

## Effect of Interactive Multimedia on The Improvement of Pre-Service Teachers' Performance in The Teaching and Learning of Cell Structure, Cell Division and Mendelian Genetics

F. Arthur-Baidoo<sup>1</sup>, C. K. Koomson<sup>2</sup>, Y. Ameyaw<sup>3</sup>, M. D. Acquah<sup>4</sup>

<sup>1</sup>Wiawso College of Education, P. O. Box 94, Sefwi Wiawso, Ghana

<sup>2</sup>Department of Integrated Science Education, UEW.

<sup>3</sup>Department of Biology Education, UEW.

<sup>4</sup>Wiawso College of Education.

\*Corresponding author: F. Arthur-Baidoo, Email address: francisarthurbaidoo@yahoo.com

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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 tests 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 study found that pre-service science teachers' academic performance in the selected biology concepts had improved significantly after they have been exposed to interactive multimedia instructional approach interventional activities with the average score in pre-test examination of 36.62 to 71.89 average score in the post-test examination. In conclusion, the implementation of IMIA with different learning strategies needs to be designed and developed to facilitate and enhance the learning ability of pre-service science teachers in terms of biology. It was therefore recommended that College of Education Biology Lecturers should adopt innovative instructional strategies such the IMIA so as to help College of Education pre-service science teachers to learn abstract biology concepts such as cell structure, cell division and Mendelian genetics at the college level better.*

**Keywords:** Interactive Multimedia, Performance, Cell structure, Cell division, Mendelian genetics.

### 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, Alsadoon, Prasad, Al-Dala'in, Rashid, Maag, & Alsadoon, 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, Pritchard, Wike, Reath, Gunawan, Prambada, & Syahbana, 2022; Ginting, & Linarsih, 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, Rasiban, and Juangsih (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.

To Adedamola (2018), Biology is a science subject which explains the existence of life. It is a natural science which is concerned with the study of living organisms, their structures, forms and functions, heredity, cell division, etc. It is a fundamental science subject which serves as the basis for understanding the complexities of how the body parts of organisms' functions. Biology, according to Taiwo and Emeke (2014), is the subject that exposes the students to the world of knowledge of self, the immediate and distant environment. This may be the bases for its inclusion in the Senior High School (SHS) and College of Education (CoE) curricula in Ghana. Traditional college biology courses, on the other hand, only allow a limited number of biology experiments in the classroom, and students are unable to control them dynamically and intuitively in order to obtain a clear biological representation of the concept (Taiwo & Emeke, 2014). Despite the adoption of multimedia instructional approaches, they remain insufficient and therefore the multimedia tools must be further developed and investigated to enhanced their application and methodology. In college biology classes, the effective use of multimedia tools can minimize the amount of written and handwritten content.

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.

Practical laboratory exercises that demand a particular degree of psychomotor abilities are used to supplement the teaching and learning in multimedia education sessions. Practical content presentation to the learner can aid in the attainment of learning objectives and hence improve the learning environment. In view of this, it is clear that introducing interactive multimedia instructional tools to students, such as virtual classrooms, distance learning, biology software (e.g., coach lab II), online concept teaching and learning, design experiments, and other tools that are not as common as face-to-face education, helped them to improved their conceptual understanding and academic performance in cell structure, cell division and Mendelian genetics. Because of the connection between a person and the learning environment, this interactive multimedia tools learning process may occur at any time, with anybody, and anywhere (Aljawarneh, 2020).

Conventional face-to-face instruction has its advantages; it does not impart the skills required in today's fast-paced economy (Aloraini, 2012). Choosing a good teaching tool is one of the problems that many instructors encounter when adding technology into the classroom. New technologies such as artificial intelligence, asynchronous computer conferencing, and interactive digital video and optical formats, according to

Hannum (2022) provides instructors with a new type of media. To Abdulrahman, Faruk, Oloyede, Surajudeen-Bakinde, Olawoyin, Mejabi, & Azeez (2020), integration of multimedia instructional aids in the learning process has been proved to improve students' engagement and performance in the classroom. The use of the most appropriate tools is crucial in attaining the intended learning outcomes, however tool selection and design is frequently centred on the software's features, such as fancy special effects, rather than the tool's influence on learning.

### 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 tools 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 tools 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 was guided by the following research question: What is the effect of interactive multimedia on the improvement of pre-service teachers' performance in the learning of cell structure, cell division and Mendelian genetics as compared to traditional instructional methods?

### Literature review

#### Conceptual Framework of the Study

Based on the blended learning and Cognitive Load Theory (CLT), a conceptual model (Figure 1) was settled on for the study. When students are exposed to difficult, confusing and complex concepts, they are thrown into a state of disequilibrium (Loh & Lim, 2021). Interactive multimedia instructional

approach administered in collaborative or individualized learning settings however, seems to enable students to develop cognitive structures or mental models or reorganize their already existing ones to better understand difficult, confusing and complex concepts, such as cell structure, cell division and mendelian genetics (Herrington, Reeves & Oliver, 2014).

