless, scholars like Goh & Sigala (2020) caution that for ICT to bring about the desired changes in the teaching and learning practices, there should be changes in the way the curriculum content is delivered. In this perspective, since secondary school students in Rwanda perform poorly in STEM (Science, Technology, Engineering and Mathematics) subjects, the present study has sought to examine the extent to which ICT-driven collaboration means and techniques are used in teaching and learning science and basic computing.

The assurance of ICT's potential to boost collaboration and thus positively impact teaching and learning is indeed provided by Orhani et al. (2023), whose study on ICT as a didactic tool has been proven to set the ground for the learner-centered learning environments and by extension, positively impact the teaching of mathematics subjects. Similarly, a study conducted at the University of Rwanda-College of Education involving postgraduate students indicated that online collaborative learning through small group discussions prompts knowledge co-construction and higher-order thinking skills in STEM subjects (Nungu et al., 2023). Furthermore, investment has been made to ensure the integration and use of ICT. This includes establishing smart classrooms, digital content development, and teacher training (Mugiraneza, 2021 ; Kimenyi & Wallet, 2019).

This study is well positioned considering the Rwandan education system, ICT is envisioned not only as a trigger for improved quality across all levels of education (MINEDUC, 2018) but also as a must-be tool to implement the Competence Based Curriculum (CBC) (MINEDUC, 2016).

Research Objectives

This study aims to examine the level of ICT-driven collaboration during the teaching and learning of science and basic computing in Rwandan secondary schools with the following specific objectives :

1. Examine the perceptions of teachers on ICT-driven Collaboration during teaching and learning;
2. Identify collaborative tools used by students during the teaching and learning process ;
3. Establish the challenges students face in using ICT to collaborate with fellow students in learning and propose potential solutions.

Literature Review

This section presents a review of the literature on ICT-driven collaboration in the teaching and learning process. It highlights, among others, tools, techniques, and benefits of using ICT-driven collaborative learning.

ICT- Driven Collaboration during the Teaching and Learning process of science and basic computing

Collaborative learning is a teaching and learning approach that involves groups of learners working together to solve a problem, complete a task, or create a product (Hernández-Sellés et al., 2019). With collaborative learning, students interact with one another, share knowledge, and encourage other group members to learn. This foundation of active learning has five basic elements: positive interdependence, individual accountability, promotive interaction, social skills, and group processing (Johnson & Johnson, 2019). Collaborative learning can occur in a face-to-face setting or be mediated by technologies (Hernández-Sellés et al., 2020).

The convergence of constructivist learning strategies, the growth of computer use, and the internet have inspired a new type of technologically mediated collaborative learning. This has led to the development of a specific

branch of constructivist teaching, formerly known as Computer-Mediated Communication (CMC) or networked learning, but now referred to as Online Collaborative Learning Theory (OCLT), where learners are encouraged to be active and engaged as defined by Harasim (2012).

Tools and Techniques for ICT-Driven Collaborative Learning in Teaching and Learning of science and basic computing

For students in different locations, collaborative learning tools facilitate their interaction. Such tools include video conferencing tools such as Google Meet, Zoom and Microsoft Teams. Video conferencing tools enable online communication through audio or video meetings along with a live chat. For example, using the screen-sharing feature, a teacher can share a PowerPoint presentation or a video with students (Widiyatmoko, 2021).

Learning management systems such as Google Classroom and Moodle include a forum component for collaborative learning (Şahin & Yurdugül, 2022). A teacher can post a discussion topic on the forum, allowing students to provide different ideas. Each student can see others' arguments and can formulate their ideas to improve or respond to previous ideas (Şahin & Yurdugül, 2022). Other collaborative learning tools include those that provide a shared workspace, such as Google Docs and Google Sheets (Paristiowati et al., 2020). These tools allow students to work on the same document, such as a group project report, simultaneously while being at different locations. Cloud storage tools such as Google Drive, DropBox, and OneDrive can also be used during the learning and teaching process. Students can use these cloud storage tools to save a big document which could not be shared otherwise.

Social software also supports a collaborative learning environment. This can be seen in different models where social software was produced to foster students' knowledge building by supporting and scaffolding students' higher-level thinking and collaborative activities. It brings up the possibility for students to share knowledge, fill knowledge gaps, provide unique interpretations, and express opinions, serving as resources for further learning, including WhatsApp and Facebook (Thurston et al., 2010). Besides, (Bell et al., 2010) described exemplary computer tools and environments that can be used to support collaborative inquiry learning processes. The mentioned tools were analyzed by describing their functionalities as well as their effects on student learning sciences.

