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TEACHERS' PREPAREDNESS TO INTEGRATE THREE DIMENSIONAL COMPUTER ANIMATION IN TEACHING DEOXYRIBONUCLEIC ACID REPLICATION IN PUBLIC SECONDARY SCHOOLS IN MURANG'A COUNTY, KENYA

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ABSTRACT

The integration of 3D computer animation in education presents a transformative opportunity to enhance the teaching of complex scientific concepts. Despite its proven effectiveness in improving conceptual understanding, its adoption has remained limited in Kenyan secondary schools. This study examined the preparedness of teachers of Biology in Murang'a County, Kenya, to integrate 3D computer animation into their teaching practices, specifically in the instruction of Deoxyribonucleic Acid (DNA) replication. The study was guided by the Technology Acceptance Model (TAM), which explored how perceived usefulness and ease of use influenced the adoption of 3D computer animation among teachers. The research design adopted descriptive methods together with mixed-methods paradigms. Structured questionnaires combined with interviews and lesson observations schedules served to measure teachers' knowledge bases and skill levels and attitude development regarding 3D computer animation integration in their educational practice. A thematic analysis approach was applied to the qualitative data while quantitative data underwent descriptive and inferential statistical analysis to study patterns and relationships and draw correlations between variables. Most teachers displayed positive feelings toward 3D computer animation but they lacked both technical competencies and sufficient institutional backing needed to implement it properly in their classrooms. The adoption of new technology faced multiple obstacles because teachers lacked digital resources and needed better training and their institutions had insufficient Information communication technology (ICT) infrastructure. Teachers who had ICT training before showed increased adoption of 3D computer animation technology because of their existing skills and knowledge. The research demonstrates that teacher education improvement combined with digital resource availability enhancement and institutional backing represent vital elements for advancing 3D computer animation implementation in Kenyan secondary education. Educational policymakers together with curriculum developers and teacher training institutions should use these findings to prove the importance of using modern teaching technologies in science education. The resolution of current obstacles will make 3D computer animation into an effective educational resource for enhancing student comprehension and achievement of complex biological concepts.

Key Words: *Level of Knowledge, Teachers of Biology, Attitudes of Teachers*

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INTRODUCTION

Modern educational systems worldwide have experienced substantial changes through technological integration in educational processes. Developed countries use advanced 3D computer animation to boost scientific concept understanding at an advanced level. Students benefit from 3D computer animation because it enables them to see processes which traditional teaching methods make difficult to understand (Ghavifekr & Rosdy, 2015). Integration of 3D computer animation in Biology education across the United States, Australia and Finland has produced exceptional results because students retain more information and develop better comprehension of difficult Biological processes such as cell division and DNA replication (Knapp et al. 2022). Science subject performance improved because students better understand and retain information taught to them.

