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Research Article

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Difficulties, Attitudes, and Benefits of the Pre-Service Science Teachers in the use of Interactive Multimedia Tools in Classrooms

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Abstract
This study seeks the implementation of an Interactive Multimedia Instructional Approach (IMIA) in enhancing the learning of biology concepts among pre-service science teachers at Wiawso College of Education in Ghana. Action research design was used to collect data from quantitative approach using questionnaires as instrument. Purposive sampling technique was for selecting participants for the study. The Accessible population consisted of 76 second-year pre-service science teacher trainees. Collected data were analysed using SPSS version 27.0. The findings of the study revealed that majority of the respondents agreed that technical difficulties hinder instruction with a mean value of 4.28 and Std. Dev. of 0.99. It was also observed that multimedia resources that align with the curriculum was perceived as more difficult, with a higher mean value of 4.41 (Std. Dev. = 0.835), thus showing a broader range of opinions and some level of agreement. Limited access to technology and multimedia resources was another common concern, with a mean value of 4.21 (Std. Dev. = 0.83) was revealed in the research. It was recommended that Wiawso College of Education Biology Lecturers should design active learning approaches and activities based on IMIA and integrate them with their usual classroom activities wherever necessary.

Keywords: *Interactive Multimedia Tool, Difficulties, Attitudes, Benefits and Pre-service Science Teachers.*

1. Introduction

Interactive Multimedia Tool (IMT) is an instrument used for communication, where by program output depends on the user's input, and the user input affect the output (Yang et al, 2022). Multimedia looks to have the ability to improve educational instruction and management by making these services available at any time. The idea that multimedia may improve the reach and quality of delivery systems and enable instructors to become better teachers has been underlined by Hall, Hearn, and Lewis, (2022). To assist learning, multimedia instructional methods must be blended with educational programs as technology improves. The use of sophisticated multimedia teaching methods in education has prompted scholars to investigate how these technologies influence learning (Way et al, 2022). Because content is presented in the form of videos or moving images coupled by sound, a multimedia teaching technique can pique students' interest in learning (Ollamina-Gerez, & Dioso, 2023). They also claimed that multimedia instructional methods or learning processes in the classroom could be viewed as an alternative educational instrument to encourage students to participate in scientific classes. Furthermore, Winarni et al (2022) argued that the direct use of multimedia instructional systems as part of education might impact student learning, when teachers utilize them to introduce new ideas and clarify concepts during main or close instruction.

Multimedia delivery in science teaching and learning, according to Mayer (2009), comprises the computer-controlled integration of text, graphics, drawings, still images, moving pictures, animation, and audio. Multimedia is a phrase that educational technologists regularly hear and debate about nowadays. Unless otherwise defined, the phrase can refer to a well-balanced mix of multiple mass media such as print, audio, and video, or it can refer to the creation of computer-based hardware and software packages that are mass-produced yet still allow for customized usage and learning.

In Biology, Adedamola (2018) evaluated how well students learned regulation of internal environment as a result of a variety of instructional approaches such as computer simulations and animation. The purpose of the computer simulation for all learners were to observe on screen text, graphic, still images, video packages and teacher's explanation on regulation of internal environment. The learners were given either graphical or written feedback. Furthermore, only half of the participants in the study got brief multimedia explanations of the biology involved, which were combined throughout the simulation. The in-writing feedback with multimedia explanation group had the highest performance. "The issue of how much learning occurs just by having participants view the explanations without engaging in the simulation is subject to dispute," the authors admitted in the absence of multimedia. Additionally, the quantity of blackboard drawings done by teachers are substantially decreased, allowing teachers to dedicate more time to the topic (Al Meajel & Sharadgah, 2018). The globe today is evolving at a rapid pace, as are the many areas of a nation's growth. Education, as one of these sectors and in reality, as the instrument of choice for national growth, follows this path by using technology and innovative ways to impact knowledge to students (Haddad & Draxler, 2002). Because of the advantages of education to society, ways to improve biology teaching and learning should be a top priority for education stakeholders (Penuel, Riedy, Barber, Peurach, LeBouef, & Clark, 2020). This study, on the other hand, provided students a new viewpoint on the usage of interactive multimedia and their consequences on conceptual understanding and performance in teaching and learning of some biology concepts.

1.1. Statement of the problem

In the Science Education Department of Wiawso College of Education in Ghana, the pre-service science teachers' conceptual grasp of cell structure, cell division and Mendelian genetics concepts is lacking, which negatively impacts their performance in Biology. In previous years, the researcher's observation from examination records and discussion with other science tutors revealed that just a few pre-service science teachers have received good grades in biology at the college, because most of them had weak foundation in biology at the SHS level, and many of them fail to answer questions in cell structure, cell division and Mendelian genetics, those who attempted to answer did so poorly. In 2019 for instance, out of the 87 candidates who sat for a course in biology examination at the end of the first semester, 61(70.114%) students either had weak passes or failed, meanings, they had grades C-E. In 2020, out of the 123 candidates who sat for General Biology Theory II at the end of second semester examination paper, 81 (65.85%) students also either had weak passes or failed, which means that, they had grade E or F. This abysmal state of performance has formed the perception among most pre-service science teachers that "biology or science in general is difficult", and view the study of science as the selected and preserved for more gifted or academically well-endowed students (Arthur-Baidoo et al, 2022). From the responses of Level 200 pre-service science teachers at Wiawso CoE to questions related to the concept of cell structure, cell division and Mendelian genetics in their mid-semester examination, the researcher realised that, the students were not able to answer the questions and this prompted the researcher to study the reasons why the students did not do well in those topic and other related concepts. The researcher realized that, the right attitude of teachers and students to the study biology was missing, and addressing these challenges could be achieved through workshops, seminars, and in-service training for teachers, revision of teaching methods, use of appropriate teaching and learning materials as well as intermittent class test for the students to achieve their goals. One research gap that was identified was the use of multimedia approaches to improve the academic performance of pre-service science teacher trainees in the teaching and learning of some biology concepts, such as, cell structure, cell division, and Mendelian genetics. Therefore, there is a need for more research on which types of multimedia approaches are most effective in teaching specific biology concepts and the researcher decided to conduct this study to improve the academic performance of pre-service science teachers in learning some biology concepts.

The study explored the difficulties, attitudes and benefits of the pre-service science teachers' use of the interactive multimedia in the classroom.

The study was guided by the following objective: to determine pre-service science teachers' difficulties, attitudes, benefits to integrate and use interactive multimedia approaches in classrooms.

The study was guided by the research question: What are the difficulties, attitudes, and benefits of the pre-service science teachers to the use of interactive multimedia approaches in classrooms?

1.2. Research Question

What are the difficulties, attitudes, and benefits of the pre-service science teachers in the use of interactive multimedia instructional approach in classrooms?

2. literature Review

2.1. Conceptual framework

The study adopts a conceptual framework grounded in blended learning and Cognitive Load Theory (CLT). When learners encounter challenging in abstract scientific concepts, such as cell division or Mendelian genetics, they often experience confusion and cognitive imbalance (Loh & Lim, 2021). To address this, the Interactive Multimedia Instructional Approach (IMIA) serves as an effective approch. Delivered either collaboratively or individually, IMIA helps learners build new mental representations or adjust existing ones, thereby enhancing their understanding of complex biology concepts (Herrington, Reeves, & Oliver, 2014).

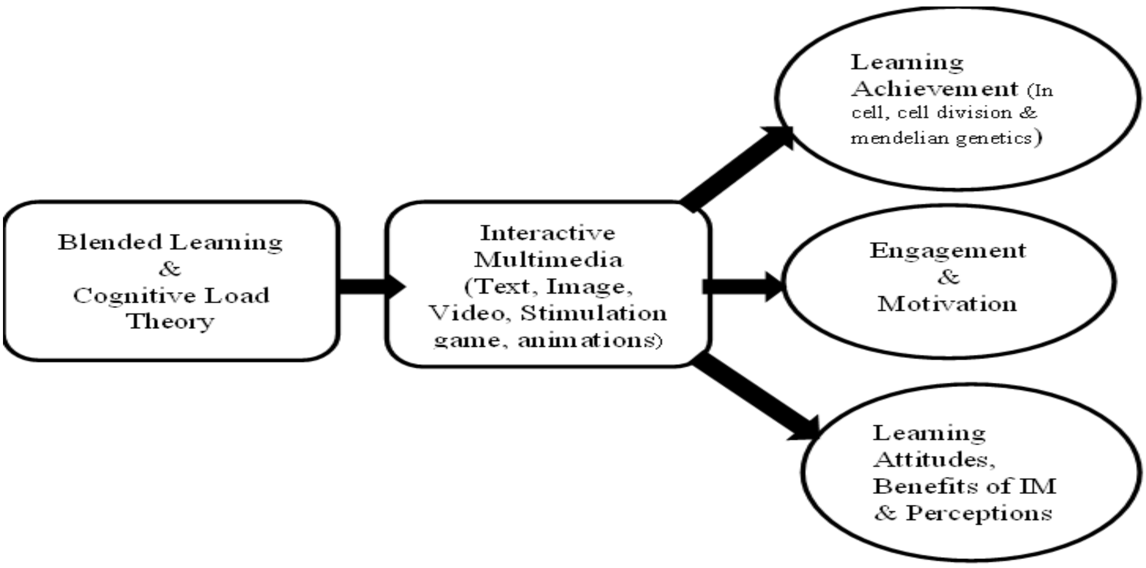

Figure 1: *Conceptual Framework for Enhancing Learning through IMIA Adapted from Al-Ani (2013).*

