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| Research Article

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Technology Integration and Science Students' Learning Outcomes

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Annotation
This study titled technology integration and science students' learning outcomes at secondary school level. The study was guided by three research questions: How does different levels of technology integration affect student learning outcomes? What is the effect of horizontal technology integration on student learning outcomes? What is the effect of vertical technology integration on student learning outcomes? Descriptive survey design was used for this study. The sample size of 90 was made up of thirty (30) teachers and 60 students from three selected schools within the Bamenda municipality. Two four-point Likert scale questionnaire were used to collect the data from the respondents. One for students and the other for teachers. The quantitative data obtained were subjected to descriptive statistical analysis, using SPSS 23.0 package program. The findings of this research show that.

Keywords: Technology Integration, Science Subjects, Student Learning Outcomes.

Introduction:

In a society that is rapidly becoming digitalized, and the use of technology has become a necessity. D'Angelo (2018), and Yılmaz (2021) are of the view that students need to use technology to have a good understanding of course content and to acquire knowledge, skills and competences that they need to belong to the work force. The use of technology in the classroom enables learners to be motivated, highly engaged and promotes learning in the classrooms. Using technology as a teaching tool to increase students desire to learn and this can result in better learning outcomes. According to Higgins et al. (2012), technology enables teachers present concepts more efficiently which makes students to learn with ease. Learners are surrounded by technology, at school and at home says Kouser & Majid (2021), and they are always using one type of technology or the other. Technology used for learning is a combination of teaching methods and different digital tool that work together to improve the teaching and learning process. Incorporating technological tools and resources promotes student engagement, promotes creativity, critical thinking, and problem-solving. Kaya & Adiguzel (2021) points out that improving students learning capabilities requires integrating technology into the curriculum.

Science nurtures curiosity in students' and helps them to make sense of their learning environment (Dantic Atrero & Rogayan 2023). In this study, it is divided into sub-branches such as physics, chemistry and biology. Science is necessary to enable students acquire scientific process skills,

gain systematic working habits, and to find solutions to problems encountered in daily life. Atrero Dantic & Rogayan (2023) are of the view that it helps to improve analytical, critical, reflective and creative thinking in students. Science also enables easy integration of technology and to have alternatives for adapting course content to technology (Yılmaz 2021). The benefits of technology-enhanced learning are many hence understanding the impact of technology integration on science student learning outcomes in schools is important for educational practices. It is therefore necessary for technology to be used in the curriculum to provide instructors with an invaluable opportunity to enhance student engagement and learning outcomes (Dinc 2019).

Literature Review

Technology is used to enhance the outcomes of teaching and learning in schools. Kalyani (2024), opines that technology has increased innovation in the teaching and learning process and according to South & Stevens (2017), it is used to personalize learning and give students the opportunity to decide how they learn and at what pace. Technology tools increase flexibility and learning supports. According to Wang (2017), it helps to produce an interactive way of learning by providing hypertexts which help extend and enrich the content to be studied. This enhances students' motivation and interest in learning, and makes learning to be active. Alvarado-Barboza (2023), is of the view that teachers need to yield to the explosion of knowledge brought about by technological tools and devices by using them in the teaching and learning process. This requires the modification of existing teaching methods according to students needs since they find the use of technology particularly helpful Kim and Kim (2017). Teachers therefore need to make use of technological devices and tools which according to Timotheou et al. (2023) are agents of change both in the nature and scope of education. They have brought about new strategies and policies to be adopted for their integration in schools and educational systems worldwide.

Technology integration

Technology integration in schools is an ongoing process which requires attention from all stake holders. Kimmons (2020), sees it as the meaningful use of technology to achieve learning objectives. This involves incorporation of digital tools, resources, and devices into educational practices to support teaching and learning. Nana (2007), describes technology integration as the use of technology resources such as computers, mobile devices like smartphones and tablets, digital cameras, power point devices networks, software applications in daily classroom practices, and in the management of a school. Integrating technology into the classroom is often challenging and presents teachers with some difficulties. In order to make learning more engaging and effective, it is necessary to have technology in the classroom. Bhat (2023) is of the view that technology integration in schools is a dynamic process that enables educators to purposefully incorporate technological and digital tools and resources into teaching in order to enhance learning. Kaya & Adiguzel (2021) says that when students are taught by integrating technological tools, they have the ability to critically and cognitively analyze problems. Technology integration also encourages the development of skills such as communication, critical thinking, collaboration, problem solving and computational thinking (Tripett, 2023; Ali et al (2023); Scalise, 2016; Shaltry, Henriksen, Wu, & Dickson, 2013). In addition, technology integration creates exciting teaching and learning environment which fosters the enhancement of motivation of learners and desirable learning outcomes. Technology integration can empower teachers and learners in the teaching-learning processes to develop their creativity, problem-solving abilities, informational reasoning skills, communication skills, and other higher-order thinking skills. Pascale, Gorghiu & Gorghiu (2017) are of the view that the inclusion of technology into teaching methods and activities will improve learning in schools. Tripett (2023) describes the process of integrating technology into the teaching and learning of STEM subjects which includes science subjects as having many benefits. According to Chongwain (2024), both science teachers and students a have great adaptability and enriched collaboration, to make learning more motivating, when technology

devices are used around the school and in the classroom. Ali et al (2023), suggest that the integration of technology has a favorable influence on mathematics students' motivation, attitudes, engagement and academic achievement.