**Figure 1:** Research conceptual framework adapted from Al-Ani (2013)

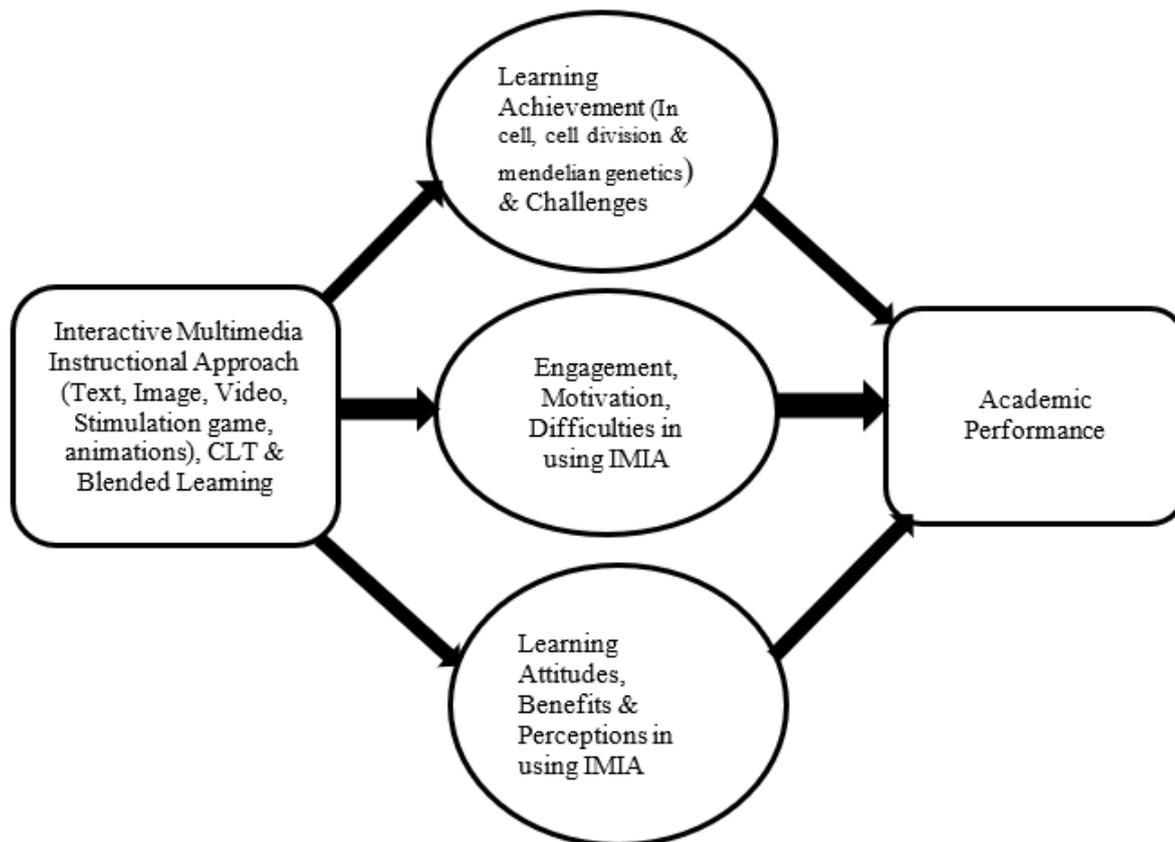


Figure 1 presents the research conceptual framework using Interactive Multimedia Instructional Approach with cognitive load theory to enhance students' learning achievement. The conceptual research framework was adapted based on the blended learning and cognitive load theory. The cognitive load theory identifies three types of cognitive loads: intrinsic load, extraneous load, and germane load (Sweller, 2010). It is believed that, when interactive multimedia tools are used by teachers or educators, it helps cognitive learning to take place by minimizing extraneous cognitive load and maximize germane cognitive load in mixing different learning environments where both Interactive Multimedia Approaches and Cognitive Load Theory will lead to students' learning achievement, learning motivation, collaboration and communication (Al-Ani, 2013).

#### Interactive Multimedia Approaches

The term interactive multimedia approach has been a very trendy and meaningful concept for a long time (Gitelman, 2008). Interactivity, in the term adopted here, means the potential of technical devices for maintaining a human-digital relationship with the required aspect of participation and interaction (Sundar & Limperos, 2013). In turn, the concept of interaction in the teaching process itself is understood as the kind of interaction between a teacher-educator and a student or a group of learners

(Khoza, 2024). The technological interaction is also mentioned which is related to the impact of technical means and innovative communication methods (Siemieniecka, Kwiatkowska, Majewska & Skibinska, 2017). In information technology, interaction means the mode of operation consisting in alternating exchange of information between the user and the computer, the user issues commands to the computer, whose effects can be monitored and used to make further decisions (Fischer, 2011; Gill, 2007). Human interaction with the computer becomes a key mechanism for acquiring knowledge, education, and furthering education, developing interests and passions, and realizing the idea of lifelong education (Ala-Mutka, 2009; Solomon, 2003).

The long-term empirical research on the use of media and digital technologies has confirmed the need to use activation methods with a high level of interaction (Pimmer, Mateescu & Gröhhbiel, 2016). To them, multimedia or digital learning resources assist learners to get on well with mental representations with the use of different media elements, which support information processing. Information, which is made up of content and sometimes learning activities, is presented with the use of the combination of text, image, video and audio by digital learning resources and it has been demonstrated by research on using multimedia for learning, that there are more positive results

observed in learners who combine picture and words than those who use words only (Chen & Liu, 2008; Mayer, 2008). As stated in Eady and Lockyer (2013), different pedagogy methods were implemented by the use of digital resources. Their paper presented how the authors were able to introduce concepts to students, demonstrate to them, stimulate a group, make different text types available and engage students in an interactive manner. Generally speaking, multimedia technology for educational purposes can be categorized according to whether they are used for teaching or for learning. Some of the different multimedia or digital learning resources are listed in Eady and Lockyer (2013). Furthermore, according to Guan et al. (2018), several studies have established the importance of multimedia technologies to education and the widespread adoption of multimedia tools. Multimedia generally involves the use of technology and the widespread adoption of multimedia applications in education is as a result of it has many benefits (Almarabeh et al., 2015).

To them, some of the benefits of the multimedia application approaches for teaching and learning are ability to turn abstract concepts into concrete contents, ability to presents large volumes of information within a limited time with less effort, ability to stimulates students' interest in learning and provides teacher with the ability to know students position in learning. Multimedia designed for learning refers to the process of building mental representation from words and pictures in different contexts, they are designed to assist learning with tools which can be used in presentations, class room or laboratory learning, simulations, e-learning, computer games, and virtual reality, thereby allowing learners to process information both in verbal and pictorial forms (Alemdag & Cagiltay, 2018). Multimedia designed for learning requires understanding of some theories such as cognitive theory of multimedia learning, which postulates three assumptions that describe how people learn from instructional multimedia materials. These assumptions can be phrased as dual-channel, limited capacity, and active processing (Alemdag & Cagiltay, 2018). Dual-channel assumes that learners have many channels to separate visual and auditory information. The restricted or limited capacity assumes that there is a limit to the load of data that can be processed in each channel. To them, understanding these will allow teachers not overwhelming learners with much information and on the other hand, learners will be aware of their information processing limitations or capabilities. According to Alemdag and Cagiltay, active processing proposes that when it comes to information selection, organization, and integration, human beings are active agents and are capable of managing the forms of information they are interacting with. The appropriate use of ICT in teaching transforms the learning environment from teacher-centred to learner-centred (Coleman et al., 2016) just as it is transforming all aspects of human life (Guan et al., 2018). Coleman et al., (2016) emphasised that the shifting from teaching to learning creates a student-centred learning where teachers are there as facilitators and not elders on the stages, thus changing the role of the teacher from knowledge transmitter to that of a facilitator, knowledge navigator and a co-learner. Keengwe et al., (2008a) concluded that the application of multimedia technologies ensures a very productive, interesting, motivating, interactive and quality delivery of classroom instruction while addressing diverse learners' needs.

### **Importance and Effects of Multimedia Approaches**

The roles of multimedia system and its effectiveness are the topic of many studies. User interactivity could be a major feature of well-designed multimedia courseware. In step with Guan, Song and Li (2018), several studies have established the importance of multimedia technologies to education and also the widespread adoption of multimedia tools. Multimedia generally the utilization of technology and also the widespread adoption of multimedia applications in education could be a result of its many benefits (Almarabeh, Amer & Suliman, 2015). A number of the advantages of the multimedia application approaches for teaching and learning are summarized as follows: Ability to show abstract concepts into concrete contents, Ability to present large volumes of knowledge within a limited time with less effort, Ability to stimulates students' interest in learning, Provides teacher with the power to understand students position in learning, Create a way of expectation in students', Energize or relax students for learning exercise, Draw on students' imagination, Improve attitudes toward content and learning, Build a reference to other students and instructor, Increase the memory of the content, Increase students understanding, Foster creativity, Stimulate the flow of ideas, Foster deeper learning, Function as vehicle for collaboration, Inspire and motivate students, Make learning fun, Set an appropriate mood or tone and Decrease anxiety and tension on scary topics/concepts and make memorable visual images.