2.2 Difficulties/Barrier of Integrating Multimedia Approaches in the Classrooms

The act of integrating ICT into teaching and learning is a complex process and one that may encounter a number of difficulties. These difficulties are known as barriers (Schoepp, 2005). According to Schoepp, a barrier is defined as any condition that makes it difficult to make progress or to achieve an objective. Using multimedia to teach biology can be an effective way to engage students and improve their understanding of complex concepts such as cell structure, cell division and Mendelian genetics. However, there are several barriers that teachers and students may face when implementing multimedia in their classrooms. For instance, some of these barriers are:

Limited access to technology

One of the primary barrirs to using multimedia in teaching biology is the lack of access to technology, such as computers, internet connectivity, and digital devices. This can limit the availability of resources and hinder the implementation of multimedia in the classroom. For example, Liu et al. (2009) found that limited access to technology can be a significant barrier to the effective use of multimedia in education.

Insufficient training for teachers

Teachers may face challenges in effectively using multimedia resources due to a lack of training or experience in incorporating these approaches into their instruction. Consequently, this can lead to inadequate use of multimedia, which may hinder student learning. For instance, Wang et al. (2014) highlighted the importance of teacher training in overcoming barriers to effective technology integration in the classroom.

Resistance to change

Some teachers may be resistant to adopting new teaching methods, especially when they perceive multimedia as an additional workload or as a threat to their authority in the classroom. This resistance can hinder the effective implementation of multimedia resources in teaching biology. For example, McLaughlin and Talbert (2005) found that teacher resistance to change is a significant barrier to the successful integration of technology in the classroom.

Copyright and licensing issues

Teachers may face challenges in finding multimedia resources that are free from copyright restrictions or have appropriate licenses for educational use. This can limit the range of resources available to them and hinder the effective implementation of multimedia in their teaching. For instance, Ginsburg (2017) discussed the importance of addressing copyright and licensing issues in the use of educational multimedia.

Classification of the barriers

Different categories have been used by researchers and educators to classify barriers to teacher use of ICT in science classrooms. Several studies have divided the barriers into two categories: extrinsic and intrinsic barriers. However, what they meant by extrinsic and intrinsic differed. In one of the studies in two decades ago, Ertmer (1999) referred to extrinsic barriers as first-order and cited access, time, support, resources and training and intrinsic barriers as second-order and cited attitudes, beliefs, practices and resistance; whereas, Al-Alwani (2005) saw extrinsic barriers as pertaining to organisations rather than individuals and intrinsic barriers as pertaining to teachers, administrators, and individuals.

Another classification found in the literature is teacher-level barriers versus school-level barriers. Becta (2004) grouped the barriers according to whether they relate to the individual (teacher-level barriers), such as lack of time, lack of confidence, and resistance to change, or to the institution (school-level barriers), such as lack of effective training in solving technical problems and lack of access to resources. Similarly, Balanskat et al. (2006) divided them into micro level barriers, including those related to teachers' attitudes and approach to ICT, and meso level barriers, including those related to the institutional context. The latter added a third category called macro level (system-level barriers), including those related to the wider educational framework. Another perspective presents the obstacles as pertaining to two kinds of conditions: material and non- material (Pelgrum, 2001). The material conditions may be the insufficient number of computers or copies of software. The non-material obstacles include teachers' insufficient ICT knowledge and skills, the difficulty of integrating ICT in instruction, and insufficient teacher time. Some of these studies look at the barriers at teacher, institution, or system level. However, since the purpose of this research was to determine the present and future barriers that face science teachers in their schools, this literature review analysis was focused on the teacher-level and school-level barriers only as discussed in the following sections:

Teacher-level barriers-Lack of teacher confidence

Several researchers have indicated that one barrier that prevents teachers from using ICT in their teaching is lack of confidence. Dawes (2001) saw this as a contextual factor which can act as a barrier. According to Becta (2004), much of the research proposes that this is a major barrier to the uptake of ICT by teachers in the classroom. In Becta's survey of practitioners, the issue of lack of confidence was the area that attracted most responses from those that took part in the study. Some studies have examined the reasons for teachers' lack of confidence with the use of ICT. For example, Beggs (2000) asserted that teachers' fear of failure caused a lack of confidence. On the other hand, Balanskat et al. (2006) found that limitations in teachers' ICT knowledge makes them feel anxious about using ICT in the classroom and thus not confident to use it in their teaching. Similarly, Becta (2004) concluded that many teachers who do not consider themselves to be well skilled in using ICT feel anxious about using it in front of a class of children who perhaps know more than they do. In Becta's survey, many of the teacher respondents who identified their lack of confidence as a barrier reported being particularly afraid of entering the classroom with limited knowledge in the area of ICT with their students knowing that this was the case.

It was argued some decades ago that lack of confidence and experience with technology influence teachers' motivation to use ICT in the classroom (Bingimlas, 2009; Shah, Cox, & Zdanowicz, 2013; Osborne & Hennessy, 2003; Balanskat et al., 2006). On the other hand, teachers who confidently use technologies in their classrooms understand the usefulness of ICT. Cox, Preston, and Cox (1999a) found that teachers who have confidence in using ICT identify those technologies are helpful in their teaching and personal work and they need to extend their use further in the future**.**

Lack of teacher competence

Another barrier, which is directly related to teacher confidence, is teachers' competence in integrating ICT into pedagogical practice (Becta, 2004). In about two decades ago, an Australian researcher, Newhouse (2002) found that many teachers lacked the knowledge and skills to use computers and were not enthusiastic about the changes and integration of supplementary learning associated with bringing computers into their teaching practices and assertion is still holds today in many teachers. Current research has shown that the level of this barrier differs from country to country (Jamil, Jamil, & Bano, 2016). In the developing countries, researchers have reported that teachers' lack of technological competence is a main barrier to their acceptance and adoption of ICT (Kim, 2022; Keengwe, Onchwari & Wachira, 2008). In Syria, for example, teachers' lack of technological competence has been cited as the main barrier (Albirini, 2006).

Likewise, in Saudi Arabia, a lack of ICT skills is a serious obstacle to the integration of technologies into science education (Al-Alwani, 2005; Emor, 2016). Emor (2016) produced a report on the use of ICT in European schools. The data used for the report came from the Head Teachers and Classroom Teachers Survey carried out in 27 European countries. The findings showed that teachers who do not use computers in classrooms claim that lack of skills are a constraining factor preventing teachers from using ICT for teaching. Another worldwide survey conducted by Bingimlas (2009), of nationally representative samples of schools, found that teachers' lack of knowledge and skills is a serious obstacle to using ICT in primary and secondary schools. The results of a study conducted by Balanskat et al. (2006) in a decade ago have shown that in Denmark many teachers still chose not to use ICT and media in teaching situations because of their lack of ICT skills rather than for pedagogical/didactics reasons while "in the Netherlands teachers' ICT knowledge and skills is not regarded any more as the main barrier to ICT use. Hence, lack of teacher competence may be one of the strong barriers to the integration of technologies into education. It may also be one of the factors involved in resistance to change.

School-level barriers

Lack of time

Several recent studies indicate that many teachers have competence and confidence in using computers in the classroom, but they still make little use of technologies because they do not have enough time (Bingimla, 2009; Habibu, 2012). A significant number of researchers identified time limitations and the difficulty in scheduling enough computer time for classes as a barrier to teachers' use of ICT in their teaching (Al-Alwani, 2005; Becta, 2004; Beggs, 2000; Schoepp, 2005; Sicilia, 2005). According to Sicilia (2005), the most common challenge reported by all the teachers was the lack of time they had to plan technology lessons, explore the different internet sites, or look at various aspects of educational software. Becta's study found that the problem of lack of time exists for teachers in many aspects of their work as it affects their ability to complete tasks, with some of the participant teachers specifically stating which aspects of ICT require more time. These include the time needed to locate internet advice, prepare lessons, explore and practise using the technology, deal with technical problems, and receive adequate training. Recent studies show that lack of time is an important factor affecting the application of new technologies in science education (Al-Alwani, 2005; Sicilia, 2005; Daniela & Visvizi, 2022; Bingimlas, 2009; Kulaksız & Karaca, 2023; Regmi & Jones, 2020). According to them, lack of time is a barrier affecting the application of ICT because of busy schedules. Al- Alwani indicated that Saudi teachers work from about 7.00 a.m. until 2.00 p.m. and the average number of class sessions taught by science teachers is 18 per week, both teachers and students have a limited number of hours during the day to work on integrating ICT into science education. Similarly, in Canada, Sicilia (2005) concluded that teachers take much more time to design projects that include the use of new ICT than to prepare traditional lessons. Teachers interviewed by Bingimlas (2009) commented that the constraints of different class schedule contributed to the lack of time they spent together to work on planning classroom activities. Kulaksiz and Karaca (2023) indicated that lack of time prevented teachers from utilizing ICT effectively in planning their lessons. Supporting this finding, the most significant constraint on use quoted by 84-89% of primary and secondary science teachers surveyed by Regmi and Jones (2020) was lack of time. Habibu (2012) concluded that one of the main reasons that science teachers do not use ICT in the classroom is lack of the time necessary to accomplish lesson plans in Uganda.