Other computer-related technology tools, such as game-based applications and Interactive whiteboards, support cooperative learning. Games-based Applications like Kahoot promote autonomy, improve classroom dynamics, and increase student outcomes (Licorish, 2018; Mdlalose et al., 2021). Interactive whiteboards increase students' engagement and cooperation while solving common problems (Bodnenko et al., 2020).

To effectively utilize ICT tools and resources, including those for *ICT-Driven Collaborative Learning*, individuals need a range of ICT competences. According to Westera (2001), competencies encompass knowledge, skills, attitudes that represent the ability to cope with complex, unpredictable situations. To achieve effective teaching

and learning using ICT, the study (Akarawang et al., 2015) suggested that teachers must receive training to improve their ICT competences. A range of guidelines for successful training was suggested. The guidelines include thoroughly evaluating teachers' training needs before instruction and creating engaging and practical training materials in collaboration with teachers. Teachers must be exposed to ICTs regularly to determine and choose the best resources (Fernández-Gutiérrez et al., 2020).

Advantages of Collaborative Learning Tools in Teaching and Learning of science and basic computing

Previous research has shown that using collaborative tools to support the teaching and learning process positively impacts students' learning outcomes (Munyakazi et al., 2022). In a comparative study conducted on the Chemistry subject, it has been identified that students who used a collaborative learning tool achieved a learning gain of 83% compared to the 78% of those who did not use *the* collaborative learning tool (Paristiowati et al., 2020). ICT collaboration tools boost students' creativity (e. g., when they manipulate ICT tools and explore online websites) and promote communication and collaboration among students worldwide (Domalewska, 2014).

For teachers, collaborative learning tools can play a role in managing large class sizes during teaching and learning. They help control the students while they are in group work, allowing them to learn and solve the problem themselves with minor intervention from the teacher (Thurston et al., 2010). This allows the teacher to easily observe students interacting, explaining their reasoning, asking questions, and discussing their ideas and concepts.

While students interact with collaborative learning tools, the teacher is often required to provide technical support, improving their experience in manipulating ICT tools. Technology-supported collaborative tools also provide an opportunity for students to ask multiple questions (Piki, 2010). As the teacher addresses these various questions, it leads them to master the content. Thus, teachers and students benefit from collaborative learning as it raises the knowledge and ability to manipulate the ICT tools.

Similarly, it has been proven that Facebook is more interesting to students than the classroom environment. This is attributed to the fact that Facebook offers a rich learning environment and process, allowing teachers to share lesson materials (Tosun, 2018). Likewise, social networks enable communication between learners and teachers, provide a broad source of information (Tosun, 2018) and help students get feedback quickly on their learning process (Menolli, 2015).

The body of research also argues that without a shift in teaching and learning practices with ICT in schools, young people are unlikely to learn how to exploit the capabilities offered by access to ICT (Rubagiza et al., 2011). During students' interaction with a collaborative learning tool, the teacher is often required to provide technical support to students, improving their experience in manipulating ICT tools. The technology-supported collaborative tool also offers an opportunity for students to ask multiple questions. As the teacher addresses these various questions, it leads

them to master the content. Thus, teachers and students benefit from implementing collaborative learning as it raises knowledge and the ability to manipulate the ICT tools.

Challenges to ICT-Driven Collaborative Learning while Teaching and Learning science and basic computing

While technology-mediated collaborative learning provides several advantages, it is often perceived to have several challenges. Researcher (Piki, 2010) listed the following when teachers use collaborative learning tools mediated by technologies: limited network connection and accessibility, limited technical support, inadequate training, time constraints, and lack of teacher competency. The study by Muuro et al. (2014) found that the main challenges include lack of feedback from instructors, lack of feedback from peers, lack of time to participate, slow internet connectivity, and low or no participation of other group members.

Methodology

The present research used a mixed research design for researchers to be able to collect, analyze and interpret the data in relation to the objectives of this study. In this perspective, a descriptive survey was employed to investigate the level of ICT-driven collaboration during the teaching and learning process in selected schools. This method involved gathering predominantly quantitative data through structured questionnaires supplemented by qualitative insights from interviews with key informants. Collecting both qualitative and quantitative data aimed to enhance our understanding of the investigated phenomenon, thereby ensuring the reliability of the findings.

Sample and Sampling Techniques

A purposive sampling method was employed to select the ten schools from four provinces of Rwanda (Western, Eastern, Northern, and Southern) and the City of Kigali. The criterion for choosing schools was the availability of ICT facilities, especially a technology-enhanced classroom.