The importance of multimedia technologies and applications in education as a teaching or learning approach cannot be over-emphasized. This has been confirmed in several studies that have investigated the impact of multimedia technology on the education system. Milovanovi, Obradovic and Milajic (2013) demonstrated that the importance of using multimedia tools in Mathematics classes and positioned that the multimedia tool greatly enhances students' learning. Several works exist that show that multimedia enhances students' learning (Aloraini, 2012; Al-Hariri & Al-Hattami, 2017; Barzegar et al., 2012; Chen & Xia 2012; Dalacosta et al., 2009; Jian-hua & Hong, 2012; Keengwe et al., 2008b; Kingsley & Boone, 2008; Shah & Khan, 2015; Taradi et al., 2005; Zin et al., 2013). Multimedia technology helps simplify abstract content, allows for differences from individuals, and allows for the coordination of diverse representation with a unique perspective (Aloraini, 2012). To Al-Hariri and Al-Hattami (2017), the utilization of the computer-based technique as an interface between students and what they are learning with suitable fonts and style is very valuable and certainly, multimedia technology brings about improvement in teaching and learning. However, there are some limitations during this technology for educational purposes. Interactive multimedia tools enable the user to govern these materials through a large type of powerful linking, sorting, searching, and annotating activities and each of those activities is made to strengthen and inculcate various intellectual skills, additionally to satisfying certain cognitive needs for quality learning, like the power to follow through links at the immediate moment when curiosity is aroused, and therefore the ability to look at different styles of the identical information side-by-side (Barzegar et al., 2012).

Interactive multimedia programs usually integrate some combination of orientation tools, like timelines, graphs, glossaries, and other pedagogical guides and these types of tools further point to a different major advantage of multimedia: The

personalization or individualization of the training experience. By allowing users to manage the sequence and also the pacing of the materials, Multimedia packages facilitate greater individualization in learning, allowing students to proceed at their own pace during a tailored learning environment (Chen & Xia 2012). In other words, object-oriented database management system, properly developed and properly implemented, could reform education. According to Roschelle, Pea, Hoadley, Gordin, and Means (2000), reform or change in education system is also a touch optimistic, multimedia system may be a promising medium for reinforcing, extending, and complementing what goes on within the classroom with print materials, lectures, and classroom discussions. Other researches have shown that an interactive learning environment can generate effective instruction and learning systems (Dalacosta et al., 2009; Jian-hua & Hong, 2012; Shinde, 2003).

Several researches conducted by Mayer many years ago indicated that using multi-modal instruction is more practical than using any single-mode (Mayer, 2005; Norhayati & Siew; 2004; Mayer, 1997). In other words, this finding demonstrates that media do impact learning, through the academic possibilities that they permit. For instance, supported Mayer's research, one could state that when used appropriately, the video medium should be more practical than radio, since the latter cannot provide visual information. The presentation of ideas in visual form has proven to be particularly important because it critically helps the academic process (Mayer, 2005). A review by various researchers of studies that have investigated the effectiveness of multimedia in learning suggested that the people that used computer-based multimedia instruction performed better in terms of test scores, compared to people who received instruction through traditional classroom lectures (Keengwe et al., 2008b; Kingsley & Boone, 2008; Shah & Khan, 2015; Taradi et al., 2005; Zin et al., 2013). Bayhan, Olgun and Yelland (2002) explored the utilization of computers reception to develop mathematical ideas and reported that there was considerable potential for computer games to support such learning. Similar research papers showed that youngsters who are exposed to or have and use the personal computer and internet reception for education can have better chances of understanding basic learning skills like the fundamentals of Mathematics and Alphabet (Charp, 2003).

This early exposure to technology may offer new potentials for both children and also the pedagogy in infancy settings. Special terms accustomed describe this new generation may be seen in several papers. For example: 'Generation Y' (Eckleberry-Hunt & Tucciarone, 2011; Charp, 2003), 'Digital natives' (Marc, 2001), and 'Millennials' (Gorman, Nelson, & Glassman, 2004; Kurz, Li & Vine, 2019). Children's homes have technology altogether facets of gadgets: TV remote, the programmable microwave, wireless phones, computers, digital games (such as Play-station, Xbox, etc) and these offer significantly alternative ways of playing from what had been possible in non-digital worlds (Zevenbergen, 2007). To him, educators have to try and stayed up and compete with those kids. To do that, educators must continuously update their knowledge and skills in order to include these methods in their delivery (at least in preparation and presentation) irrespective of what's their major. Nocek's (2015) study showed that the utilization of animation in teaching cell biology and every one fields of biology are beneficial. Ward's (2013) also, found that scalable interactive animation

with hotkeys and rollover help to boost the educational effectively. The animated illustration accompanied with audio, video, and kinetic are far better for cell biology learners than static illustrations (Stith, 2004). Cronje and Fouche (2008) investigated the differences of mental models of learners and designers. Their study was supported by six high school students (3 males & 3 females) attempting to be told the principles of electricity. The scholars in the study were selected during a way that reflects three levels (i.e., weak, middle, and good) for every gender. The results revealed considerable differences between the mental models of learners and designers (Cronje & Fouche, 2008). The free navigation of the multimedia learning program helps good students to accelerate their learning (Nusir, Alsmadi, Al-Kabi, & Sharadgah, 2013). Holzinger, Kickmeire-Rust, Wassertheurer and Hessinger (2009) addressed the results of using simulation to show complex physiological models to 96 students of the school of medication. Their study also, found that the effectiveness of the designed simulator and also the conventional text lessons are equivalent. Using additional guidance to the designed simulator helps to enhance the training process (Holzinger et al, 2009). Kamat and Shinde (2009) project was supported by the results of a test on several hypermedia packages for grades I to IV.

They concluded that multimedia packages are usually used for subjects like science, mathematics, geography, history, etc. Again, they settled that interactive multimedia instructional approach of teaching and learning is far better than traditional educational methods of teaching and learning, which rely on classrooms and lecturers using chalk and talk (Kamat & Shinde, 2009). Computer games may be used as a teaching and learning tool. Ke's study aimed to seek out the effect of educational computer games on the 4th and 5th graders on mathematics. To attain this goal the study tested the effect of educational games on cognitive maths achievement, metacognitive awareness, and positive attitudes toward maths learning. Results revealed that educational computer games help to draw in students towards learning maths during the primary five weeks. (Ke, 2008). Liu, Liao and Pratt (2009) study also confirmed previous findings on the positive effect of media richness within e-learning educational systems on the user's intention to use such systems. E-learning systems that present their materials using text, audio, and video stimulate higher perceived usefulness and concentration than their counterparts which used text-only, text and audio, or text and video, or audio and video (Jenkinson, 2017).

Evans and Gibbons (2007) tried to search out the consequences of adding interactivity to computer-based learning packages of business and management on a tiny low sample of undergraduate students (22 males, and 11 females). The sample was randomly divided into two groups, to check the effect of interactivity versus the non-interactive modules. The results reaffirmed the positive effects of using visualization to enhance the depth of learning and understanding. Nusir, et al. (2012) found that the dynamic nature of multimedia looked as if it would help children to form mental models more effectively and improve comprehension. Studying the impact of using multimedia interactive programs on children ability to be told basic maths skills, Nusir, et al. (2012) for instance observed that, the continuous inventions and evolutions in all information technology fields open new channels and opportunities to enhance teaching and educational methods. In their study it was

revealed that in one side, it may improve the abilities of educators to present information in an interactive and media enhanced formats relative to traditional methods.