Lack of effective training

The barrier most frequently referred to in the literature is lack of effective training (Albirini, 2006; Balanskat et al., 2006; Habibu, 2012; Özden, 2007; by Regmi & Jones, 2020; Sicilia, 2005; Toprakci, 2006). One finding of Habibu's (2012) study was that there were not enough training opportunities for teachers in the use of ICTs in a classroom environment. Similarly, Regmi and Jones (2020) found that one of the top three barriers to teachers' use of ICT in teaching students was the lack of training. Recent researches in Turkey found that the main problem with the implementation of new ICT in science was the insufficient amount of in-service training programs for science teachers (Özden, 2007; Toprakci, 2006) concluded that limited teacher training in the use of ICT in Turkish schools is an obstacle. According to Becta (2004), the issue of training is certainly complex because it is important to consider several components to ensure the effectiveness of the training. These were time for training, pedagogical training, skills training, and an ICT use in initial teacher training. Correspondingly, recent research by Kulaksiz and Karaca (2023) relating to science education concluded that lack of training in digital literacy, lack of pedagogic and didactic training in how to use ICT in the classroom, and lack of training concerning the use of technologies in science specific areas were obstacles to using new technologies in classroom practice. Some of the Saudi Arabian studies reported similar reasons for failures in using educational technologies: the weakness of teacher training in the use of computers, the use of a delivery teaching style instead of investment in modern technology (Quamar, 2020), as well as the shortage of teachers who are qualified to use the technology confidently (Silva, 2010).

Providing pedagogical training for teachers, rather than simply training them to use ICT approaches, is an important issue (Becta, 2004). Cox et al. (1999a) argued that if teachers are to be convinced of the value of using ICT in their teaching, their training should focus on the pedagogical issues. The results of the research by Cox et al. (1999a) showed that after teachers had attended professional development courses in ICT, they still did not know how to use ICT in their classrooms; instead, they just knew how to run a computer and set up a printer. They explained that this is because the courses only focused on teachers acquiring basic ICT skills and did not often teach teachers how to develop the pedagogical aspects of ICT. In line with the research by Cox et al. (1999a) and Balanskat et al. (2006) indicated that inappropriate teacher training is not helping teachers to use ICT in their classrooms and in preparing lessons. They asserted that this was because training programs do not focus on teachers' pedagogical practices in relation to ICT but on the development of ICT skills. However, beside the need for pedagogical training, according to Becta (2004), it is still necessary to train teachers in specific ICT skills. Schoepp (2005) claims that when new technologies need to be integrated in the classroom, teachers have to be trained in the use of these particular ICTs. According to Newhouse (2002), some initial training is needed for teachers to develop appropriate skills, knowledge, and attitudes regarding the effective use of computers to support learning by their students. He argued that this also requires continuing provision of professional development to maintain appropriate skills and knowledge.

Fundamentally, when there are new approaches and approaches to teaching, teacher training is essential (Osborne & Hennessy, 2003) if they are to integrate these into their teaching. However, according to Balanskat et al. (2006), inadequate or inappropriate training leads to teachers being neither sufficiently prepared nor sufficiently confident to carry out full integration of ICT in the classroom. Newhouse (2002) stated that teachers need to not only be computer literate but they also need to develop skills in integrating computer use into their teaching/learning programs. According to Newhouse (2002), teachers need training in technology education by focusing on the study of technologies themselves and educational technology support for teaching in the classroom. Similarity, Sicilia (2005) found that teachers want to learn how to use new technologies in their classrooms but the lack of opportunities for professional development obstructed them from integrating technology in certain subjects such as science or mathematics. Other problematic issues related to professional development in ICT are that training courses are not differentiated to meet the specific learning needs of teachers and the sessions are not regularly updated (Balanskat et al., 2006). Pre-service science teachers' education can also play a significant role in providing opportunities for experimentation with ICT before using it in classroom teaching (Albirini, 2006). Lack of ICT focus in initial teacher education is a barrier to teachers' use of what is available in the classroom during teaching practice (Becta, 2004). Where training is ineffective, teachers may not be able to accessed ICT resources.

Lack of accessibility

Several research studies indicate that lack of access to resources, including home access, is another complex barrier that discourages teachers from integrating new technologies into education and particularly into science education as the following discussion illustrates. The various research studies indicated several reasons for the lack of access to technologies occurred. A study conducted by Francom (2020) indicated that barriers to technology integration continue to make it difficult for teachers to use educational technologies in the classroom. The 3-year time-series survey conducted in K-12 public schools in a North Midwestern US state investigated teachers' perceptions of how barriers to technology integration change over time, and how barriers may not be the same in different settings including small and large school districts. Results indicated that time was the most sTable and persistent barrier to technology integration (Sicilia, 2005). Access to technology approaches and resources increased and teachers from smaller school districts reported higher access to technology approaches and resources with higher administrative support than the large school districts. In Sicilia's study, teachers complained about how difficult it was to always have access to computers. The author gave reasons like computers had to be booked in advance and the teachers would forget to do so, or they could not book them for several periods in a row when they wanted to work on several projects with the students. In other words, a teacher would have no access to ICT materials because most of these were shared with other teachers. According to Becta (2004), the inaccessibility of ICT resources is not always merely due to the non-availability of the hardware and software or other ICT materials within the school. It may be the result of one of a number of factors such as poor organisation of resources, poor quality hardware, inappropriate software, or lack of personal access for teachers (Becta, 2004).

The barriers related to the accessibility of new technologies for teachers are widespread and differ from country to country (Francom, 2020). Emor (2016) in a European study's found that lack of access is the largest barrier and that different barriers to using ICT in teaching were reported by teachers, for example a lack of computers and a lack of adequate material. Similarly, Hüsing, Gareis and Korte (2006) found that in Europe and schools there have some infrastructure barriers in ICT such as broadband access not yet being available to some schools. They concluded that one third of European schools still do not have broadband internet access. Pelgrum (2001) explored practitioners' views from 26 countries on what were the main obstacles to the implementation of ICT in schools. He concluded that four of the top ten barriers were related to the accessibility of ICT. These barriers were insufficient numbers of computers, insufficient peripherals, insufficient numbers of copies of software, and insufficient simultaneous internet access. ToPrakci (2006) found that low numbers of computers, oldness or slowness of ICT systems, and scarcity of educational software in the school were barriers to the successful implementation of ICT into science education in Turkish schools. Similarly, Al-Alwani (2005) found that having no access to the internet during the school day and lack of hardware were impeding technology integration in Saudi schools. Research on Syrian schools indicated that insufficient computer resources were one of the greatest impediments to technology integration in the classroom (Albirini, 2006).

Lack of technical support

Without both good technical supports in the classroom and whole-school resources, teachers cannot be expected to overcome the barriers preventing them from using ICT (Mathayo, 2016). Pelgrum (2001) found that in the view of primary and secondary teachers, one of the top barriers to ICT use in education was lack of technical assistance. In Sicilia's study (2005), technical problems were found to be a major barrier for teachers. These technical barriers included waiting for websites to open, failing to connect to the internet, printers not printing, malfunctioning computers, and teachers having to work on old computers. Technical barriers impeded the smooth delivery of the lesson or the natural flow of the classroom activity (Sicilia, 2005). Hüsing, Gareis and Korte (2006) argued that ICT support or maintenance contracts in schools help teachers to use ICT in teaching without losing time through having to fix software and hardware problems. Becta (2004) report stated that if there is a lack of technical support available in a school, then it is likely that technical maintenance will not be carried out regularly, resulting in a higher risk of technical breakdowns. Many of the respondents to Becta's survey indicated that technical faults might discourage them from using ICT in their teaching because of the fear of equipment breaking down during a lesson.

2.3 Resistance to change and negative attitudes

Much research into the barriers to the integration of ICT into education found that, teachers' attitudes and an inherent resistance to changes was a significant barrier (Hashmi, 2016; Gomes, 2005; Schoepp, 2005). From his analysis of the questionnaires, Gomes (2005) found that science teachers' resistance to change concerning the use of new strategies is an obstacle to ICT integration in science teaching. At a broader level, Becta (2004) argued that resistance to change is an important barrier to teachers' use of new technologies in education. Bingimlas (2009), an Australian researcher argued that integrating the new technologies into educational settings requires change and different teachers will handle this change differently.