Technology integration brings about modifications in the teaching and learning process, which makes learning fun and effective (Pascale et al. 2017; Dancsa et al. 2023). Hence using technology in the classroom can bring about many benefits (Mittha 2021; Tripett, 2023). Some of the benefits of using technology include; enhanced feedback between teachers and learners, better connections between teachers and students, parents, and other key stakeholders, improves adaptability especially to accommodate different learning styles. Technology also promotes enriched collaboration from peer discussions to formal group project work for both teachers and learners, D'Angelo (2018).

In a world filled with technological tools and devices, Dede (2009) & Nair (2021) are of the view that the availability technological devices and use of technical skills is a requirement for using technology in the classroom. Technology integration needs to be introduced into the teaching and learning process gradually with focus on curriculum content. The integration of technology into the teaching and learning process does not only make the teacher to be at ease when teaching, but it is also used to enhance learning. Roblyer & Hughes (2018). It is also important for to ensure that students get the full advantages of educational technology. Thus, technology integration will may promote both teachers' activities and students learning outcomes.

Levels of technology integration

Levels of technology integration include entry, adoption, adaptation, infusion and transformational levels. Entry level of technology integration involves active learning and students receive information from the teacher or from other sources passively. Sources of information can range from instructional video on a website to using a computer program for "drill and practice" activities. The teacher may be the only one actively using technology Ain et al (2019). This may include using presentation software to support delivery of a lecture. The teacher may also have the students complete "drill and practice" activities on computers to practice basic skills (Kalyani, 2024 & Haelermans, 2017). At the adoption level of technology integration, the teacher directs students in the conventional and procedural use of technology devices. At this level, the devices are used in conventional ways. The teacher decides what technology device that the students will use. They are expected to carry out work that involve procedural understanding (Haelermans, 2017; Fahadi et al. 2022). The adaptation level of technology integration, the teacher selects appropriate technology tools to complete set teaching and learning activities that have a meaningful context beyond the instructional setting. Students regularly use technology tools, and are comfortable in choosing and using the tools that best match the assigned task which enables them to achieve individual interests (Kalyani, 2024). The transformation level allows for innovative use of technology devices to carry out higher-order learning activities that may not be possible without the use of technology. At this level students use technology tools flexibly to achieve specific learning outcomes. This leads to students having a good understanding of concepts and what technological devices to use. The teacher at this level is a facilitator or mentor, who models technologyusage (Haelermans, 2017).

Horizontal technology integration

Horizontal technology integration involves using technology to connect different aspects of the curriculum and learning environment. This approach focuses on utilizing technology to enhance communication, collaboration, creativity, critical thinking, and assessment within a specific grade level. The horizontal integration occurs between parallel contents taught at the same stage or level of the curriculum. According to Keengwe et al. (2019), communication and collaboration in the classroom enhances horizontal technology integration. Technology facilitates communication

between teachers, and students, which improves connected learning environment. Lee & Lee, (2018) are of the view that it increases creativity and critical thinking resulting in acquisition of problem-solving, and higher-order thinking skills. Learners diverse learning styles and needs according to Chu et al. (2020) are also taken care of when allowed to participate in individualized instruction, using horizontal technology integration; they gain personalized learning experiences. Teachers can create a more engaging and effective learning environment by engaging in horizontal technology integration to enhance teaching and learning. This will result in improved learner outcome. The use of horizontal technology integration increases communication, collaboration, creativity, critical thinking, and personalized learning experiences, among students at the same level of learning.

Vertical technology integration

Vertical technology integration focuses on aligning technology use and learning experiences across different educational levels and between disciplines traditionally taught in different phases of the curriculum. Vertical technology integration according to Lai & Hwang (2016) facilitates a smoother transition between educational levels by ensuring familiarity with technology tools and expectations. Boswell, Gersten, & Dimino (2017) opine that vertical technology integration enhances curriculum alignment, and aligning technology use across levels helps ensure that students build upon previously learned skills and knowledge, fostering a more coherent learning experience. Bhat (2023), states that technology integration promotes improved learning outcomes. When teachers from different grade levels are involved in planning and implementing technology integration, alignment and continuity as well as collaborative planning is ensured. This according to Acemoglu et al. (2010) also enhances their understanding and skills development in using technology effectively thereby encouraging the professional development of the teachers. Vertical technology integration has the potential to enhance teaching and learning by creating a more cohesive and progressive learning experience. By aligning technology use and learning objectives across educational levels, educators can prepare learners for success. (Mittha 2021, Higgin Xiao & Katsipataki 2012).