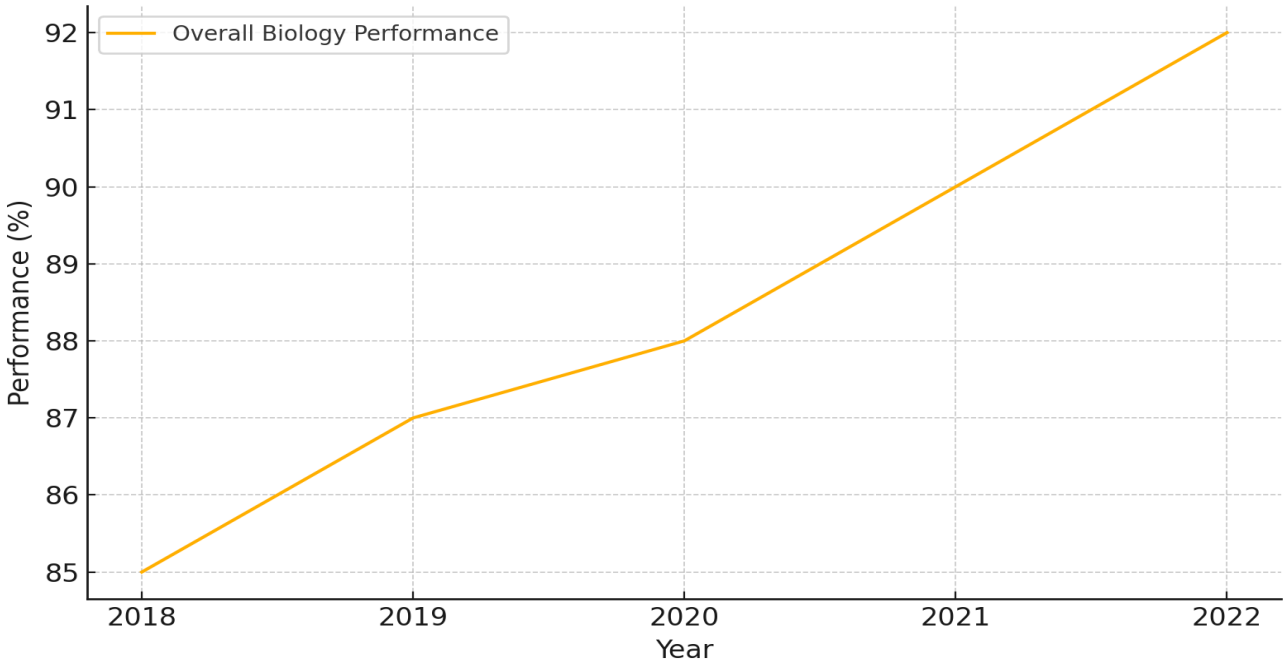

Figure 1: Finland Biology Performance 2018-2022

Source of data: MEB, Finland 2022 Report

Figure 1 illustrates Finland's student performance in Biology from 2018 to 2022. The education approach in Finland assesses students by evaluating their critical thinking abilities and problem-solving competencies as part of integrated learning techniques rather than traditional segmented examinations (MEB, Finland 2022). According to the data the steady upward trend demonstrates that Finland's student-centered and project-based learning approach succeeded in reaching 92% Biology performance in 2022.

The adoption of advanced technological tools for educational purposes remains underdeveloped throughout in Africa. The adoption of educational technology faces challenges across multiple African nations because these countries lack resources and their teachers are not well trained to make use of ICT tools in teaching (Ghavifekr & Rosdy, 2015). The educational sector has experienced minor advancements across certain nations. Yisa and Ojiaku (2016) research found that 3D computer animation helps Nigerian students learn Biology through improved comprehension of difficult Biological concepts. South African educational institutions have seen better student achievement through animated teaching methods such as in cell division specifically the teaching of mitosis according to Moyo (2019).