This assertion made by Bingimlas was reaffirmed by Habibu (2012) in Uganda. According to him, considering different teachers' attitudes to change is important because teachers' beliefs influence what they do in classrooms. Becta (2004) claims that one key area of teachers' attitudes towards the use of technologies is their understanding of how these technologies will benefit their teaching and their students' learning. Schoepp's (2005) study found that, although teachers felt that there was more than enough technology available, they did not believe that they were being supported, guided, or rewarded in the integration of technology into their teaching. According to Korte & Hüsing (2006), teachers who are not using new technology such as computers in the classroom are still of the opinion that the use of ICT has no benefits or unclear benefits. Resistance to change seems not to be a barrier itself; instead, it is an indication that something is wrong. In other words, there are reasons why resistance to change occurs. According to Earle (2002), the change from a present level to a desired level of performance is facilitated by driving (encouraging) forces such as the power of new developments, rapid availability, creativity, internet access, or ease of communication, while it is delayed by resisting (discouraging) forces such as lack of technical support, teacher expertise, or time for planning. In their study, Cox et al. (1999a) found that teachers are unlikely to use new technologies in their teaching if they see no need to change their professional practice. They showed that teachers who resist change are not rejecting the need for change but lack the necessary education in accepting the changes and are given insufficient long-term opportunities to make sense of the new technologies for themselves. Obviously, not all communities have this barrier. In Europe, for example, Korte and Hüsing (2006) stated that only very few teachers can be regarded as fundamentally opposing the use of ICT in the classroom.to them, only a fifth of European teachers believe that using computers in class does not have significant learning benefits for students.

2.4 The Long-term Benefits of Interactive Multimedia Applications and Retention of biology concepts

Interactive multimedia applications have been found to have several long-term benefits for pre-service science teachers in retaining biology concepts. Some of these benefits include:

Improved long-term retention

Interactive multimedia can lead to better long-term retention of biology concepts. A study by Mayer (2005) found that multimedia presentations that combined narration with on-screen text and graphics improved students' long-term recall of the material compared to presentations that used text alone.

Enhanced problem-solving skills

Interactive multimedia applications can foster problem-solving skills in pre-service science teachers. According to a study by Azevedo and Kali (2010), students who used interactive multimedia approaches were better able to solve complex biology problems than those who used traditional textbooks.

Increased curiosity and interest

Interactive multimedia can stimulate curiosity and interest in biology, leading to increased motivation and engagement. A study by Hong, Chuang and Hsu (2016) found that pre-service science teachers who engaged with interactive multimedia approaches reported higher levels of interest and curiosity in biology than those who used traditional methods.

Facilitation of deeper learning

Interactive multimedia can facilitate deeper learning by providing opportunities for active learning and critical thinking. A study by Clark and Mayer (2023) found that multimedia presentations that encouraged active learning and critical thinking led to a deeper understanding of biology concepts compared to passive presentations.

Adaptability

Interactive multimedia applications can be easily adapted to meet the needs of individual learners. A study by Brame (2016) found that personalized multimedia learning environments improved students' understanding and retention of biology concepts. In conclusion, interactive multimedia applications have the potential to significantly improve the long-term retention of biology concepts for pre-service science teachers. By promoting active learning, critical thinking, and curiosity, these applications can lead to a more engaging and effective learning experience.

3. Methodology

The design used in this study was action research design. The participants in this study were all the pre-service science teachers from Wiawso College of Education, Sefwi Wiawso during the academic year 2023/2024. But for the purpose of this study, the target population for the research were the level 200 pre-service science teachers at Wiawso College of Education (Table 1). The level 200 pre-service science teachers were grouped into science/mathematics and science/ICT students.

3.1 Participants

Table 1: Participants in the Study.

School	Class	**Males** (%)	Females (%)	Total (%)
Wiawso CoE	L200 Science/Maths	41 (53.95)	06 (7.89)	47 (61.84)
	L200 Science/ICT	14 (18.42)	15 (19.74)	29 (38.16)
		55 (72.37)	**21 (27.63)**	**76 (100.00)**

Source: Field Data, 2024

3.2 Sampling Technique and sample size

The study used purposive sampling technique to sample pre-service science teachers in the second-year of Science Department in Wiawso College of Education. The college and the classes were purposively selected. The sample size of the study consisted of 76 second-year pre-service science teacher trainees.

3.4 Instrumentation

The study used questionnaire to collect data from the pre-service science teachers. The questionnaires used for the study were pilot-tested at Komenda College of Education using 20 of the second-year pre-service science teachers.

3.5 Data collection procedure

The main pre-intervention activities involved extensive discussions with respect to the purpose of the study; administration of some selective biology concepts difficulty questionnaire.

Day One Activities

On day one of the first week, the researcher met the pre-service science teachers at the laboratory in the afternoon. We had open and frank discussions with respect to the purpose of the study, a study timeline and benefit/significance of the study. Series of engagements in the form of discussions were also held with the participants. They were assured that there would be no risk involved in participating in the study and that they had the right to withdraw from the study if they wished. They were informed about the context of the study and how the results would be evaluated. An informed consent form was given to the pre-service science teachers to read and fill them with their detailed information; after which the session was closed.

Day Two Activities

On the second day of the first week, the researcher met the pre-service science teachers at the laboratory in the morning. Upon series of engagements, the pre-service science teachers' cell structure, cell division and Mendelian genetics difficulty questionnaire in Appendix A were distributed or given to them to fill in my presence. The supervision of the administration of questionnaire was done in relaxed. After the 60 minutes, the questionnaires were collected from the respondents; after which the session was closed.

3.6 Data Analysis Procedure

The data obtained from the student's responses to the questionnaire was analysed with the help of a Statistical Package for Social Scientists (SPSS) software version 27. The frequency, mean and standard deviation of each item were determined.

3.7 Ethical Consideration

After getting the ethical clearance from the University of Education, Winneba. Permission and approval were sought from the Principal, Vice principal and the Head of Science Education Department of Wiawso College of Education. They had an open and frank discussion with respect to the purpose of the study, a study timeline and benefit/significance of the study. Again, the pre-service science teachers who met inclusion criteria and selected were approached, informed of the study's purpose and significance of the study. Series of engagements in the form of discussions were held with the participants. They were assured that there would be no risk involved in participating in the study and that they had the right to withdraw from the study if they wished. They were informed about the context of the study and how the results would be evaluated.

4. Results and Discussion

4.1 pre-service science teachers' attitude towards the use of interactive multimedia approaches in their classrooms' interactions

The research question was supported by the rationale of establishing the difficulties that pre-service science teachers have to integrate and use interactive multimedia instructional approaches in their future classroom. Findings with respect to research question was positive in that, the responses from the pre-service science teachers helped the researcher to select appropriate multimedia approaches for the intervention. Table 2 is the respondents' view about the attitude of pre-service science teachers to integrate and use interactive multimedia approaches in their future classrooms.

Table 2: *Views of pre-service science teachers' attitude towards the use of interactive multimedia approaches in their classrooms' interactions.*

S/N	Statements	Mean	Std. Dev.
1	Using interactive multimedia improves teaching and learning	4.690	0.632
2	I believe interactive multimedia approaches are helpful in enhancing student's engagement in science lessons	4.630	0.561
3	Interactive multimedia approaches provide opportunities for more interactive and hands-on learning experiences.	4.310	0.906
4	Integrating interactive multimedia approaches in science instruction can help students develop deeper understanding concepts.	4.480	0.683
5	Interactive multimedia approaches enable me explain complex scientific phenomena more effectively.	4.470	0.774
6	Overall	4.516	0.711

Source: Field Data, 2024

From Table 2 there is strong evidence to support the claim that pre-service science teachers have positive attitude toward the use of the interactive multimedia approaches in science education. The mean of 4.69 and standard deviation of 0.632 suggested that many respondents agreed that multimedia using interactive multimedia improves teaching and learning in biology. In the same way, interactive multimedia approaches are helpful in enhancing student's engagement in science lessons had a mean of 4.63 standard deviation of 0.561 indicating a strong agreement with the claim. The statement regarding interactive multimedia approaches provides opportunities for more interactive and hands-on learning experiences had a mean of 4.31 and standard deviation 0.906, reflecting agreement. The mean of 4.48 and standard deviation of 0.683 for integrating interactive multimedia approaches in science instruction can help students develop deeper understanding concepts, even though there were slightly varied responses. Finally, the students' approach to the use the of interactive media effectively explaining complex scientific phenomena was positive and had a significant level of agreement, with a mean of 4.47 and standard deviation of 0.774.