Learning outcomes

Learning is viewed as a process of acquiring, organizing, and retrieving information, guided by cognitive structures and strategies. Learning outcomes are statements of the knowledge, skills and abilities individual students should possess and can demonstrate upon completion of a learning experience or sequence of learning experiences and are similar to learning objectives (Zama & Endeley, 2023; Sc.edu, 2024). They can also be seen as measurable skills, abilities, knowledge or values that students can demonstrate at the end of a period of study. Learning outcomes can be defined according to Bhat (2023) as the end result of what the learner is expected to do or produce by the end of any course. These outcomes hold enormous value for educators, administrators, and students. It allows instructors or educators to assess the students' understanding. Goh et al. (2017), are of the notion that interaction with other students makes the strongest contributions to learning outcomes especially with technological devices. Among all learning activities and experiences that learners participate in, while at school, technology integration and improved learning outcomes in areas like literacy, numeracy, and social-emotional development (Wong, 2017).

Theoretical Review

Theoretically, technology integration in this study is based on connectivism and social constructivism theories. Social constructivism theory postulates that learners actively construct their knowledge through interactions with more knowledgeable others and within their social environment. According to Vygotsky (1978), the student can learn through social interaction with a skillful person. This perspective offers valuable insights for the integration of technology. Technology integration in the classroom is based on social constructivist principles. Vygotsky

refers to this as cooperative or collaborative dialogue. It involves co-construction of knowledge between the students and teachers allowing them to engage in shared learning experiences, exchange ideas, and collectively solve problems (Saleem Kausar & Deeba (2021). Social constructivism is also based "zone of proximal development, (ZPD)" which promotes the learners' acquisition of knowledge skills and attitudes with the guidance and support of more capable individuals. Studies have shown that when students seek to understand technology guided instruction provided by the teacher, and they master the concepts, they can use it to regulate their learning outcome. Social interaction, therefore, supports learners in the ZPD, leading to a higher level of reasoning. Chen, Law & Huang (2023); Chang & Yang (2023); Wang, Gao, & Chen (2024). Connectivism theory focuses on connecting information sources and technological devices in the learning process through group interaction and conversation, which allows learners to express their opinions when making choices, solving problems Pappas (2023). Connectivism according to Downes (2022) focuses on learning which occurs throughout human and non-human networks and also on the learner's capacity to function within a wider interconnected community. Learners therefore need knowledge is the network that is grown and developed from interactions with other entities in the network. Pappas (2023) is also of the view that connectivism also encourages education through online communities, blogs, and other public spaces.

Technology integration promotes and supports collaborative learning environments. And teachers require adequate training and support to effectively integrate technology and leverage the principles of connectivism in their classrooms (Alvarado-Barboza 2023; Pascale et al. 2017; Kropf, 2013; Higgins et al. 2012). Hence the objective of teaching is to stimulate interactions, collaborative and constructivist learning which can be achieved by technology integration.

Statement of the Problem

The use of technology in education, makes teaching easier for the teacher and motivates students in the learning process. Technology tools and resources can offer new opportunities to engage students, foster creativity, and promote skill development in areas such as literacy, numeracy, critical thinking, problem-solving skills among others. Understanding the impact of technology integration on student learning outcomes for optimizing educational practices and preparing science students for success is paramount in this technological age. Despite the growing emphasis on technology integration into schools, gaps exist in the understanding of the impact of technology on student learning outcomes. The effectiveness of technology tools in enhancing learning, the benefits of technology integration, and the optimal strategies for incorporating technology into the teaching and learning process remains unclear. This study intends to provide valuable insights into the impact of technology in shaping educational experiences of students. The integration of technology devices, such as computer, telephone and television, has significantly impacted the teaching methods in recent years. However, the levels of technology integration and the extent to which these technologies have impacted the learning outcome of science students is not very clear. Some institutions have incorporated and used various technological tools to enhance learning experiences. Yet, the integration of these technologies has not been consistent leading to concerns about the potential for widening the gap in educational outcomes. This research therefore aims at investigating the impact of technology integration and science students' learning outcomes at secondary school level.

Objective of the Study

The specific objective of this study is to:

- Find out the effect of levels of technology integration on science students learning outcomes (entry, adoption, adaptation, infusion and transformational level)
- Examine the effect of horizontal technology integration on science students learning outcomes.

- Find out the effect of vertical technology integration on science students learning outcomes.

Research Questions

- How does different levels of technology integration affect student learning outcomes?
- What is the effect of horizontal technology integration on student learning outcomes?
- What is the effect of vertical technology integration on student learning outcomes?