These methods may help students or learners by offering them the information in channels and methods that can be easier to understand, deal with, and retrieve. On the other hand, offering those alternative methods of teaching can be helpful particularly for children, people with special needs, or students in rural areas where they can have virtual or remote instructors especially for major ones that have shortages. Their purpose of the study was to investigate the impact of utilizing multimedia technologies on enhancing, or not, the effectiveness of teaching students at early stages in Jordanian primary schools. To achieve this objective a program was developed to test the students' abilities to understand mathematical basic knowledge and skills. Two groups were selected from a local school based on their own class distribution where one group was taught the subject in basic math using a program developed for this purpose. The second class was taught the same subject using traditional methods of teaching. After study data was collected and analysed, the results revealed that in such maths skills at that age, using programs or multimedia enhanced methods of teaching can be effective in getting students attention especially when cartoon characters are used. Other results also, showed that there was no significant difference in learning and knowledge skills and information absorption was based on gender distribution where results comparison between little boys and girls displayed no significant difference in their learning skills (Nusir, et al., 2012).

Roschelle et al. (2000) have suggested that such research has indicated that learning is only when characterized by: active engagement, participation in groups; frequent interaction and feedback are provided, and connections to real-world contexts are made. They asserted traditional teaching method was quite poor at providing such contexts and after all, the characteristics of innovative uses of computers are conducive to learning that's all of those listed. Again, they explained that educators should incorporate entertainment through education and may get students involved actively in classes. This could be achieved by showing them the items they use and appreciate like games, social websites, etc., which might be used and utilized within the class in addition for educational purposes. Well-designed hypermedia system e-learning systems can attract the learners to possess more information (Mustafa, & Sharif, 2011). Active engagement is very important about improving the training process. Said, (2007) explained that, attempts to put down a foundation of a design model of multimedia system in e-learning system can offer active engagement (Said, 2007).

### **Role of Multimedia Technology in Teaching and Learning**

Technology is evolving and scholars in the areas of Information Technology (IT) and education technology are continuing to study how multimedia technologies can be harnessed for the enhancement of teaching and learning (Laurillard, Oliver, Wasson, & Hoppe, 2009). A software tool can be used to expand teaching and learning in various fields. It is important to provide students with practical experience in most fields of learning. The importance of multimedia technologies and applications in education as a teaching or learning tool cannot be over emphasized. This has been confirmed in several studies that have investigated the impact of multimedia technology to the

education system and found that multimedia enhances students' learning (Aloraini, 2012; Al-Hariri & Al-Hattami, 2017; Barzegar et al., 2012; Chen & Xia 2012; Dalacosta et al., 2009; Jian-hua & Hong, 2012; Keengwe et al., 2008b; Kingsley & Boone, 2008; Shah & Khan, 2015; Taradi et al., 2005; Zin et al., 2013). Again, Abdulrahman et al. (2020) demonstrated in their study, the importance of using multimedia tools in Mathematics classes and found that the multimedia tool greatly enhances students' learning. Multimedia communication has close similarities to face-to-face communications. To them, multimedia technology helps simplify abstract content, allows for differences from individuals and allows for coordination of diverse representation with a different perspective. The use of the computer-based technique as an interface between students and what they are learning with suitable fonts and design can be very valuable. Certainly, multimedia technology brings about improvement in teaching and learning, however, there are a number of limitations in this technology for educational purposes. Some of these limitations include unfriendly programming or user interface, limited resources, lack of required knowledge and skill, limited time and high cost of maintenance among others (Aljazzaf, 2020; Putra, 2018).

Multimedia tools are easily accessible and seem acceptable to language instructors, as video, film, and computerized learning methodologies, to include it in their lesson and assessment plans make their teaching effective. Students remain surrounded by technology and this technology can offer exciting and novel methods to language learning because the usage of technology is advancing their school in the proper way (Healey et al., 2008). To them, using multimedia in this way, the instructors can use technology to teach their courses. To Rana (2013), some of the major benefits of using multimedia technology are as follows: Motivation to learners; Rana said in this regard, we must also consider that we are very visual people, as human beings, that what we see tends to influence our judgment more and technology helps us bring this visual component to education. Who would prefer a lecture class to a lecture? It makes information about the target language culture easier to obtain. The multimedia tools produce a real-like speaking atmosphere for the learners and promote students' curiosity in language acquisition with such qualities as enough information, beyond the limits of time and space (Kumar, 2021). Enhancing communicative abilities: Multimedia technology has now provided significant support for integrating education and learning and gives students more incentives to achieve the future competitiveness of students at work (Healey et al., 2008). The instructions of the teachers lead to the students' thinking and motivation. According to Hossain (2021), multimedia technologies break the monotony of classroom education and make it fun and inspiring. The usage of the PowerPoint template for example enables students to understand the language and think. To him, this generates a healthy platform for group discussions, concepts, and debates, which can provide greater communication chances among them. Hossain then concluded that multimedia tools, therefore, promotes communicative abilities of the learners.

Familiarity with science culture; The usage of multimedia tools is also linked to the target culture. It encourages students to get more information related to cultural backgrounds and resources for real-life experiences that can encourage students to study (Dema & Moeller, 2012). Increase in teachers' efficiency:

Multimedia tools add to the teaching materials and takes time to best practice. It undermines the standard teaching technique focusing on instructors and fundamentally enhances teaching effectiveness and is essential to practice for language learning (Motteram, 2013). It is not feasible for students to practice speaking in crowded classrooms and voluminous courses, but the use of multimedia tools can materialize one-on-one participation. The traditional teaching strategies solely concentrate on teacher training and supply learners with minimal knowledge. The multimedia tools extend beyond time and location, creating more real-like teaching environments. It generates initiatives for learners, reduces class time and provides students with additional knowledge. Enhanced teacher-student engagement; Motteram (2013), in one of his studies on the efficiency of technology usage, says, this is still a good starting place for most instructors to work in physical classrooms and to look at ways in which digital technology may increase these spaces. Multimedia technology focuses on active student involvement and emphasizes the value of teacher-student engagement. The function of the instructor as an enabler is especially significant in this process. The use of multimedia technology may create a situation in which students and instructors may share information stressing students' commitment to real, meaningful connection (Warschauer, 2013). The typical teaching paradigm in the classroom increases this opportunity. In this way, teachers are no longer obliged to passively obtain information from learners in the classes. Conducive teaching-learning environment; The employment of multimedia tools in schools provides an atmosphere conducive to science education. Healey et al. (2008), stressed the necessity of its application, saying, "Even the most modern technology is not going to be added to bad teaching; the right use of the technology will be used to assist learners to reach their objectives". To them, multimedia technology has distinctive characteristics, such as visibility and vibrancy, which provide the participants' distinct impact. While teaching science, sounds and images can be used to increase both instructors' and students' active engagement.

### **Benefits and Challenges of Online Technology**

The traditional face-to-face mode of delivery in the form of lecturing and storytelling has been the norm ever since the establishment of the world's first university (Baltes, 1993; El-Soussi, 2022). Knowledge used to be something acquired on the basis of experience over time. To Baltes (1993), experts knew a lot about a particular subject matter, and they transmitted it to the novices. According to El-Soussi (2022), in the traditional face-to-face approaches, teachers tend to continue with their long-embodied lecture-based instructivist approaches which rely on the development of a set of instructional sequences with predetermined outcomes based on a one-size fits-all approach. To him, teachers practise by talking most of the time at an abstract level, disconnected from practice and experience. Thus, gaps currently exist between practice and what is actually required to address the learning needs, styles, and preferences of majority of today's students who prefer to learn in context (Pashler, McDaniel, Rohrer, & Bjork, 2008).