4.2 Pre-service science teachers' perceived benefits of interactive multimedia approaches in their classrooms' interactions

The study indicated that interactive multimedia approaches enable biology teachers explain complex scientific phenomena more effectively as agreed by the respondents. Teachers must integrate multimedia resources into their lesson plans to create an engaging and interactive learning experience (Pryor & Bitter, 2008). For instance, using videos to explain complex concepts, interactive simulations to demonstrate biological processes, or audio clips to discuss the role of organisms in ecosystems can help students grasp the subject matter more effectively (Mayer, 2005).

Table 3: *Views of pre-service science teachers' perceived benefits of interactive multimedia approaches in their classrooms' interactions.*

S/N	Statements	Mean	Std. Dev.
1	Using interactive multimedia approaches helps in presenting abstract concepts in a concrete and visual manner	4.690	0.917
2	Interactive multimedia approaches improve students' engagement and motivation in science lessons	4.630	0.815
3	Using interactive multimedia helps in accommodating different learning styles and abilities	4.360	0.832
4	Using interactive multimedia approaches facilitates the exploration of real-life scientific situation.	4.480	0.842
5	Interactive media enables me to explain complex scientific phenomena more effectively	4.470	0.791
6	Overall	4.456	0.839

Source: Field Data, 2024

From Table 3 there is strong evidence to support the claim that interactive multimedia approaches are beneficial in various aspects of science education. The mean of 4.69 and standard deviation of 0.917 suggested that many respondents agreed that multimedia was helpful in presenting abstract concepts in a concrete and visual manner. Similarly, the use of multimedia approaches to improve students' engagement and motivation had a mean of 4.63 standard deviation of 0.815 indicating a strong agreement with the claim. The statement regarding accommodating different learning styles and abilities through multimedia had a mean of 4.36 and standard deviation 0.832, reflecting agreement, but with some diversity in opinion. The mean of 4.48 and standard deviation of 0.842 for using multimedia to facilitate exploration of real-life scientific situations showed general agreement, even though there were slightly varied responses. Finally, the effectiveness of interactive media in explaining complex scientific phenomena had a significant level of agreement, with a mean of 4.47 and standard deviation of 0.791.

4.3 Pre-service science teachers' perceived difficulties in using interactive multimedia approaches in science education

Present research by Kulaksiz and Karaca (2023) relating to science education concluded that lack of training in digital literacy, lack of pedagogic and didactic training in how to use ICT in the classroom, and lack of training concerning the use of technologies in science specific areas were obstacles to use new technologies in classroom practice. Some of the Saudi Arabian studies reported similar reasons for failures in using educational technologies: the weakness of teacher training in the use of computers, the use of a delivery teaching style instead of investment in modern technology (Quamar, 2020), as well as the shortage of teachers who are qualified to use the technology confidently (Silva, 2010). Providing pedagogical training for teachers, rather than simply training them to use ICT tools, is an important issue (Becta, 2004). Cox et al. (1999a) argued that if teachers are to be convinced of the value of using ICT in their teaching, their training should focus on the pedagogical issues.

The results of the research by Cox et al. (1999a) showed that after teachers had attended professional development courses in ICT, they still did not know how to use ICT in their classrooms; instead, they just knew how to run a computer and set up a printer. They explained that this is because the courses only focused on teachers acquiring basic ICT skills and did not often teach teachers how to develop the pedagogical aspects of ICT. Balanskat et al. (2006) indicated that, inappropriate teacher training is not helping teachers to use ICT in their classrooms and in preparing lessons.

Table 4: *Views of pre-service science teachers' perceived difficulties in using interactive multimedia approaches in science education.*

S/N	Statements	Mean	Std. Dev.
1	Technical difficulties in using interactive multimedia approaches can hinder instruction.	4.280	0.990
2	Finding appropriate interactive multimedia resources that align with curriculum can be difficult.	4.410	0.835
3	Limited access to technology and interactive multimedia resources can restrict the use of the approaches.	4.210	0.830
4	Lack of training, lack of teacher competence and professional development opportunities for teachers in using interactive multimedia approaches in science education.	4.320	0.789
5	Integrating interactive multimedia approaches effectively requires additional time and effort.	3.880	1.300
6	Overall	4.220	0.948

Source: Field Data, 2024

The information in Table 4 revealed that several challenges are perceived in using interactive multimedia approaches in science education. Most respondents agreed that technical difficulties could hinder instruction, with a mean of 4.28 and standard deviation of 0.99, indicating some variation in responses. Finding appropriate multimedia resources that align with the curriculum was perceived as more difficult, with a higher mean of 4.41and standard deviation of 0.835, showing a broader range of opinions and some level of agreement. Limited access to technology and multimedia resources was another common concern, with a mean of 4.21 and standard deviation of 0.83, suggesting overall agreement with relatively less variability. Respondents also agreed that a lack of training, lack of teacher competence and professional development opportunities for teachers is a challenge, reflected in a mean of 4.32 and standard deviation of 0.789, with minimal variation in responses. Finally, integrating multimedia approaches effectively was seen as requiring additional time and effort, with a mean of 3.88 and standard deviation of 1.30, indicating that most respondents recognized this challenge with moderate variability in their views.

5.1 Conclusions and Recommendations

The results of the study revealed that several difficulties or barriers are perceived by the pre-service science teachers in using interactive multimedia tools in science education and most them agreed that technical difficulties could hinder instruction, with a mean of 4.280 and standard deviation of 0.990. This finding is in agreement with Lewis (2003) which revealed in his study that without both good technical supports in the classroom and whole-school resources, teachers cannot be expected to overcome the barriers preventing them from using ICT. They also indicated that integrating interactive multimedia in science instruction can help develop a deeper understanding of concepts and again, showed with strong evidence with a mean of 4.690 and standard deviation of 0.917 to support the claim that interactive multimedia tools are beneficial in various aspects of science education. The study also revealed that pre-service science teachers who were taught the selected biology concepts such as cell structure, cell division and Mendelian genetics using the interactive multimedia interventional activities had a higher positive perceptions and attitude towards the selected concepts in biology. This is an important finding that the use of interactive multimedia interventional activities to learn these concepts, aided to developed their interest and generally improved their performance and also increased their attitudes positively towards the selected concepts in the biology

Since lack of training, lack of teachers' confidence/competence and professional development opportunities for teachers was a challenge. It is recommended that more training workshop should be giving to the teachers/students by the college.

It was again revealed in the findings that pre-service science teachers have challenge in selecting appropriate multimedia to use, it is recommended that Wiawso College of Education Biology Lecturers should design active learning approaches and activities based on Interactive Multimedia Instructional Approach and integrate them with their usual classroom activities wherever necessary.

Again, it is recommended that college of education biology lecturers should guide and counsel their pre-service science teachers to develop positive attitudes towards abstract and difficult biology concepts such as cell structure, cell division and Mendelian genetics.

As interactive multimedia tools are beneficial in various aspects of science education, it is recommended that the curriculum developers, course experts at the various mentoring universities and other stakeholders should take advantage of the on-going review of educational reforms at the college of education level to inject some new teaching strategies such as the Interactive Multimedia Instructional Approach into the science program so that college biology lecturers could adopt the Interactive Multimedia Instructional Approach to improve pre-service science teachers' performance and attitudes in learning and teaching of biology.

References

1. Aarts, E. (2004). Ambient intelligence: a multimedia perspective. *IEEE multimedia*, *11*(1), 12-19
2. Adedamola A. K. (2018). The use of multimedia in teaching biology and its impact on students' learning outcomes. *The Eurasia Proceedings of Educational & Social Sciences*, 9, 157-165.
3. Akinbadewa, B. O. (2020). The effect of multimedia instructional packages on students' academic achievement in Biology. *International Online Journal of Education and Teaching (IOJET), 7*(4). 1266-1281.