Methodology

A quantitative research design specifically, descriptive survey design was used for this study. the purposive sampling technique and simple random sampling technique were used. Purposive sampling to select the level or class and simple random to select the teachers and students who responded to the questionnaire. The accessible population comprised of secondary school science teachers and students and the sample size of 90 was made up of thirty (30) teachers and 60 students from three selected schools within the Bamenda municipality

Data Collection and Analysis

A four-point Likert scale questionnaire for teachers and a "Yes/No" questionnaire for students were used to collect the data from the respondents. One for science students and the other for science teachers The respondents were to rate on four points Likert scale as follows ; strongly agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). The simple random sampling technique was used in this study and descriptive statistics were used for data analysis using SPSS version 23.

Table 1: Different levels of technology integration (science teachers)

S/N	SA	A	No	%	D	SD	No	%
1	11	16	27	90.0	2	1	3	10.0
2	12	15	27	90.0	3	0	3	10.0
3	13	16	29	96.7	1	0	1	3.3
4	14	13	27	90.0	0	3	3	10.0
5	16	11	27	90.0	3	0	3	10.0
6	0	2	2	6.7	13	15	28	93.3

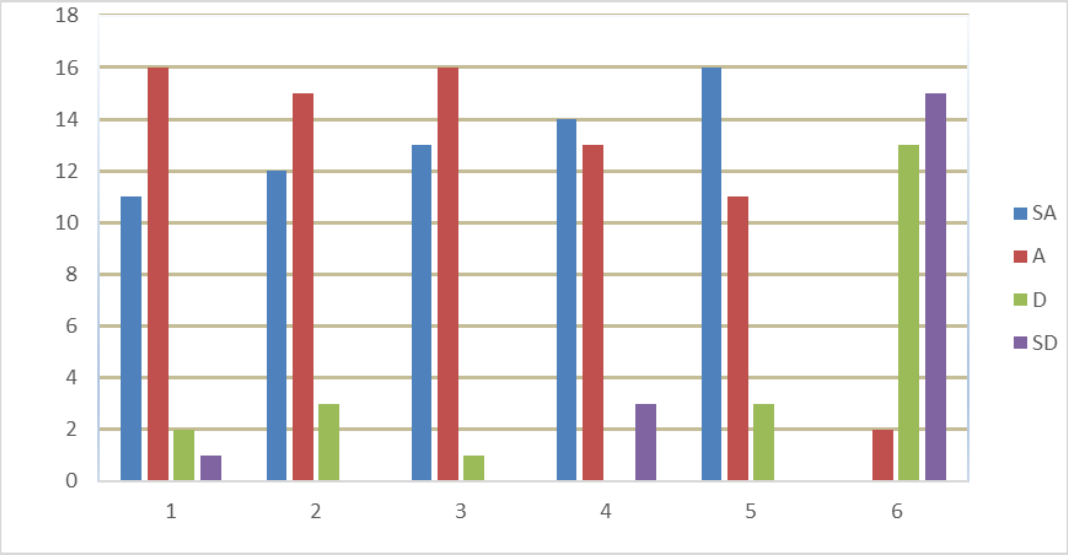

Figure 1: Different levels of technology integration (science teachers)

The table 1 above shows that out of the 30 science teachers who took part in this survey, 90% were of the option that, exposure to basic technologies like computer for word processing or

accessing the internet for research builds learners literacy skills and 10% were against. Majority of the respondents (90%) agreed that broad use of technology like phones for communication improves students' communication skills and barely 10% thought otherwise. 96.7% of the respondents were of the fact that using technology for specialized functions, helps improve students learning while 3.3% hold the contrary view on this aspect. A good majority of the respondents who took part in this survey 90% accepted that introducing technologies to students impact their thinking abilities and overall learning outcomes meanwhile 10% refuted the fact. A majority of the respondents 90% holds that the practice of using computers improves on students typing skills and their overall learning outcomes. Likewise, 10% of the respondents disputed the fact.

Majority of the respondents 93.3% are of the view that technology integration has an effect on students while a minority 6.7% agreed that technology integration does not have any effect on them. From the data analysis above, it is evident that quite a significant number of the respondents (91.6%) confirmed that, different levels of technology integration have a positive influence on students learning outcomes.

Table 2: Levels of technology integration (science students)

S/N	YES	Percentage	NO	Percentage
1	53	88.3	7	11.7
2	55	91.7	5	8.3
3	49	81.7	11	18.3
4	52	86.7	8	13.3
5	50	83.3	10	16.7
6	5	8.3	55	91.7