Further, the concept of knowledge and its nature have changed dramatically in the recent past especially with the advent of the World Wide Web and the Internet (Pallen, 1995), the kind of skills students need to develop to be prepared for the workforce of the 21st century is a lot different from their predecessors.

Over the years, increasing demands for access to higher education, dwindling resources, and burgeoning calls for better quality education have led universities to explore alternative methods of teaching and course offerings (Alexander, 2020). Thus, an evolutionary transformation of teaching and learning in the institutions are considered inevitable. Gerbic (2011) distinguished between face-to-face and online approaches to instruction in terms of three major areas of difference which throws light on their strengths and weaknesses in addressing learner needs. Despite the concerns about traditional face-to-face learning, it has also significant strengths of its own such as the possibility of strong human interaction which is generally more powerful than in the online mode due to its capability for visual cues (Singh, Steele & Singh, 2021).

Although earlier studies have indicated that distance and online learning courses are usually as effective as classroom-based instruction (Unal, 2005), a more recent detailed analysis of existing online learning research by Howell, Sorensen and Tippets (2009) found that, students who took all or part of their class online performed not just as good as but better, on average, than those taking the same course through traditional face-to-face instruction. To them, unique strengths of online technology include its capability to expand instructional options and strategies, and to facilitate and extend the interaction between students and the teacher resulting in personalised learning, as well as among the students through synchronous (real time) and asynchronous (delayed) methods. Schoenfeld-Tacher McConnell and Graham (2001) conducted a study to examine the effects of distance delivery on student performance and classroom interactions in an upper-level science course-Histology. The outcomes were assessed by comparing performance on content pre- and post-tests for students enrolled in on-campus and on-line sections of the same course. The resulting patterns were analyzed and compared with behaviours in different settings. It was found that although the groups were indistinguishable in content knowledge at the outset of the study, by the end of the semester, students in the on-line group significantly out-performed their peers in the on-campus section. The on-line settings had a greater proportion of high-level interactions than the on-campus setting. To them, the extent of students' interactions indicated that interactions in an online course may surpass those in traditional classroom courses. Interactions in technology-supported practices can be through tutor-students contact by email; developing communities of practice; online discussions, engaging in active learning; and providing quick, rich feedback, all these supporting collaborative and cooperative learning (Schoenfeld-Tacher, McConnell, & Graham, 2001).

Though a possibility of higher interaction is commonly assumed as a possibility in face-to-face classrooms, it is not always the case; the fact is that usually interactions run out of time unlike in the online mode which can be anytime anywhere (Freiermuth, 2001). To him, another opportunity accorded to students by online technology is the increased time on task through the availability of learning materials anytime anywhere and the use of asynchronous online communication tools; long time possible for a task allows deep engagement with the learning activities and results in self-paced learning. The time lag possible in asynchronous communication (e.g., discussion and email) enables students to control, to some extent, the pace and timing of their learning, allows for and encourages reflective learning,

and hence higher-level cognitive transactions (Robertson, 2007). Thus, both the traditional face-to-face and online instructions have their own unique strengths and weaknesses. To Bowden (2022), that is why a strong case is now being made for a blended approach whereby both online and face-to-face modes of delivery are appropriately integrated to maximize the strengths and minimize the weaknesses of both. Blended learning approach is the best way of unlocking the educational potential of new technology.

**Methodology**

**The design that was used in this study was action research.**

The participants in this study were all 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.

**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)
<b>Total</b>		<b>55 (72.37)</b>	<b>21 (27.63)</b>	<b>76 (100.00)</b>

Source: Field Data, 2024

**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.

**Instrumentation**

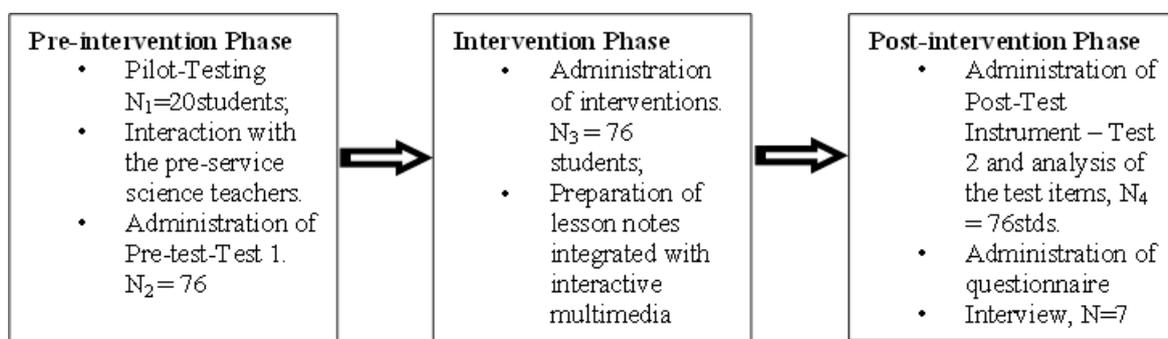
The study used questionnaire to collect data from the pre-service science teachers. The questionnaires used for the study were

pilot-tested at Komenda College of Education using 20 of the second-year pre-service science teachers.

**Data collection procedure**

In all, eight (8) weeks were used for the entire study. Out of the eight (8) weeks, one (1) week was used for the pre-intervention stage activities; six (6) weeks were used for the intervention stage activities; whereas the last one week was used for the post-intervention activities. Data collection was done in three (3) phases namely; pre-intervention phase, intervention phase and post-intervention phase. This is illustrated diagrammatically below:

**Figure 2: The process of data collection.**



These three phases are described extensively below as follows:-

**Pre-intervention phase**

The main pre-intervention activities involved extensive discussions with respect to the purpose of the study; administration of some selective biology concepts difficulty questionnaire, conduction of pre-interview sessions and pre-intervention test. These four major activities under the pre-intervention phase have been described briefly below as follows:-

**Day One Activities:**

On the 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 questionnaires 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.

**Day Three Activities:**

On the third day of the first week, the subjects were met at the laboratory in the morning. Upon series of engagements and discussions in a friendly manner, the pre-service science teachers' difficulties to use interactive multimedia tools in classrooms in the teaching and learning of biology concepts questionnaires in Appendix B were given to the pre-service science teachers to answer. All 76 pre-service science teachers took part in this session. This session lasted between 25minutes to 35minutes depending on the ability of the respondents.

**Day Four Activities:**

In order to determine each pre-service science teacher's performance prior to the start of the Interactive Multimedia Instructional Approach intervention activities; a 90 minutes pre-intervention test, called pre-service science teachers' cell structure, cell division and Mendelian genetics diagnostic test (TEST 1) was conducted for all the participants. The test was done under strict but relaxed supervision. The respondents were to answer the 90 multiple-choice objective questions for 90 marks. After the 90 minutes, the pre-intervention test papers were collected, marked and scored using the marking scheme prepared by the researcher. The pre-intervention test was used to assess the pre-service science teachers' conceptual understanding of the selected biology concepts mainly cell structure, cell division and Mendelian genetics before the implementation of the IMIA intervention activities.