The target study participants were students at ordinary level and teachers of sciences (Biology, Chemistry and Physics), including those who teach ICT as a standalone subject. Specifically, this study's target population was 2,820 respondents, including ten deputy head teachers in charge of studies, 40 teachers (from biology, chemistry, physics, and ICT subjects), and 2,760 lower secondary students. All these are from the ten different schools selected for this study. In total, 40 teachers and ten school leaders in charge of studies were selected and participated in this study. Also, 354 ordinary-level high school students, particularly seniors two and three, were purposively chosen.

Data Collection Tools

Data were collected through a structured questionnaire with open-ended items and an interview guide. The questionnaire items were derived from the conceptual elements of the literature review. The questionnaires were administered to students and science teachers, while the interview guide was used to collect data from school leaders in charge of studies.

For this research, researchers opted to use inter-rater reliability. Before being administered to the participants, the data collection tools were piloted on a small sample of teachers and students. The piloting was done to uncover any ambiguous questions, responses' biases, assess the practicality of administering the tools, and gauge participants' understanding of the items in the questionnaire or areas where participants could face difficulty comprehending. The piloting feedback helped refine and improve the tools to ensure reliable and valid data collection. After refining the tools, they were administered to the participants in printed form. That process also provided the researchers with content validity.

Data Analysis

The collected data was digitilized for easy analysis, while the interviews were recorded and transcribed. Univariable analysis using frequency distribution tables was conducted for quantitative data, while qualitative data was thematically analysed. The main themes were derived from the transcribed data, which were further categorised into sub-themes based on the objectives of the study. Quantitative and qualitative data were presented using tables, figures, and narrative.

Findings

This section presents the study's findings, describing teachers' perceptions of ICT-driven collaboration during teaching and learning. It highlights the frequency with which students use various collaborative tools for online learning purposes, the difficulties encountered when using ICT to collaborate with their peers in learning, and the challenges to ICT-led engagement and collaboration in active teaching and learning of sciences and basic computing.

Perceptions of teachers on ICT - driven collaboration during the teaching and learning

Teachers ' perceptions regarding ICT-driven collaboration during teaching and learning activities were assessed, and the table below provides details of the responses.

Table 1

Teachers' responses to focused statements about ICT-driven collaboration in the teaching and learning process

SN	Statement	Strongly disagree n (%)	Disagree n (%)	Agree n (%)	Strongly agree n (%)
1	We mentor each other on the use of ICT for teaching-related purposes	1 (2.5)	10 (25)	22(55)	6 (15)
2	I encourage my students to collaborate in learning using ICT (e.g., sharing learning resources and creating learning communities)	2 (5)	7 (17.5)	25 (62.5)	5 (12.5)

3	I use online platforms (e.g., REB-eLearning) for knowledge sharing and professional development	5 (12.5)	8 (20)	21 (52.5)	5 (12.5)
4	I collaborate with colleagues to design ICT-led learning activities for students	5 (12.5)	15 (37.5)	16 (40)	3 (7.5)
5	My school organises workshops on the use of ICT collaborative teaching and learning tools such as Google Slides, Google Classroom, docs, teams, forums, and others.	7(17.5)	14 (35)	17(42.5)	1 (2.5)
6	I use cloud storage services (e.g., Google Drive, OneDrive, or Dropbox) to develop and share teaching materials with peer teachers	9 (22.5)	16 (40)	13 (32.5)	1 (2.5)

Source : Primary data (2023).

It is worth noting that one respondent chose not to respond to this particular question, which reduced our sample from 40 respondents to 39 respondents for this item. In this table, n represents the actual number of respondents, whereas the numbers in the parenthesis are percentages.

Table 1 shows varying responses to focused statements about ICT-driven collaboration in the teaching and learning of science and basic computing. More than 60% of the respondents agreed or strongly agreed with statements such as: 'We mentor each other on the use ICT for teaching-related purposes', 'I encourage my students to collaborate in learning using ICT (e.g., sharing learning resources, creating learning communities)'; and 'I use online platforms (e.g., REB-eLearning) for knowledge sharing and professional development'. On the other hand, over 50% of the respondents disagree with statements such as: 'I collaborate with colleagues to design ICT-led learning activities for students', 'My school organises workshops on the use of ICT collaborative teaching and learning tools such as Google Slides, Google classroom, docs, teams, forum, and others' and 'I use cloud storage services (e.g. Google Drive, OneDrive, or Dropbox) to develop and share teaching materials with peer teachers.