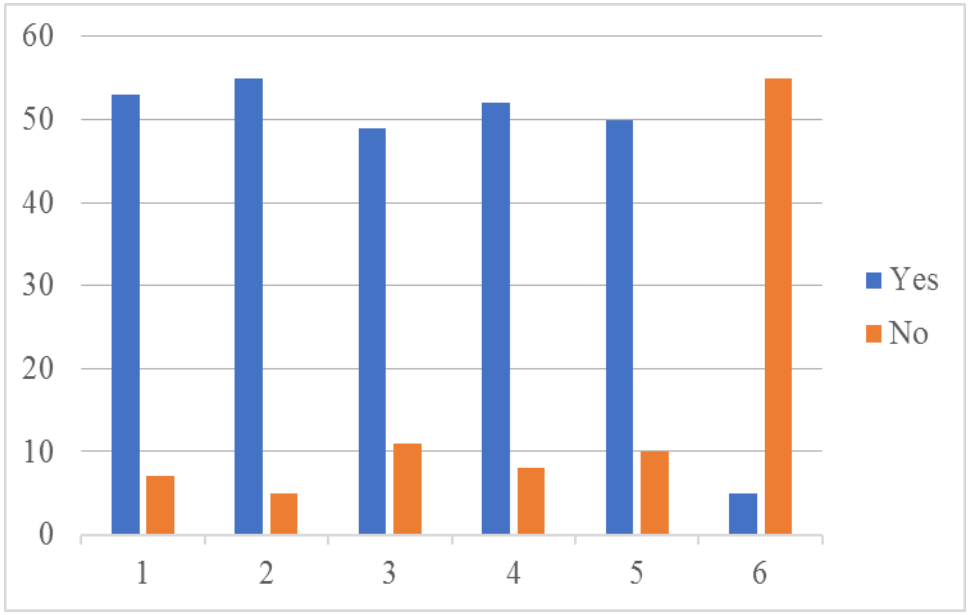

Figure 2: Levels of technology integration (science students)

From table 2 above we can see that out of the 60 science students who took part in this survey, 88.3% were of the option that, exposure to basic technologies like computer for word processing or accessing the internet for research builds their literacy skills and 11.3% were against. Majority of the respondents (91.7%) agreed that broad use of technology like phones for communication improves their communication skills and barely 8.3% thought otherwise. 81.7% of the respondents were of the fact that using technology for specialized functions, helps improve on their learning outcomes while 18.3% hold the contrary view on this aspect. A good majority of the

respondents who took part in this survey 86.7% accepted that introducing technologies to students impact their thinking abilities and overall learning outcomes meanwhile 13.3% refuted the fact. A majority of the respondents 83.3% holds that the practice of using computers improves on their typing skills and their overall learning outcomes. Likewise, 16.7% of the respondents disputed the fact. Majority of the respondents 91.7% holds that technology integration have an effect on students while a minority 8.3% accepted that technology integration does not have any effect on students. Judging from the data analysis above, different levels of technology integration used for science students has a positive influence on their learning outcomes. Generally, from the above analysis, it can be concluded that different levels of technology integration for science students have a significant impact of 87.2% on their learning outcomes.

Table 3: Horizontal technology integration for science teachers

S/N	SA	A	No	%	D	SD	No	%
7	15	14	29	97.7	0	1	1	3.3
8	16	13	29	97.7	1	0	1	3.3
9	15	14	29	97.7	0	1	1	3.3
10	16	13	29	97.7	1	0	1	3.3
11	8	16	24	80.0	6	0	6	20.0
12	14	12	26	86.7	4	0	4	13.3