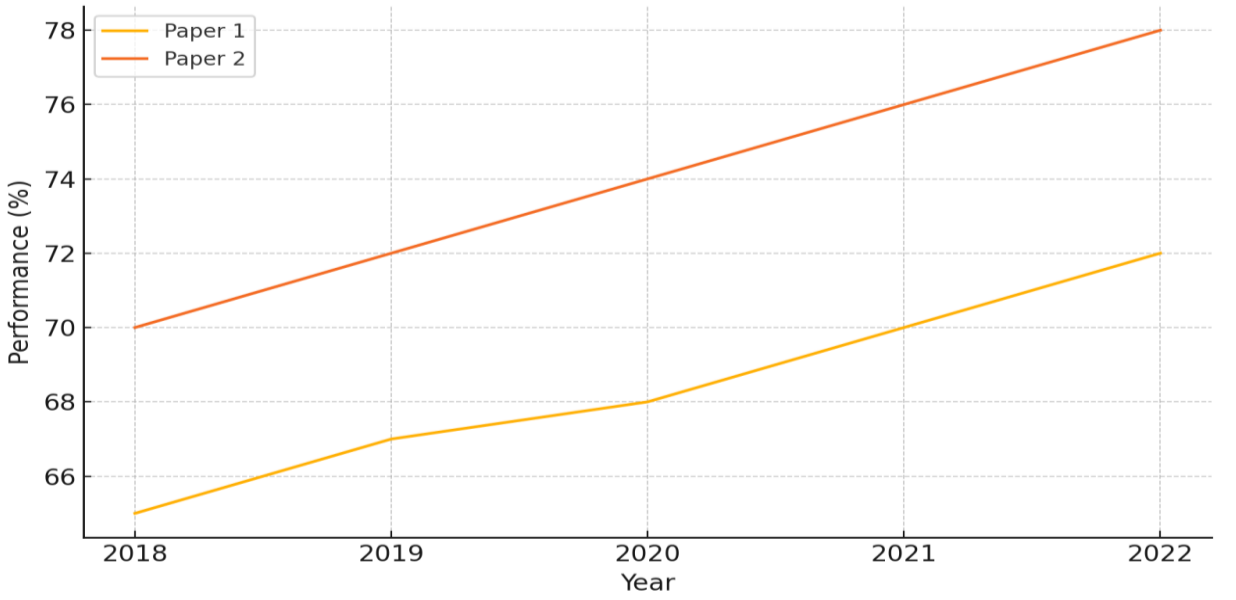

Figure 2: South Africa Biology Performance 2018-2022
Source of Data: DBE, South Africa 2022 Report

Figure 2 shows South African student results in Life Sciences in both Paper 1 and Paper 2 from 2018 to 2022. The molecular biology and genetics along with environmental studies content are evaluated in Paper 1 where student mastery of complex cellular reactions and genetic principles are tested. The content in Paper 2 includes evolution, human reproduction and ecology which require students to analyse concepts and think critically (Richardson et al. 2020). The South African Life Sciences curriculum has shown continuous improvement since 2018 with Paper 1 reaching 72% and Paper 2 reaching 78% in 2022.

The integration of 3D computer animation in teaching science subjects is the primary driver behind the observed improvement in student performance. Students can explore difficult biological features and processes such as cellular reactions and DNA replication and ecological patterns through 3D computer animation and digital displays (Lebata, 2014). Student interaction enhances the accessibility and engagement with abstract subject matter while deepening overall understanding. The integration of 3D technology improves teaching methods and student learning outcomes which is displayed in better performance on both examination papers (Moyo, 2019).

The Kenyan educational system depends on traditional educational methods for teaching sciences including Biology. The educational system now faces numerous challenges because theory-based teaching methods dominate student education as well as instruction at schools. The theoretical content knowledge examined in the two papers of the Kenya Certificate of Secondary Education (KCSE) Biology exams consistently demonstrates lower performance than the practical content-based paper 3 (KNEC 2022). Results indicators reveal that education needs to embrace modern teaching approaches which capture student attention better. The following graph shows student performance in Biology KCSE Papers 1, 2 and 3 throughout 2018 to 2022.