**Intervention phase**

The intervention phase dealt with the implementation of "Interactive Multimedia Instructional Approach" (IMIA) for 3 hours duration per week for six weeks period. The IMIA intervention activities started from the second (2nd) week to the seventh (7th) week (20th February to 16th April, 2024). In all, six IMIA lessons were taught for the six weeks period. Each week was used to teach one of the selected biology concepts based on Interactive Multimedia Instructional Approach as follows: -

- Week Two Lesson: The Cell Structure & Classification of Cell Concepts
- Week Three Lesson: Plant and Animal Cell
- Week Four Lesson: Membrane transport
- Week Five Lesson: Cell Division-Cell Cycle (Mitosis and Meiosis Concepts)
- Week Six Lesson: Mendelian Genetics-Definition of terms & Monohybrid Inheritance
- Week Seven Lesson: Mendelian Genetics-Di-hybrid Inheritance

The IMIA intervention activities materials for each lesson consisted of IM-based lesson plan that is courseware, PowerPoint, video presentations. In all six (6) lesson plans,

activity guides interactive multimedia tools were prepared altogether on these selected biology topics and was taught for six weeks. For each of the six biology topics, six lesson plans, activity guides and IM were prepared using interactive multimedia instructional approaches.

During each lesson, the pre-service science teachers were taught each biology concepts using the interactive multimedia instructional approach in line with lesson's plan procedure prepared by the researcher. For each lesson, the pre-service science teachers were put into groups of eleven (11). Each member in group was given a role to play such as group leader, recorder, time keeper, etc and these roles were on rotational basis. The groups were made to prepare a short lesson on the topic taught using interactive multimedia of their choice and present in the next lesson before the researcher takes them through the week activities. In each lesson presented by the researcher, pre-service science teachers were exposed to series of multimedia tools during the studies.

**Post intervention phase**

After the interventional activities, post interventional activity was carried out. The post-intervention activity involved was the conduction of a 90 minutes post-test, on the concepts cell structure, cell division, Mendelian genetics. The test was done under strict but relaxed supervision. The participants were to answer the 90 multiple-choice objective questions for 90 marks. The post-test was used to assess the pre-service science teachers' conceptual understanding after the implementation of the IMIA intervention activities. After the 90 minutes, the papers were collected, marked, scored, recorded, analysed and compared with the pre-test scores to see variations in their performance.

**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.

**Results and Discussion**

**Results**

The research question of the study was to find out how effective interactive multimedia is in enhancing the performance of pre-service teachers in the learning of the following biology concepts, namely, cell structure, cell division, and Mendelian genetics. To answer this research question or objectives, scores from the pre-test and post-test examination of the students were used. Independent sample t-test of the difference in average scores of both pre-test and post-test examination. The result is shown in the Table 18 and 19 below.

**Table 2: Group Statistics.**

	EXAMES_TYPE	N	Mean	Std. Deviation	Std. Error Mean
EXAMS_SCORE	Pre-Test	76	36.6184	10.23454	1.17398
	Post-Test	76	71.8947	7.18624	.82432

Source: Field Data, 2024 (N = 76)

Table 2 displays the pre and post-tests statistics. From the table, the average score of the pre-service science teachers in pre-test examination was 36.62, whilst the average score of pre-service science teachers in the post-test examination is 71.89. This means that pre-service science teachers' performance in the post-test examination was much better than that of pre-test examination, which also signifies the effectiveness of interactive

multimedia in enhancing pre-service science teachers' performance in the learning of the following biology concepts: cell structure, cell division and Mendelian genetics. The standard deviation values from the table shows that most of the pre-service science teachers scores from pre-test deviated more than that of the scores of pre-service science teachers in the post test examination.

**Table 3: Independent Samples Test.**

	t-test for Equality of Means						
	t	df	Sig. (2-tailed)	(2-Mean Difference)	Std. Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Equal variances assumed	-24.592	75	.000	-35.27632	1.43448	-38.11071	-32.44192
Equal variances not assumed	-24.592	75	.000	-35.27632	1.43448	-38.11337	-32.43926

Source: Field Data, 2024 (N = 76)

H0: There is no difference between the means of students on their examination score

H1: There is difference between the means of students on their examination score

Table 3 discloses the independent samples t-test of the distribution of scores of pre-service science teachers. From the Table, since the (0.00<0.050), we reject the H0 and concluded that there is difference between the means of pre-service science teachers on their examination scores. Which means that the average pre-service science teacher score in post-test is different and significant than that of pre-test. This also signifies that pre-service science teachers' performance in post-test is better than that of pre-test examination.

### Discussion

The research question of the study was to find out how effective interactive multimedia is in enhancing the performance of pre-service science teachers in the learning of the following biology concepts, namely, cell structure, cell division, and mendelian genetics. To answer this research question or objective, scores from the pre-test and post-test examination of the students were used. From the Table 18 above which displays the pre and post-tests statistics, the average score of the pre-service science teachers in pre-test examination was 36.62, whilst the average score of pre-service science teachers in the post-test examination was 71.89. This means that pre-service science teachers' performance in the post-test examination was much better than that of pre-test examination, which also signifies the effectiveness of interactive multimedia in enhancing pre-service science teachers' performance in the learning of the following biology concepts: cell structure, cell division and mendelian genetics.

The present study revealed that pre-service science teachers' performance in the post-intervention test score was far better than that of the pre-intervention test. This means that pre-service science teachers' performance had improved greatly after they have been exposed to interactive multimedia instructional approach intervention activities used. This improved performance of the pre-service science teachers might be attributed to the interactive multimedia instructional approach intervention activities used in the teaching and the learning of cell structure, cell division and Mendelian genetics. The interactive multimedia instructional approach intervention activities helped to organised the pre-service science teachers' conceptual structure in a particular way to aid in better understanding of these concepts in biology. This finding is in agreement with Thompson et al. (2014) that interactive

multimedia positively impacts students' knowledge acquisition. In a randomized controlled trial conducted by the researchers, students who were exposed to interactive multimedia resources showed significantly higher scores on post-assessment tests compared to those in traditional instructions groups. Again, research by Chen and Lee (2018) revealed that students who utilized interactive multimedia resources had a deeper understanding of cellular processes and mendelian genetics concepts, as evidenced by their ability to apply acquired knowledge and skills in solving complex problem.

Also, the study showed that there was a statistically significant improvement in pre-service science teachers' performance with respect to their mean pre-test and that of their post-test scores. In fact, interactive multimedia instructional approaches have been found to be contributed significantly to pre-service science teachers' performance or achievement at all grade levels, in different subject areas and in different geographical locations. This finding is in support with the result of (Mayer, 2005; Azevedo & Kali, 2010), in their studies they found that, students who took part in the interactive multimedia based instructional strategies had statistically significant improved performance at the end of the study.