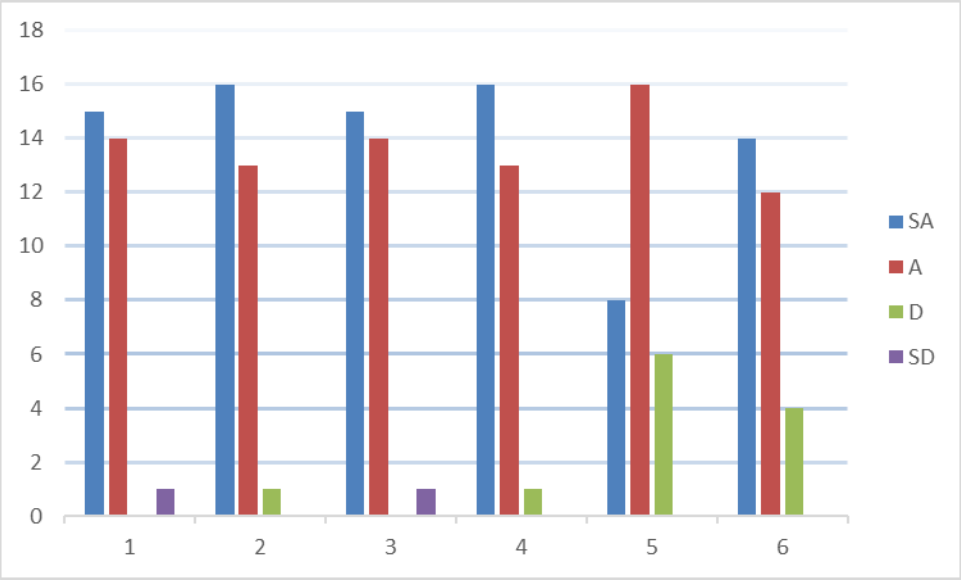

Figure 3: Horizontal technology integration for science teachers

The table 3 above reveals that, the use of technology across subjects such as Chemistry, Physics, and Biology improves their learning outcomes represented by 96.7% agreement and 3.3% otherwise.96.7% of the respondents confirmed that the use of computers and multimedia resources improves learners thinking abilities. With only 3.3% against this view. The majority of the respondents agreed that the use of technology tools and resources to support learning in different concepts leads to improved learning outcomes in students. Meanwhile, barely 3.3% of the respondents objected this view. 96.7% of the respondents were of the fact that the use of technology for students promotes understanding of concepts and subjects by students. Minority (3.3%) of the respondents were of the contrary view. A good majority (80%) of the respondents who took part in this survey holds that, integrating technology into learning increases students' interest and engagement in learning activities. Unlike, 20% of the respondents who disagreed on this fact. 86. 7% of the respondents agreed that the use of digital technology in learning enhances students learning experience while 13.3% disagreed on this point. From the analysis above, most

of respondents (91.4%) are of the opinion that horizontal technology integration has a positive impact on students learning outcomes.

Table 4: Horizontal technology integration (students)

S/N	YES	Percentage	NO	Percentage
7	52	86.7	8	13.3
8	46	76.7	14	23.3
9	49	81.7	11	18.3
10	51	85.0	9	15.0
11	50	83.3	10	16.7
12	56	93.3	4	6.7

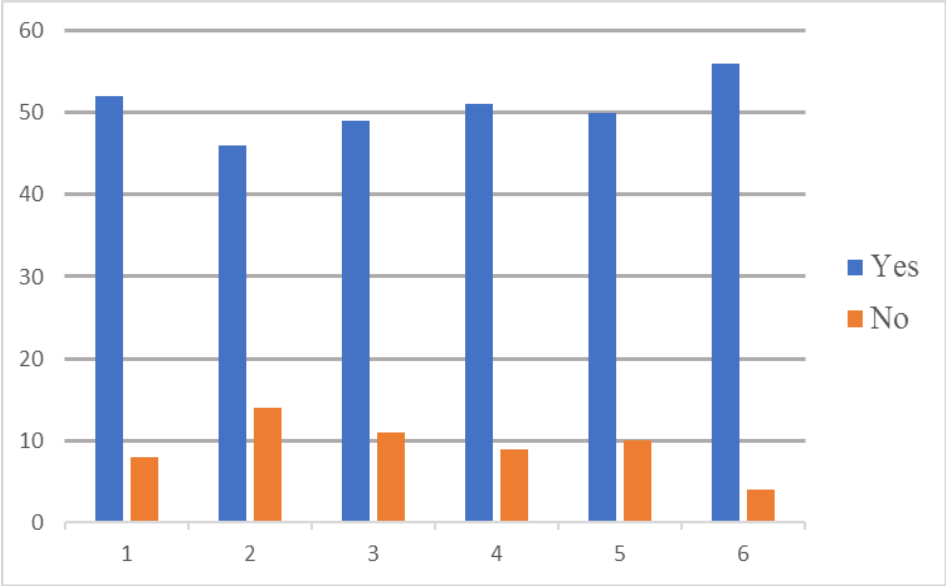

Figure 4: Horizontal technology integration (students)

The table 4 above shows that, technology integration in science subjects such as Chemistry Physics, and Biology improves students learning outcomes. This is represented by 86.7% agreement and 13.3% otherwise. 76.7% of the respondents confirmed that the use of television motion pictures improves their thinking abilities. With only 23.3% against this view. The majority 81.7% of the respondents agreed that the use of technology tools and resources to support learning in different concepts leads to improved learning outcomes in them. Meanwhile, barely 18.3% of the respondents objected this view. 85% of the respondents were of the fact that the use of technology across different levels of technology promotes understanding of concepts and subjects by students. Minority (15%) of the respondents were of the contrary view. A good majority (83.3%) of the respondents who took part in this survey hold that, integrating technology into learning increases their interest and engagement in learning activities. Unlike, 16.7% of the respondents who disagreed on this fact. 93.3% of the respondents agreed that the use of digital technology in learning enhances students learning experience while 6.7% disagreed on this point.

It is very clear from the analysis above that, a good number of respondents (84.45%) are of the opinion that horizontal technology integration has a positive impact on science students learning outcomes.

Table 5: Vertical technology integration for science teachers

S/N	SA	A	No	%	D	SD	No	%
13	5	18	23	76.7	7	0	7	23.3
14	10	19	29	96.7	1	0	1	3.3
15	11	18	29	96.7	1	0	1	3.3
16	13	15	28	93.3	1	1	2	6.7
17	15	13	28	93.3	2	0	2	6.7
18	0	4	4	13.3	7	19	26	86.7