4. Al Meajel, T. M., & Sharadgah, T. A. (2018). Barriers to using the blackboard system in teaching and learning: Faculty perceptions. *Technology, Knowledge and Learning*, *23*, 351-366.
5. Al-Ani, W.T. (2013). Blended Learning Approach Using Moodle and Student's Achievement at Sultan Qaboos University in Oman. *Journal of Education and Learning*, 2, 96-110.
6. Al-Alwani, A. (2005). *Barriers to Integrating Information Technology in Saudi Arabia Science Education*. Doctoral dissertation the University of Kansas, Kansas.
7. Al-Alwani, A. (2005). *Barriers to Integrating Information Technology in Saudi Arabia Science Education*. Doctoral dissertation the University of Kansas, Kansas.
8. Ala-Mutka, K. (2009). Review of Learning in ICT-enabled Network sand Communities. *European Commission. Institute for Prospective Technological Studies*.
9. Albirini, A. (2006). Teachers' attitudes toward information and communication technologies: The case of Syrian EFL teachers. *Computers & Education*, *47*, 373-398.
10. Al-Hariri, M.T., Al-Hattami, A.A., (2017). Impact of students' use of technology on their learning achievements in physiology courses at the University of Dammam. *Journal of Taibah University Medical Science, 12 (1)*, 82–85.
11. Almarabeh, H., & Amer, E., & Sulieman, A. (2015). The Effectiveness of Multimedia Learning Tools in Education. *International Journal of Advanced Research in Computer Science and Software Engineering*, *5*. 761.
12. Aloraini, S. (2012). The impact of using multimedia on students' academic achievement in the College of Education at King Saud University. *Kind Saud Univ. J. King Saud Univ. Lang. Transl.* 24, 75–82.
13. Arthur-Baidoo, F., Azumah, D. A., Osei-Manu, F., & Annan, M. K. (2022). Learners' Perceptions of Computer-Assisted Instruction Approach Teaching and Learning of photosynthesis in Biology Lessons. *Online Journal of Microbiological Research*, *1*(1), 8-16.
14. Balanskat, A., Blamire, R., & Kefala, S. (2006). The ICT impact report. *European Schoolnet*, *1*, 1-71.
15. Barzegar, N., Farjad, S., Hosseini, N. (2012). The effect of teaching model based on multimedia and network on the student learning (case study: guidance schools in Iran*)*. *Procedia-Social and Behaviour Science*, *47*, 1263 1267
16. Bayhan, P., Olgun, P. & Yelland, N.J. (2002). A Study of Pre-school Teachers' Thoughts about Computer assisted, Instruction. *Contemporary Issues in Early Childhood*, *3*(2), 298-303. http://dx.doi.org/10.2304/ciec.2002.3.2.11
17. Becta, (2004). *A review of the research literature on barriers to the uptake of ICT by teachers* Retrieved August 13, 2008, from http://www.becta.org.uk
18. Beggs, T. A. (2000). *Influences and barriers to the adoption of instructional technology. Paper presented at the Proceedings of the Mid-South Instructional Technology Conference, Murfreesboro,* TN.
19. Bingimlas, K. A. (2009). Barriers to the successful integration of ICT in teaching and learning environments: A review of the literature. *Eurasia Journal of Mathematics, science and technology education*, *5*(3), 235-245
20. Borner, T. (2019). Teaching and learning of biology with multimedia: State of the art and future trends. *International Journal of Computer-Aided Learning*, *25*(2), 158–167.
21. Campbell-Kelly, M., Aspray, W. F., Yost, J. R., Tinn, H., & Díaz, G. C. (2023). *Computer: A history of the information machine*. Routledge.
22. Çeliker, H. D. (2015). Prospective science teachers' levels of understanding and explanation of animal and plant cells: Draw-write. *Journal of Baltic Science Education*, *14*(4), 501-512.
23. Charp, S. (2003). Engaging the tech-savvy generation. *THE Journal*, *30*(7), 8-9.
24. Chen, S., Xia, Y. (2012). Research on application of multimedia technology in college physical education. *Procedia Engineering*, *29*, 4213-4217.
25. Cronje, J. C., & Fouche, J. (2008). Alternatives in evaluating multimedia in secondary school science teaching. *Computers & Education*, *51*(2), 559-583.
26. Dalacosta, K., Kamariotaki-Paparrigopoulou, M., Palyvos, J.A., Spyrellis, N. (2009). Multimedia application with animated cartoons for teaching science in elementary education. *Computer Education*, *52* (4), 741–748.
27. Daniela, L., & Visvizi, A. (2022). *Remote learning in times of pandemic*. Routledge, London New York.
28. Dawes, L. (2001). *What stops teachers using new technology*? In M. Leask (Ed.), Issues in Teaching using ICT (pp. 61-79). London: Routledge.
29. Dema, O., & Moeller, A. K. (2012). *Teaching culture in the 21st century language classroom*.
30. Dhiya Eddine, A. B. A. S. S. I., & Abdelfettah, G. U. E. R. D. O. U. H. (2020). *EFL Learners' Attitudes towards Integrating Multimedia Technology to Develop Intercultural Communicative Competence* (Doctoral dissertation, Abdelhafid boussouf university Centre mila).
31. Dizon, G. (2016). Measuring Japanese EFL Student Perceptions of Internet-Based Tests with the Technology Acceptance Model. *Tesl-Ej*, *20*(2), n2.
32. Duranti, L., & Thibodeau, K. (2006). The concept of record in interactive, experiential and dynamic environments: the view of InterPARES. *Archival science*, *6*, 13-68.
33. Earle, R. S. (2002). The integration of instructional technology into public education: Promises and challenges. *Educational technology*, *42*(1), 5-13.
34. Eckleberry-Hunt, J., & Tucciarone, J. (2011). The challenges and opportunities of teaching "Generation Y". *Journal of Graduate Medical Education*, *3*(4), 458-461.
35. Emor, T. N. S. (2016). *Benchmarking access and use of ICT in European schools 2006: final report from head teacher and classroom teacher surveys in 27 European countries*.
36. Ertmer, P. A. (1999). Addressing first-and second-order barriers to change: Strategies for technology integration. *Educational technology research and development*, *47*(4), 47-61.
37. Evans, C., & Gibbons, N. J. (2007). The interactivity effect in multimedia learning. *Computers & Education*, *49*(4), 1147-1160.
38. Francom, G. M. (2020). Barriers to technology integration: A time-series survey study. *Journal of Research on Technology in Education*, *52*(1), 1-16.
39. Frid, E. (2019). Accessible digital musical instruments-a review of musical interfaces in inclusive music practice. *Multimodal Technologies and Interaction*, *3*(3), 57.

40. Furht, B. (Ed.). (2008). *Encyclopedia of multimedia*. Springer Science & Business Media.
41. Gill, S. P. (Ed.). (2007). *Cognition, communication and interaction: transdisciplinary perspectives on interactive technology*. Springer Science & Business Media.
42. Ginsburg, J. C. (2017). *Copyright and control over new technologies of dissemination. In Law and Society Approaches to Cyberspace* (pp. 385-419). Routledge.
43. Ginsburg, J. C. (2017). *Copyright and control over new technologies of dissemination. In Law and Society Approaches to Cyberspace* (pp. 385-419). Routledge.
44. Gomes, M. J. (2005). E-learning: reflections on the concept. *Challenges*, *5*, 229-236.
45. Gómez-Albarrán, M. (2005). The teaching and learning of programming: A survey of supporting software tools. *The Computer Journal*, *48*(2), 130-144.
46. Gorman, P., Nelson, T., & Glassman, A. (2004). The Millennial generation: A strategic opportunity. *Organizational Analysis (15517470)*, *12*(3).
47. Guan, N., Song, J., & Li, D. (2018). On the advantages of computer multimedia-aided English teaching. *Procedia computer science*, *131*, 727-732.
48. Haddad, W. D., & Draxler, A. (2002). The dynamics of technologies for education. *Technologies for education: Potentials, parameters, and prospects*, 2-17.
49. Hall, M., Hearn, J., & Lewis, R. (2022). *Digital gender-sexual violations : Violence, technologies, motivations*. Taylor & Francis.
50. Hashmi, N. A. (2016). Computer-assisted language learning (CALL) in the EFL classroom and its impact on effective teaching-learning process in Saudi Arabia. *International Journal of Applied Linguistics and English Literature*, *5*(2), 202-206.
51. Haskell, B. G., Puri, A., & Netravali, A. N. (2007). *Digital video: an introduction to MPEG-2*. Springer Science & Business Media.
52. Hassall, C., & Lewis, D. I. (2017). Institutional and technological barriers to the use of open educational resources (OERs) in physiology and medical education. *Advances in Physiology Education*, *41*(1), 77-81.
53. Hassoun, D. (2014). Tracing attentions: Toward an analysis of simultaneous media use. *Television & New Media*, *15*(4), 271-288.
54. He, W., Holton, A. J., & Farkas, G. (2018). Impact of partially flipped instruction on immediate and subsequent course performance in a large undergraduate chemistry course. *Computers & Education*, *125*, 120-131.
55. Holzinger, A., Kickmeier-Rust, M. D., Wassertheurer, S., & Hessinger, M. (2009). Learning performance with interactive simulations in medical education: Lessons learned from results of learning complex physiological models with the HAEMOdynamics SIMulator. *Computers & Education*, *52*(2), 292-301.
56. Hough, M. K. (2019). *The impact of professional development through a graduate course on multimedia technology on teachers' beliefs about multimedia and their implementation of multimedia into their teaching practice, including to meet the Common Core state standards* (Doctoral dissertation, Rutgers the State University of New Jersey, School of Graduate Studies).
57. Howell, S. L., Sorensen, D., & Tippets, H. R. (2009). The new (and old) news about cheating for distance educators. *Online Journal of Distance Learning Administration*, *12*(3), n3.
58. Hüsing, T., Gareis, K., & Korte, W. B. (2006). *The impact of ICT on social cohesion: Looking beyond the digital divide* (pp. 75-123). Springer Berlin Heidelberg.
59. Hüsing, T., Gareis, K., & Korte, W. B. (2006). *The impact of ICT on social cohesion: Looking beyond the digital divide* (pp. 75-123). Springer Berlin Heidelberg.
60. Hussain, T. (2020). *Multimedia Computing*. Booksclinic Publishing.
61. Islam, F. S. P. (2020). The Use of Multimedia and Its Impact on Bangladeshi EFL Learners at Tertiary Level. *International Journal of Language Education*, *4*(1), 150-157.
62. Jack, K. (2011). *Video demystified: a handbook for the digital engineer*. Elsevier.
63. Jamil, M., Jamil, S., & Bano, S. (2016). Extrinsic and intrinsic barriers of integrating ICTs tools in teaching at undergraduate and elementary level: A comparative study. *Pakistan Journal of Social Sciences*, *36*(2), 1073-1087.
64. amil, M., Jamil, S., & Bano, S. (2016). Extrinsic and intrinsic barriers of integrating ICTs tools in teaching at undergraduate and elementary level: A comparative study. *Pakistan Journal of Social Sciences*, *36*(2), 1073-1087.
65. Jenkinson, J. (2017). The role of craft-based knowledge in the design of dynamic visualizations. *Learning from dynamic visualization: Innovations in research and application*, 93-117.
66. Jian-hua, S., Hong, L. (2012). Explore the effective use of multimedia technology in college physics teaching. *2012 International Conference on Future Electric Power Energy System Explore*, *17*, 1897-1900.
67. Jon Fauer, A. S. C. (2013). *DVCAM: a practical guide to the professional system*. Routledge.
68. Kamat, V. & Shinde, J. (2009). *"Enrichment of the learning experience of rural children through interactive multimedia,"* The Pan-Commonwealth Forum on Open Learning.
69. Kavi Kishor, P. B., Hima Kumari, P., Sunita, M. S. L., & Sreenivasulu, N. (2015). Role of proline in cell wall synthesis and plant development and its implications in plant ontogeny. *Frontiers in Plant Science*, *6*, 544.
70. Ke, F. (2008). A case study of computer gaming for math: Engaged learning from gameplay? *Computers & Education*, *51*(4), 1609-1620.
71. Keengwe, J., Onchwari, G., Wachira, P. (2008b). Computer technology integration and student learning: barriers and promise. *Journal of Science Education Technology*, *17*, 560-565.
72. Keengwe, S., Onchwari, G., Wachira, P. (2008a). The use of computer tools to support meaningful learning. *Journal of Education Technology Review*, *16* (1), 77-92.
73. Kefauver, A. P., & Patschke, D. (2007). *Fundamentals of digital audio* (Vol. 22). AR Editions, Inc.
74. Kerr, D. (2009). MIDI: the musical instrument digital interface. *Cleveland, OH*.
75. Kim, J., & Lee, K. S. S. (2022). Conceptual model to predict Filipino teachers' adoption of ICT-based instruction in class: using the UTAUT model. *Asia Pacific Journal of Education*, *42*(4), 699-713.