### Conclusion

The result of the study indicated that pre-service science teachers who were exposed to the interactive multimedia instructional approach performed better in their post-test scores than that of their pre-test scores. That was an increase in performance due to the exposure pre-service science teachers exposed to Interactive Multimedia Instructional Approach. The research suggests that pre-service science teachers exposed to Interactive Multimedia Instructional Approach retained significantly the selected biology concepts taught better in class. The result of the study indicated statistically significant difference existed between the performance of their mean post-test scores and that of their pre-test scores. 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 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 develop their interest and generally

improved their performance and also increased their attitudes positively towards the selected concepts in the biology. In conclusion, the findings of the present research lend credence to the results of (Bingimlas, 2009; Habibu, 2012; Balanskat et al., 2006; Thompson et al., 2014; Chen & Lee, 2018; Mayer, 2005; Azevedo & Kali, 2010) which showed that students exposed to interactive multimedia intervention activities displayed better performance and a more favourable attitude towards the scientific concept taught. Therefore, biology lecturers in the Ghanaian colleges of education should be encouraged to use Instructional Multimedia Instructional Approach in teaching and learning abstract biology concepts to college of education pre-service science teachers to understand biology and other science concepts better in colleges.

### Recommendation

The finding indicated the improvement in pre-service science teachers' performance in the post test. It is therefore recommended that college of education biology lecturers should adopt and use effective teaching methods such as interactive multimedia instructional approach in order to help develop the pre-service science teachers' conceptual understanding, improve their performance and also develop positive attitudes towards abstract biology concepts understudied at the college level.

### References

1. Abdulrahman, M. D., Faruk, N., Oloyede, A. A., Surajudeen-Bakinde, N. T., Olawoyin, L. A., Mejabi, O. V., ... & Azeez, A. L. (2020). Multimedia tools in the teaching and learning processes: A systematic review. *Heliyon*, 6(11).
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. 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.
4. Ala-Mutka, K. (2009). Review of Learning in ICT-enabled Networks and Communities. *European Commission. Institute for Prospective Technological Studies*.
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. Alemdag, E., & Cagiltay, K. (2018). A systematic review of eye tracking research on multimedia learning. *Computers & Education*, 125, 413-428.
7. Alexander, B. (2020). *Academia next: The futures of higher education*. Johns Hopkins University Press.
8. 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.
9. Aljawarneh, S. A. (2020). Reviewing and exploring innovative ubiquitous learning tools in higher education. *Journal of Computing in Higher Education*, 32(1), 57-73.
10. Aljazzaf, Z. (2020). Factors influencing the use of multimedia technologies in teaching English language in Kuwait. *International Journal of Emerging Technologies in Learning (iJET)*, 15(5), 212-234.
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 in teaching and learning of photosynthesis in biology lessons. *Online Journal of Microbiological Research*, 1(1), 8-16.
14. Azevedo, R. A., & Kali, G. (2010). The effects of interactive multimedia simulations on students' problem-solving ability and conceptual understanding in biology. *International Journal of Science Education*, 32(9), 1341-1358.
15. Balanskat, A., Blamire, R., & Kefala, S. (2006). The ICT impact report. *European Schoolnet*, 1, 1-71.
16. Baltes, M. (1993). Plato's school, the academy. *Hermathena*, (155), 5-26.
17. 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.
18. 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.
19. Bingimlas, K. A. (2009). Barriers to the successful integration of ICT in teaching and learning environments: A review of the literature. *EurasiaJournal of Mathematics, Science and Technology Education*, 5(3), 235-245.
20. Bowden, J. L. H. (2022). Analogues of engagement: Assessing tertiary student engagement in contemporary face-to-face and blended learning contexts. *Higher Education Research & Development*, 41(4), 997-1012.
21. Charp, S. (2003). Engaging the tech-savvy generation. *THE Journal*, 30(7), 8-9.
22. Chen, Y. L., & Lee, Y. H. (2018). Using interactive multimedia instructional approach in genetics instruction to enhance students' learning outcomes. *Journal of Science Education and Technology*, 27(6), 557-570.
23. Chen, H. Y., & Liu, K. Y. (2008). Web-based synchronized multimedia lecture system design for teaching/learning Chinese as second language. *Computers & Education*, 50(3), 693-702.
24. Chen, S., Xia, Y. (2012). Research on application of multimedia technology in college physical education. *Procedia Engineering*, 29, 4213-4217.
25. Coleman, L. O., Gibson, P., Cotten, S. R., Howell-Moroney, M., & Stringer, K. (2016). Integrating computing across the curriculum: The impact of internal barriers and training intensity on computer integration in the elementary school classroom. *Journal of Educational Computing Research*, 54(2), 275-294.
26. Cronje, J. C., & Fouche, J. (2008). Alternatives in evaluating multimedia in secondary school science teaching. *Computers & Education*, 51(2), 559-583.

27. 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.
28. Dema, O., & Moeller, A. K. (2012). *Teaching culture in the 21st century language classroom*.
29. Eady, M. J., & Lockyer, L. (2013). *Tools for learning: technology and teaching strategies. Learning to teach in the primary school, 71*. Queensland University of Technology, Australia.
30. Eckleberry-Hunt, J., & Tucciarone, J. (2011). The challenges and opportunities of teaching “Generation Y”. *Journal of Graduate Medical Education*, 3(4), 458-461.
31. El-Soussi, A. (2022). The shift from face-to-face to online teaching due to COVID-19: Its impact on higher education faculty's professional identity. *International Journal of Educational Research Open*, 3, 100139.
32. Evans, C., & Gibbons, N. J. (2007). The interactivity effect in multimedia learning. *Computers & Education*, 49(4), 1147-1160.
33. Fischer, J. (2011). *Understanding receptivity to interruptions in mobile human-computer interaction* (Doctoral dissertation, University of Nottingham).
34. Freiermuth, M. R. (2001). Native speakers or non-native speakers: Who has the floor? Online and face-to-face interaction in culturally mixed small groups. *Computer assisted language learning*, 14(2), 169-199.
35. Gerbic, P. (2011). Teaching using a blended approach-what does the literature tell us? *Educational Media International*, 48(3), 221-234.
36. Gill, S. P. (Ed.). (2007). *Cognition, communication and interaction: transdisciplinary perspectives on interactive technology*. Springer Science & Business Media.
37. Ginting, D., & Linarsih, A. (2022). Teacher professional development in the perspective of Technology Pedagogical Content Knowledge theoretical framework. *Journal Visi Ilmu Pendidikan*, 14(1), 1-10.
38. Gitelman, L. (2008). *Always already new: Media, history, and the data of culture*. MIT press.
39. Guan, N., Song, J., & Li, D. (2018). On the advantages of computer multimedia-aided English teaching. *Procedia Computer Science*, 131, 727-732.
40. Gorman, P., Nelson, T., & Glassman, A. (2004). The Millennial generation: A strategic opportunity. *Organizational Analysis (15517470)*, 12(3).
41. Habibu, T. (2012). *A study of difficulties faced by teachers in using ICT in classroom teaching-learning in technical and higher educational Institutions in Uganda* (Doctoral dissertation, Department of Technical and Vocational Education (TVE), Islamic University of Technology (IUT).
42. Haddad, W. D., & Draxler, A. (2002). The dynamics of technologies for education. *Technologies for education: Potentials, parameters, and prospects*, 2-17.
43. Hall, M., Hearn, J., & Lewis, R. (2022). *Digital gender-sexual violations: Violence, technologies, motivations*. Taylor & Francis.
44. Hannum, I., Dahlan, Z., & Budianti, Y. (2022). Implementation of the Madrasah Curriculum 1984 to 2013 in Al-Washliyah Private Madrasah 30 City of Binjai. *Budapest International Research and Critics Institute-Journal (BIRCI-Journal)*, 5(1), 2221-2229.
45. Healey, D., Hegelheimer, V., Hubbard, P., Iannou-Georgiou, S., & Ware, P. K. G. (2008). *TESOL Technology Standards Framework*. Virginia: *Teachers of english to speakers of other language*. Inc. Print.
46. Herrington, J., Reeves, T. C., & Oliver, R. (2014). *Authentic learning environments* (pp. 401-412). Springer New York.
47. 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.
48. Hossain, M. M. (2021). The Role of Multimedia in ESL Classroom: An Overview from Teaching Perspective. *International Journal of Teacher Education and Teaching*, 1(2), 11.
49. 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.
50. 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.
51. 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.
52. Kamat, V. & Shinde, J. (2009). “Enrichment of the learning experience of rural children through interactive multimedia,” The Pan-Commonwealth Forum on Open Learning.
53. Ke, F. (2008). A case study of computer gaming for math: Engaged learning from gameplay? *Computers & Education*, 51(4), 1609-1620.
54. Keengwe, J., Onchwari, G., Wachira, P. (2008b). Computer technology integration and student learning: barriers and promise. *Journal of Science Education Technology*, 17, 560-565.
55. 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.
56. Khoza, H. C. (2024). Dialogue with Students as a Valuable Tool in Teacher Inquiry for Professional Development: A narrative of a novice science teacher educator learning about student interaction in biology classrooms. *Journal of the Scholarship of Teaching and Learning*, 24(1). <https://doi.org/10.14434/josotl.v24i1.3548>
57. 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.
58. Kumar, T. (2021). Desire to learn, learn to shine’: Idolizing motivation in enhancing speaking skill among L2 learners. *Kıbrıslı Eğitim Bilimleri Dergisi*, 16(1), 411-422.
59. Kurz, C. J., Li, G., & Vine, D. J. (2019). Are millennials different? In *Handbook of US consumer economics* (pp. 193-232). Academic Press.
60. Laurillard, D., Oliver, M., Wasson, B., & Hoppe, U. (2009). Implementing technology-enhanced learning. *Technology-enhanced learning: Principles and products*, 289-306.