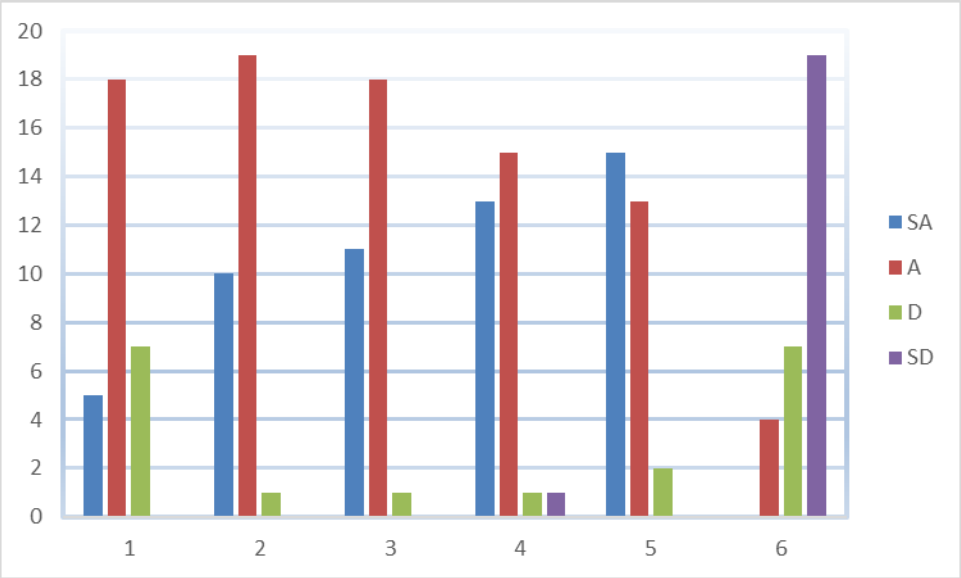

Figure 5: Vertical technology integration for science teachers

The above table 5 indicates that, out of the 30 science teachers who took part in this survey, 76.7% are of the opinion that using technology vertically across different levels facilitates a transition and progression in science students learning while 23.3% disagreed on this view.

96.7% of the correspondents hold on the fact that, vertical technological integration helps build strong foundation of knowledge and skills that align with the developmental stage of students. Meanwhile, 3.3% are of the contrary view. A good majority (96.7%) of the respondents agreed that, the use of technology across different concepts and subjects improves on students learning while a minority of 3.3% disagreed on this view. 93.3% of the respondents confirmed that practice of online learning using technologies exposes students to new methods of learning while 6.7% were against the view. 93.3% of the respondents who took part in this study accepted that, manipulation with technological tools such as computer keyboard improves on learners typing skills and overall learning. Unlike 3.3% who disagreed on this point. Finally, on this table, 13.3% of the respondents hold that, vertical integration does not bring about learning outcomes in learners while 86.7% disagreed on this view.

Conclusively, out of the 30 science teachers who took part in this survey, 89.34% are of the view that vertical technology integration for science students has a positive impact on their learning outcomes.

Table 6: Vertical technology integration of science students.

S/N	YES	Percentage	NO	Percentage
13	57	95.0	3	5.0
14	52	86.7	8	13.3
15	56	93.3	4	6.7
16	52	86.7	8	13.3
17	50	83.3	10	16.7
18	2	3.3	58	96.7

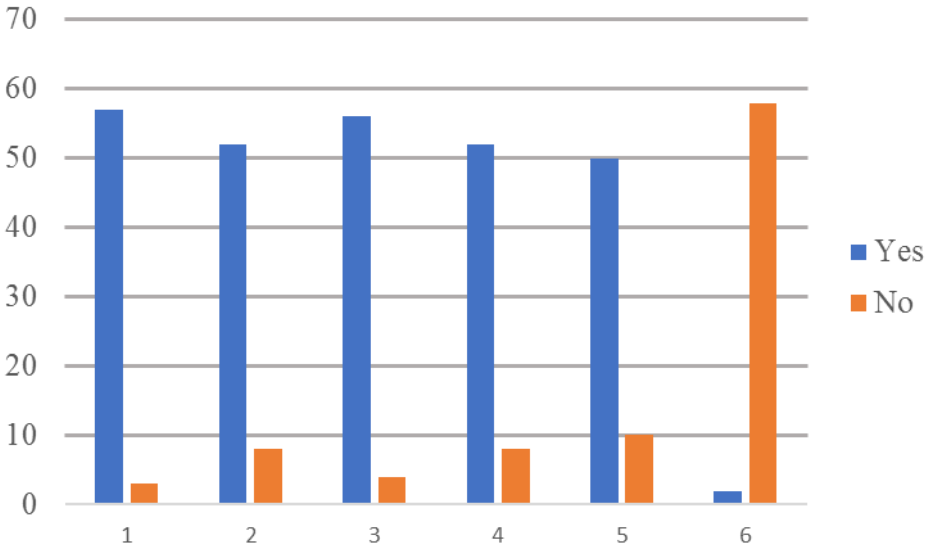

Figure 6: Vertical technology integration of science students.