These findings suggest that teachers are making efforts to leverage information and communication technologies to collaborate and interact with each other for teaching-related purposes, knowledge sharing and professional development. Moreover, the findings also indicate that teachers encourage their students to collaborate

using ICT to share learning resources and create learning communities. Focus Group Discussions (FGDs) further revealed that the ICT-driven collaboration among teachers involves online discussions and sharing of resources and materials through digital platforms. These results corroborate the findings of Munyakazi et al. (2022), which show that utilising collaborative tools in teaching and learning positively impacts students' learning outcomes. Paristiowati et al. (2020) also found that students who utilized a collaborative learning tool achieved a learning gain of 83% compared to 78% for those who did not use the tool. ICT collaboration tools enhance students' creativity by enabling them to manipulate ICT tools and explore online websites while promoting communication and collaboration among students worldwide (Domalewska, 2014).

The findings of the present study, however, reveal that while teachers are taking initiatives to use ICT-driven collaborative teaching and learning science and basic computing, there appears to be minimal collaboration specifically in designing ICT-led learning activities for students and utilizing cloud storage services (e.g., Google Drive, One Drive, or Dropbox) to develop and share teaching materials with peer teachers. Interviews with key informants suggest that this lack of collaboration can be attributed to insufficient ICT skills and lack of regular access to ICT facilities.

Usage of collaborative tools by students for online learning purposes

The frequency with which students use various collaborative tools for online learning was assessed, and Table 2 provides details of the responses.

Table 2

Frequency of usage of ICT tools for online learning purposes

SN	Tool	Never n (%)	Rarely n (%)	Often n (%)	Very often n (%)	Mean
1	Computers (Desktop/Laptop)	46 (12.8)	102 (28.5)	113 (31.6)	93 (26)	2.71
2	Telephone	116 (32.4)	59 (16.5)	60 (16.8)	116 (32.4)	2.5
3	Facebook	174 (48.6)	57 (15.9)	38 (10.6)	88 (24.6)	2.11
4	Emails	197 (55)	75 (20.9)	49 (13.7)	36 (10.1)	1.79
5	WhatsApp	230 (64.2)	60 (16.8)	45 (12.6)	20 (5.6)	1.59
6	Video conference	243(67.9)	47 (13.1)	31 (8.7)	32 (8.9)	1.58
7	Online Forums	265 (74)	53 (14.8)	24 (6.7)	12 (3.4)	1.39
8	Twitter	299 (83.5)	38 (10.6)	9 (2.5)	11 (3.1)	1.25
9	Postcards	285 (79.6)	29 (8.1)	7 (2.0)	5 (1.4)	1.18
10	Wikis	315 (88)	23 (6.4)	10 (2.8)	6 (1.7)	1.17

Source : Primary data (2023). Here, *n stands for the actual number of respondents, whereas the numbers in parathesis are percentages.*

As depicted in Table 2, apart from computers/desktops and telephones, for which the responses are skewed towards "often," the general trend of responses indicates that all other tools assessed are rarely or never used by students for online learning purposes. Upon further probing, it was pointed out that the plausible reasons for students' minimal or no use of collaborative tools include limited ICT skills, insufficient time allotted for ICT use, and unreliable internet connectivity.

These findings align with Piki's (2010) assertion that technology-mediated collaborative learning, despite its numerous advantages in terms of collaboration among students and teachers through digital platforms, has associated challenges. These challenges include, among other things, limited network connectivity and accessibility, insufficient technical support, inadequate training, time constraints, and inadequate ICT skills among teachers and students. The present study's findings also agree with Muuro et al. (2014), who found that student online collaborative learning is constrained by factors such as lack of time to participate and slow internet connectivity.

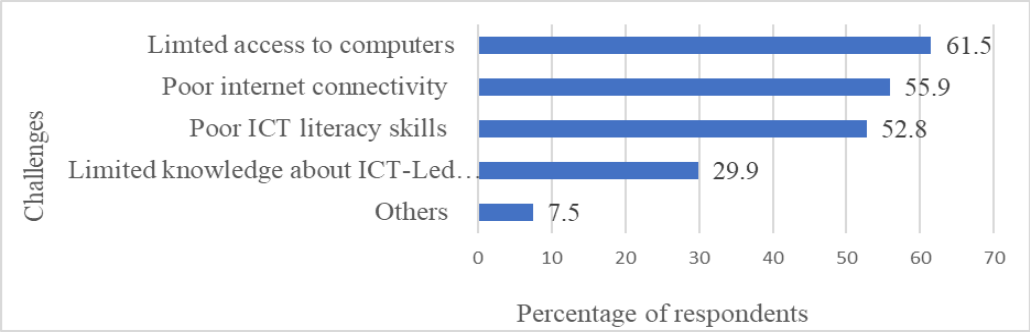
It can be argued that the effective use of collaborative digital tools can enable students to develop digital literacy skills and encourage active participation and engagement. Collaborative digital tools can also create opportunities for students to interact with their peers and exchange ideas. Collaborative learning tools are helpful for teachers, especially in managing big class sizes during teaching and learning. They facilitate the control of students during group work and allow them to learn independently with minimal intervention from teachers (Thurston et al., 2010). Moreover, these tools enable teachers to easily observe student interactions and discussions of learning materials.