76. Kim, N. J. (2017). *Enhancing students' higher order thinking skills through computer-based scaffolding in problem-based learning*. Utah State University.
77. Kingsley, K. V., & Boone, R. (2008). Effects of multimedia software on achievement of middle school students in an American history class. *Journal of Research on Technology in Education*, *41*(2), 203-221.
78. Korkut, C. (2022). Television Technique in New Media. *Gümüşhane Üniversitesi İletişim Fakültesi Elektronik Dergisi*, *10*(1), 469-493.
79. Kulaksız, T., & Karaca, F. (2023). A path model of contextual factors influencing science teachers' Technological Pedagogical Content Knowledge. *Education and Information Technologies*, *28*(3), 3001-3026.
80. Kuo, P., Hillman, P., & Hannah, J. (2005). *Improved lip fitting and tracking for model-based multimedia and coding*.
81. Kurz, C. J., Li, G., & Vine, D. J. (2019). Are millennials different? In *Handbook of US consumer economics* (pp. 193-232). Academic Press.
82. Liang, F., Luo, C., Xiong, R., Zeng, W., & Wu, F. (2017). Hybrid digital-analog video delivery with Shannon–Kotel'nikov mapping. *IEEE Transactions on Multimedia*, *20*(8), 2138-2152.
83. Lim, C. P., Zhao, Y., Tondeur, J., Chai, C. S., & Tsai, C. C. (2013). Bridging the gap: Technology trends and use of technology in schools. *Journal of Educational Technology & Society*, *16*(2), 59-68.
84. Liu, S. H., Liao, H. L., & Pratt, J. A. (2009). Impact of media richness and flow on e-learning technology acceptance. *Computers & Education*, 52(3), 599-607.
85. Marc, P. (2001). Digital natives, digital immigrants. *On the horizon*, *9*(5), 1-6.
86. Mathayo, M. H. (2016). *Teachers' experience on the use of ICT to facilitate teaching: A case of Ilala District Secondary Schools* (Doctoral dissertation, The Open University of Tanzania).
87. Mayer, R. E. (1997). Multimedia learning: Are we asking the right questions? *Educational Psychologist*, 32(1), 1-19.
88. Mayer, R. E. (2005). *Cognitive theory of multimedia learning*. Cambridge University Press.
89. Mayer, R. E. (2005). *Multimedia learning*. Cambridge University Press.
90. Mayer, R. E. (2017). Using multimedia for e-learning. *Journal of computer assisted learning*, *33*(5), 403-423.
91. Mayer, R.E., (2009). Applying the science of learning: evidence-based principles for the design of multimedia instruction. *American Psychology 63* (8), 760–769.
92. McLaughlin, M., & Talbert, R. (2005). Acceptance of change: The role of teachers in integrating technology in classroom instruction. *Technology, Pedagogy, and Education*, *14*(1), 109-118.
93. McLaughlin, M., & Talbert, R. (2005). Acceptance of change: The role of teachers in integrating technology in classroom instruction. *Technology, Pedagogy, and Education*, *14*(1), 109-118.
94. Milovanovic, M., Obradovic, J., Milajic, A., (2013). Application of interactive multimedia tools in teaching mathematics-examples of lessons from geometry. *Turkey Online Journal of Educational Technology-TOJET 12 (1)*, 19–31.
95. Moxey, C. E., Sangwine, S. J., & Ell, T. A. (2003). Hypercomplex correlation techniques for vector images. *IEEE Transactions on Signal Processing*, *51*(7), 1941-1953.
96. Mukherjee, S. (2018). Role of multimedia in education. *Edelweiss Applied Science and Technology*, *2*(1), 245-247.
97. Mustafa, Y. E. A., & Sharif, S. M. (2011). An approach to adaptive e-learning hypermedia system based on learning styles (AEHS-LS): Implementation and evaluation. *International Journal of Library and Information Science*, *3*(1), 15-28.
98. Myhill, D. (2005). Prior Knowledge and the (RE) Production of School Written Genres: An Analysis of British Children's Meaning-making Resources. *Writing in Context (s) Textual Practices and Learning Processes in Sociocultural Settings*, 117-136.
99. Newhouse, C. P., Trinidad, S., & Clarkson, B. (2002). Quality Pedagogy and Effective Learning with Information and Communications Technologies (ICT): a review of the literature. *Western Australia Department of Education*.
100. Nocek, A. J. (2015). *Animate Biology: Data, Visualization, and Life's Moving Image* (Doctoral dissertation).
101. Norhayati, A. M., & Siew, P. H. (2004). Malaysian Perspective: Designing Interactive Multimedia Learning Environment for Moral Values Education. *Educational Technology & Society*, 7 (4), 143-152.
102. Nusir, S., Alsmadi, I., Al-Kabi, M., & Sharadgah, F. (2013). Studying the impact of using multimedia interactive programs on children's ability to learn basic math skills. *E-learning and Digital Media*, *10*(3), 305-319.
103. Nusir, S., Alsmadi, I., Al-Kabi, M., & Sharadgah, F. (2013). Studying the impact of using multimedia interactive programs on children's ability to learn basic math skills. *E-learning and Digital Media*, *10*(3), 305-319.
104. Ogli, A. E. T., & Dilshod, B. (2021). Raster and vector formats of electronic document of technical documentation. *Universum: технические науки*, (7-3 (88)), 35-37.
105. Ollamina-Gerez, K. M., & Dioso, E. D. (2023). Teaching strategies using the multimedia and student's academic achievement: An experimental study. *EPRA International Journal of Multidisciplinary Research (IJMR)*, *9*(7), 307-315.
106. Osborne, J., & Hennessy, S. (2003). Literature review in science education and the role of ICT: Promise, problems and future directions.
107. Özden, M. (2007). Problems with science and technology education in Turkey. *Eurasia Journal of Mathematics, Science and Technology Education*, *3*(2), 157-161.
108. Painter, T., & Spanias, A. (2000). Perceptual coding of digital audio. *Proceedings of the IEEE*, *88*(4), 451-515.
109. Pallant, J. (2020). *SPSS survival manual: A step-by-step guide to data analysis using IBM SPSS*. Routledge.
110. Parekh, R. (2006). *Principles of multimedia* (p. 727). Tata McGraw-Hill.
111. Parent, R. (2012). *Computer animation: algorithms and techniques*. Newnes.
112. Pelgrum, W. J. (2001). Obstacles to the integration of ICT in education: results from a worldwide educational assessment. *Computers & Education*, *37*, 163-178.