Table 6 revels that, out of the 60 students who took part in this survey, 95% are of the option that, using technology vertically across different levels facilitates a transition and progression in their learning while 5% disagreed on this view. 86.7% of the correspondents hold on the fact that, vertical technological integration helps build strong foundation of knowledge and skills that align with their understanding of concepts. Meanwhile, 13.3% are of the contrary view. A good majority (93.3%) of the respondents agreed that, the use of technology across different concepts and subjects improves their learning outcomes while a minority of 6.7% disagreed on this view. 86.7% of the respondents confirmed that practice of online learning using technologies exposes them to new methods of learning while 13.3% were against the view. 83.3% of the respondents who took part in this study accepted that, manipulation with technological tools such as computer keyboard improves on their typing skills and overall learning. Unlike 16.7% who disagreed on this point. Finally, on this table, 3.3% of the respondents hold that, vertical integration does not bring about improved learning outcomes in science students while 96.7% disagreed on this view.

From the above data gathered, we can conclude that vertical technology integration for science students has a positive impact (92.2%) on their learning outcomes.

Summary of findings

Findings are:

- Different levels of technology integration like entry level, adoption level, adaptation level, infusion level, and transformation level for science students has a significant positive impact on science students' learning outcomes.
- Secondly, horizontal technology integration for science students has a significant positive impact on science students' learning outcomes.

- Lastly, vertical technology integration for science students has a positive impact on science students' learning outcomes.

Discussion

- Objective One: Find out the effect of levels of technology integration on science students learning outcomes (entry, adoption, adaptation, infusion and transformational level)

From data analysis on different levels of technology integration and its effect on students' learning outcomes, it was discovered that quite a significant number of respondents 91.6% teachers and 87.2% students confirmed that different levels of technology integration have a positive effect on science students' learning outcomes. This finding is in conformity with Bhat (2023). Level 1and 2: Entry/Adoption: Technology is introduced by the teacher at the entry level to deliver curriculum content. Adoption involves directing students in the procedural use of technology but limited impact on deeper learning or skill development.

Level 3 and 4: Adaptation/Infusion: The teacher facilitates students in exploring and independently using technology. For infusion, the teacher provides the learning context and the students choose the technology which is incorporated into existing activities and curriculum.

Level 5: Transformation: At this level, technological devices are used to facilitate higher order learning activities. Technology is used to fundamentally change teaching and learning through pedagogical practices. It has significant potential for enhancing cognitive skills, creativity, higher-order thinking and problem-solving. This promotes learning of concepts and personalized learning Schwier & Misfeldt (2017) Lai & Hwang (2016). Vertical

- Objective Two: Examine the effect of horizontal technology integration on science students learning outcomes.

The findings show that horizontal technology integration for science students has a significant positive impact on science students' learning outcomes. Horizontal technological integration refers to using technology across different subject areas and learning activities within a classroom. It allows for a more holistic and connected learning experience. Ali et al (2023) & Boswell et al (2017) are in agreement with the above finding. Horizontal integration for science students according to Chu et al. (2020) can enhance learning by making connections between different subject areas and fostering a more comprehensive understanding of concepts It was observed that horizontal integration can improve communication and collaboration skills for students. Technology can facilitate laboratory work, group projects, shared learning activities, and communication with peers and teachers. It also suggests that horizontal integration can promote creative thinking and problem-solving. Students can apply their knowledge from different subject areas to solve complex problems or create innovative solutions. Keengwe et al (2019).

- Objective Three: Find out the effect of vertical technology integration on science students learning outcomes.

Findings show that a substantial number of respondents (92%) are of the opinion that vertical technology integration for science students has a significant impact on their learning outcomes. (Mittha 2021, Lai & Hwang 2016; & Higgin, Xiao & Katsipataki 2012) are in agreement with this finding, Vertical integration involves using technology to connect learning across different grade levels, fostering a seamless learning progression. Results show that vertical integration can promote a sense of continuity and connectedness in learning, making it more meaningful and engaging for learners. Technology use across levels helps ensure that students build upon previously learned skills and knowledge, fostering a more coherent learning experience. This also enhances their understanding and skills development in using technology effectively thereby encouraging the professional development of the teachers. By aligning technology use and learning objectives across educational levels, educators can prepare learners for success. Finally

Conclusion

Technology integration for science students has the potential to significantly enhance their learning outcomes, particularly when implemented strategically. Moving beyond basic entry level, to adoption, adaptation to infused and transformation levels is essential for both teachers and students. Horizontal integration across subject areas and vertical integration across grade levels can promote a more holistic and connected learning outcomes for students. However, it is important to address more availability of technology devices, provide ongoing teacher training, and ensure that technology complements rather than replaces traditional teaching methods. It is equally very important for policy makers to provide technological resources for all levels of learning.

Recommendations

- Teachers are encouraged to integrate technology devices into lesson plans and activities to enhance students' engagement and learning outcomes.
- Students are encouraged to show more interest in class activities that are based on technology integration so as to improve their learning outcomes
- Policymakers should ensure that more classrooms have adequate access to devices, software, and connectivity. Periodic programing of training to equip teachers with knowledge and skills necessary to integrate technology effectively should be done.

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