Challenges faced by students in using ICT to collaborate with each other in learning

The perceived challenges encountered by students in using ICT to collaborate with each other in learning were explored. Students were requested to rate the challenges they faced according to their magnitude. Figure 1 presents details of the students' ratings

Figure 1

Challenges students face in using ICT to collaborate in learning



Source : Primary data (2023)

Figure 1 shows that the main challenges militating against student use of ICT to collaborate with each other in learning include limited access to computers (61.5%) followed by poor internet connectivity (55.9%) and poor ICT literacy skills (52.9%). Although not mentioned by a large proportion of respondents, other challenges include limited knowledge about ICT-led collaboration practices, unstable electricity, poor English Language proficiency, a large number of students compared to available computers, and a lack of sufficient ICT teachers.

The challenges mentioned above were also echoed by key informants (Deputy Head Teachers) during the interview. They pointed out that learners' level of ICT use is still low and that learners hardly get sufficient time for hands-on practice on computers. It was also revealed that the time dedicated to ICT skills is not enough. Through interviews, the key informants further mentioned several challenges t related to attitude, knowledge, workload, and skills/level of ICT proficiency. These include but are not limited to lack of digital learning resources/materials; big workload of teachers; inadequate/lack of training on the use of ICT in collaborative teaching and learning; lack of skills in collaborative tools such as Google Forms, Google Classroom, google documents; school leaders' negative attitude towards ICT adoption; overloaded curriculum content; limited time to use ICT to prepare teaching and learning materials; and management of big class sizes, among others. It was also pointed out that the number of computers is not commensurate with the number of students, making it difficult for all learners to collaborate effectively in learning sciences and basic computing. It was found that even in schools with a reasonable computer-student ratio, students do not effectively use them due to the little time allocated to ICT coupled with insufficient ICT teachers. The study found that some computers in the sampled schools were not functional, and maintenance support came late, hampering students' use. Some schools operate during the day, meaning students cannot access ICT tools at home. As a result, they are unable to engage in collaborative learning activities and share learning materials with each other, thus impeding the use of ICT in learning science and basic computing. Additionally, it was noted that students misuse the opportunities they have in smart classrooms. Instead of using their time for learning purposes, such as searching for relevant learning materials, they squander it by playing games, watching videos, and watching movies.

Conclusion

The findings of this study highlight significant obstacles faced by teachers, including insufficient ICT skills, limited access to ICT facilities, and lack of familiarity with ICT-driven collaboration tools. Based on these findings, the paper concludes that prioritizing teachers' access to and proficiency in using ICT is crucial for achieving a modernized approach to teaching science subjects. This emphasis on ICT skills is seen as imperative for positively influencing learning outcomes in science and computing basic education.

Recommendations

Based on the study findings, several recommendations are proposed to enhance ICT-driven collaboration in the teaching and learning of sciences and basic computing. Providing professional development opportunities for teachers of science and basic computing subjects is recommended, especially focusing on the effective utilization of ICT in collaborative teaching and learning. Furthermore, the continuous journey of ICT penetration into schools, encompassing aspects such as electricity, computers, and Internet access, should be a concerted effort involving the government, Development Partners (DPs), and school initiatives. Lastly, there is a suggestion to cultivate a culture of collaboration among students and teachers, aiming to improve practices in terms of resources and knowledge sharing. These might be done through the school-based Community of Practice (CoP). Researchers would like to inform that the results cannot be generalized due to the limited sample size. However, they mirror the real picture of the intended outputs and hence can be used by researchers who might wish to dig deeper into this research domain.

Acknowledgement

This research was supported by a grant from the Leaders In Teaching (LIT) supported by MasterCard Foundation. We would like to express our gratitude to LIT for their generous support. Their funding played a crucial role in the successful completion of this study.

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