113. Pelgrum, W. J. (2001). Obstacles to the integration of ICT in education: results from a worldwide educational assessment. *Computers & Education*, *37*, 163-178.
114. Pelgrum, W. J. (2001). Obstacles to the integration of ICT in education: results from a worldwide educational assessment. *Computers & Education*, *37*, 163-178.
115. Penuel, W. R., Riedy, R., Barber, M. S., Peurach, D. J., LeBouef, W. A., & Clark, T. (2020). Principles of collaborative education research with stakeholders: Toward requirements for a new research and development infrastructure. *Review of Educational Research*, *90*(5), 627-674.
116. Pohlmann, K. C. (2000). *Principles of digital audio*. McGraw-Hill Professional.
117. Pryor, C. R., & Bitter, G. G. (2008). Using multimedia to teach in-service teachers: Impacts on learning, application, and retention. *Computers in Human Behavior*, *24*(6), 2668-2681.
118. Quamar, M. M. (2020). *Education system in Saudi Arabia: Of change and reforms*. Springer Nature.
119. Ramaiah, C. K. (2005). An overview of electronic books: a bibliography. *The Electronic Library*, *23*(1), 17-44.
120. Raper, J. (2020). Progress towards spatial multimedia. In *Geographic Information Research* (pp. 525-543). CRC Press.
121. Regmi, K., & Jones, L. (2020). A systematic review of the factors–enablers and barriers–affecting e-learning in health sciences education. *BMC medical education*, *20*, 1-18.
122. Roschelle, J. M., Pea, R. D., Hoadley, C. M., Gordin, D. N., & Means, B. M. (2000). Changing how and what children learn in school with computer-based technologies. *The Future of Children*, 76-101.
123. Rusdewanti, P. P., & Gafur, A. (2014). Development of interactive learning media for music arts for junior high school students. *Journal of Educational Technology Innovation*, *1*(2), 153-164.
124. Said, N. S. (2007). Towards a 'model of engagement' Designing Multimedia Application for Children. *Digital Learning*, *3*(1), 133-139.
125. Schoenfeld-Tacher, R., McConnell, S., & Graham, M. (2001). Do no harm-A comparison of the effects of on-line vs. traditional delivery media on a science course. *Journal of Science Education and Technology*, *10*, 257-265.
126. Schoepp, K. (2005). Barriers to technology integration in a technology-rich environment. *Learning and teaching in higher education: Gulf perspectives*, *2*(1), 56-79.
127. Shah, I., & Khan, M. (2015). Impact of multimedia-aided teaching on students' academic achievement and attitude at elementary level. *US-China Education Review A*, *5*(5), 349-360.
128. Shah, S., Cox, A. G., & Zdanowicz, M. M. (2013). Student perceptions of the use of pre- recorded lecture modules and class exercises in a molecular biology course. *Currents in Pharmacy Teaching and Learning*, *5*(6), 651-658.
129. Shinde J. (2003). *Effectiveness of Multimedia CAI Package with reference to Levels of Interactivity and Learning Styles*. Unpublished thesis, SNDT Women's University, Mumbai.
130. Shuib, L., Shamshirband, S., & Ismail, M. H. (2015). A review of mobile pervasive learning: Applications and issues. *Computers in Human Behavior*, *46*, 239-244.
131. Shumack, K., & Sheridan Burns, L. (2017). On-campus or online: Learning resources and communities of practice make the difference. *Spark: UAL Creative Teaching and Learning Journal*, 111-122.
132. Sicilia, C. (2005). *The Challenges and Benefits to Teachers' Practices in Constructivist Learning Environments Supported by Technology*. Unpublished master's thesis, McGill University, Montreal. Saudi Arabia: Alroshed press.
133. Solomon, J. (2003). The passion to learn. *An inquiry into autodidactism*.
134. Stith, B. J. (2004). Use of animation in teaching cell biology. *Cell biology education*, *3*(3), 181-188.
135. Suchyadi, Y., & Suharyati, H. (2021). The Use of Multimedia as an Effort to Improve the Understanding Ability of Basic School Teachers 'Creative Thinking in The Era 'Freedom of Learning,'. *Yogyakarta: Zahir Publishing*, 42-53.
136. Susanto, A. (2017). *Teacher Performance Improvement Management (Concept, Strategy, and Implementation)*. Jakarta: Pernada Media Group.
137. Taradi, S.K., Taradi, M., Radic, K., & Pokrajac, N. (2005). Blending problem-based learning with Web technology positively impacts student learning outcomes in acid-base physiology. *Advanced Physiological Education, 29* (1), 35-39.
138. Tekalp, A. M. (2015). *Digital video processing*. Prentice Hall Press.
139. Toprakci, E. (2006). Obstacles at integration of schools into information and communication technologies by taking into consideration the opinions of the teachers and principals of primary and secondary schools in Turkey. *Journal of Instructional Science and Technology (e-JIST)*, *9*(1), 1-16.
140. Tversky, B., Morrison, J. B., & Betrancourt, M. (2002). Animation: can it facilitate? *International journal of human-computer studies*, *57*(4), 247-262.
141. Tzeng, S. Y., Lin, K. Y., & Lee, C. Y. (2022). Predicting college students' adoption of technology for self-directed learning: a model based on the theory of planned behaviour with self-evaluation as an intermediate variable. *Frontiers in Psychology*, *13*, 865803.
142. Unal, Z. (2005). *Comparing the learning outcomes and course satisfaction of web-based vs. classroom-based instruction* (Doctoral dissertation, The Florida State University).
143. Vaughan, N. D. (2016). A programmatic blended learning approach through the use of digital technologies. In *Enhancing European Higher Education: Opportunities and impact of new modes of teaching: The online, open and flexible higher education conference proceedings, Rome, Italy* (pp. 323-336).
144. Vijapurkar, J., Kawalkar, A., & Nambiar, P. (2014). What do cells really look like? An inquiry into students' difficulties in visualising a 3-D biological cell and lessons for pedagogy. *Research in Science Education*, *44*, 307-333.
145. Wang, J., Chen, C., Tuan, S., & Lin, C. (2014). The effectiveness of professional development for integrating technology in science teaching: Tutorials and teacher training. *Journal of Science Education and Technology, 23*(5), 961-975.
146. Wang, J., Chen, C., Tuan, S., & Lin, C. (2014). The effectiveness of professional development for integrating technology in science teaching: Tutorials and teacher training. *Journal of Science Education and Technology, 23*(5), 961-975.

147. Ward, P. (2013). Animation studies as an interdisciplinary teaching field. In *Pervasive animation* (pp. 317-337). Routledge.
148. Watkinson, J. (2012). *Introduction to digital video*. Routledge.
149. Watkinson, J. (2013). *Introduction to digital audio*. Routledge.
150. Way, L., Pritchard, M. E., Wike, L., Reath, K., Gunawan, H., Prambada, O., & Syahbana, D. (2022). Detection of thermal features from space at Indonesian volcanoes from 2000 to 2020 using ASTER. *Journal of Volcanology and Geothermal Research*, *430*, 107627.
151. Wells, B. (2011). Frame of reference: Toward a definition of animation. *Animation Practice, Process & Production*, *1*(1), 11-32.
152. Williams, R., & Newton, J. (2009). *Visual communication: Integrating media, art, and science*. Routledge.
153. Winarni, R. S., Rasiban, L. M., & Juangsih, J. (2022). The Effect of YouTube Video Learning Media on the Students' Basic Japanese Listening Ability. In *Sixth International Conference on Language, Literature, Culture, and Education (ICOLLITE)* (pp. 455-459). Atlantis Press.
154. Xu, Y., Liu, X., Cao, X., Huang, C., Liu, E., Qian, S., & Zhang, J. (2021). Artificial intelligence: A powerful paradigm for scientific research. *The Innovation*, *2*(4).
155. Yang, H., Alsadoon, A., Prasad, P. W. C., Al-Dala'in, T., Rashid, T. A., Maag, A., & Alsadoon, O. H. (2022). Deep learning neural networks for emotion classification from text: enhanced leaky rectified linear unit activation and weighted loss. *Multimedia Tools and Applications*, *81*(11), 15439-15468.
156. Zammit, K. (2011). Moves in hypertext: The resource of negotiation as a means to describe the way students navigate a pathway through hypertext. *Linguistics and Education*, *22*(2), 168-181.
157. Zevenbergen, R. (2007). Digital natives come to preschool: Implications for early childhood practice. *Contemporary Issues in Early Childhood, 8*(1), 18-28.
158. Zin, M.Z.M., Sakat, A.A., Ahmad, N.A., & Bhari, A., (2013). Relationship between the multimedia technology and education in improving learning quality. *Procedia-Social and Behavioral Science*, *90*, 351-355.