61. 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.
62. Loh, K. H., & Lim, Y. P. (2021). Exploring the Relationship Between Learners' Uncertainty Level and Learning Performance in an Authentic Problem-Based Learning Environment. In *Transforming curriculum through teacher-learner partnerships* (pp.179-198). IGI Global.
63. Marc, P. (2001). Digital natives, digital immigrants. *On the Horizon*, 9(5), 1-6.
64. Mayer, R. E. (2005). *Cognitive theory of multimedia learning*. Cambridge University Press.
65. Mayer, R. E. (2005). *Multimedia learning*. Cambridge University Press.
66. Mayer, R. E. (2008). Applying the science of learning: evidence-based principles for the design of multimedia instruction. *American Psychologist*, 63(8), 760.
67. Mayer, R.E., (2009). Applying the science of learning: evidence-based principles for the design of multimedia instruction. *American Psychology* 63 (8), 760–769.
68. Milovanovic, M., Obradovic, J., & Milajic, A. (2013). Application of interactive multimedia instructional approach instructional approach in teaching mathematics-examples of lessons from geometry. *Turkey Online Journal of Educational Technology-TOJET*, 12 (1), 19-31.
69. Motteram, G. (2013). *Innovations in learning technologies for English language teaching*. British Council.
70. 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.
71. Nocek, A. J. (2015). *Animate Biology: Data, Visualization, and Life's Moving Image* (Doctoral dissertation).
72. Norhayati, A. M., & Siew, P. H. (2004). Malaysian Perspective: Designing Interactive multimedia instructional approach Learning Environment for Moral Values Education. *Educational Technology & Society*, 7(4), 143-152.
73. 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.
74. 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.
75. Pallen, M. (1995). Guide to the Internet: the world wide web. *BMJ*, 311(7019), 1552-1556.
76. Pashler, H., McDaniell, M., Rohrer, D., & Bjork, R. (2008). Learning styles: Concepts and evidence. *Psychological Science in the Public Interest*, 9(3), 105-119.
77. 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.
78. Pimmer, C., Mateescu, M., & Gröhbil, U. (2016). Mobile and ubiquitous learning in higher education settings. A systematic review of empirical studies. *Computers in Human Behaviour*, 63, 490-501.
79. Putra, C. A. (2018). Utilization of multimedia technology for instructional media. *Journal of ICT in Education (JICTIE)*, 5(1), 1-8.
80. Rana, P. S. (2013). Education and the Use of Technology. *Republica The Week*, 12.
81. Robertson, O. A. (2007). *Students' perceptions of online asynchronous discussion and group learning in graduate distance education courses*.
82. 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.
83. Said, N. S. (2007). Towards a 'model of engagement' Designing Multimedia Application for Children. *Digital Learning*, 3(1), 133-139.
84. 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.
85. 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.
86. Shinde J. (2003). *Effectiveness of Multimedia CAI Package with reference to Levels of Interactivity and Learning Styles*. Unpublished thesis, SNDT Women's University.
87. Siemieniecka, D., Kwiatkowska, W., Majewska, K., & Skibinska, M. (2017). The Potential of Interactive Media and Their Relevance in the Education Process. *International Journal of Psycho-Educational Sciences*, 6(3), 1-10.
88. Singh, J., Steele, K., & Singh, L. (2021). Combining the best of online and face-to-face learning: Hybrid and blended learning approach for COVID-19, post vaccine, & post-pandemic world. *Journal of Educational Technology Systems*, 50(2), 140-171.
89. Solomon, J. (2003). The passion to learn. *An inquiry into autodidacticism*.
90. Stith, B. J. (2004). Use of animation in teaching cell biology. *Cell Biology Education*, 3(3), 181-188.
91. Sundar, S. S., & Limperos, A. M. (2013). Uses and grats 2.0: New gratifications for new media. *Journal of broadcasting & electronic media*, 57(4), 504-525.
92. Sweller, J. (2010). Element interactivity and intrinsic, extraneous, and germane cognitive load. *Educational Psychology Review*, 22(2), 123-138.
93. Taiwo, S. K., & Emeke, E. A. (2014). Relationship among learning style preference, gender, age and students' achievement in senior secondary school biology. *West African Journal of Education*, XXXIV.
94. 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.
95. Thompson, H., Lee, J., & Davis, C. (2014). Effectiveness of interactive multimedia in teaching mitosis and meiosis in high school biology. *Journal of Science Education and Technology*, 23(4), 527-539.
96. Unal, Z. (2005). *Comparing the learning outcomes and course satisfaction of web-based vs. classroom-based instruction* (Doctoral dissertation, The Florida State University).

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97. Ward, P. (2013). Animation studies as an interdisciplinary teaching field. In *Pervasive animation* (pp. 317-337). Routledge.
98. Warschauer, M., & Meskill, C. (2013). Technology and second language teaching. In *Handbook of undergraduate second language education* (pp. 303-318). Routledge.
99. 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.
100. 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.
101. 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.
102. Zevenbergen, R. (2007). Digital natives come to preschool: Implications for early childhood practice. *Contemporary Issues in Early Childhood*, 8(1), 18-28.
103. 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.

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