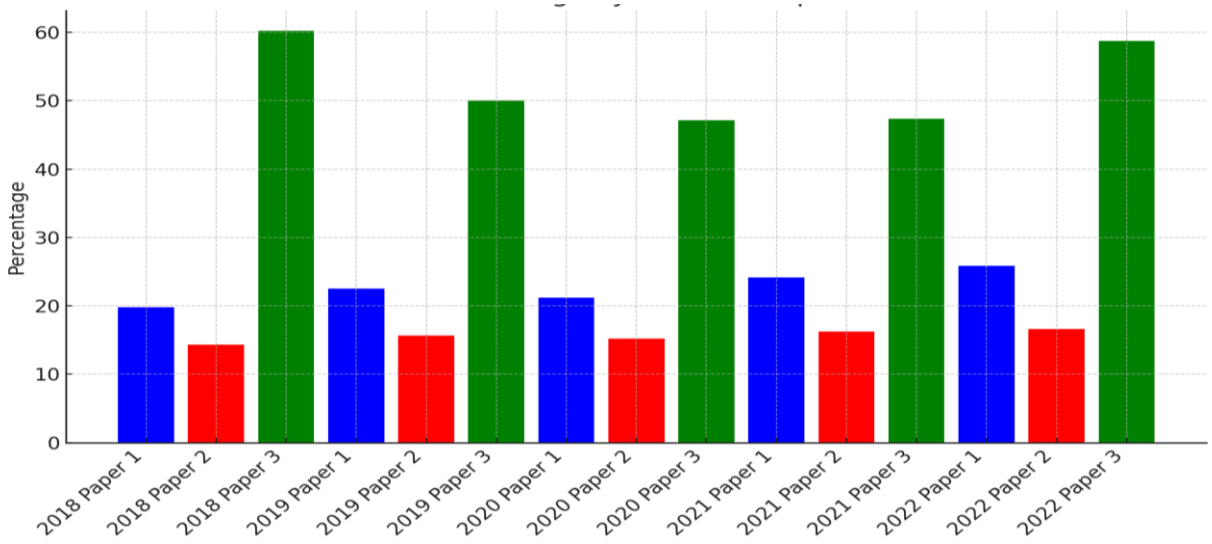

Figure 3: KCSE Biology Performance 2018-2022

Source of data KNEC 2022 Report

Figure 3 clearly shows that students consistently perform better in Paper 3, which involves practical work, compared to Papers 1 and 2. This trend suggests that students have a better understanding of concepts when they can engage with the material in a hands-on, practical approach. The performance in Papers 1 and 2, on the other hand, remains relatively low, indicating a struggle in grasping theoretical concepts when taught through traditional methods.

The implementation of interactive teaching methods combined with technological advancements through 3D computer animation has led to substantial biology performance growth for Finland and South Africa throughout 2018 to 2022. The Finnish education system which prioritizes problem-solving and critical thinking skills has produced steady academic growth resulting in a 92% success rate in 2022. South Africa achieved consistent progress through 3D simulations and virtual models in biological instruction which led to 72% in Paper 1 and 78% in Paper 2 during 2022. The traditional teaching methods used in Kenya produce subpar results particularly in theory-based examinations including Papers 1 and 2. The better results in Paper 3 that focuses on practical work demonstrate the necessity for interactive teaching methods to improve theory-based content delivery. The analysis demonstrates that Kenya should introduce 3D computer animation into Biology education because it helps students understand better and closes the gap between theory and practical work which leads to better academic results.

The research limited itself to Biology due to its complex DNA replication content which receives substantial educational benefits from visual and interactive instructional tools. The complex biological processes and structures which students need to understand cannot be effectively learned through traditional teaching methods in Biology classes. Teachers who employ 3D computer animation present dynamic visualizations which improve student understanding and memory retention of complicated biological processes. Biology stands out as the ideal field to examine 3D technology effectiveness in education because it needs advanced visualizations which other subjects lack.

The research evaluated the teaching readiness of Biology instructors across Murang'a County who wanted to implement 3D computer animation for DNA replication instruction. This research examined both the existing knowledge levels and skills along with attitude patterns of Biology teachers regarding this modern teaching instrument while also evaluating its influence on student academic results.

Statement of the Problem

Despite global strides in educational technology, Kenya's secondary schools education system still leans heavily on traditional teaching methods, especially in Biology. This reliance on lecture-based instruction and textbook learning has played a significant role in the on-going underperformance of students, particularly in the theory-intensive sections tested in Papers 1 and 2 of the KCSE Biology exams.

The differences between the possibilities of using modern tools in education and their actual use in Kenyan classrooms are striking. 3D computer animation enhances understanding and retention of concepts through the physical representation of the concepts but their use in teaching Biology is limited. This is a major shortcoming that has left many students in a position where they cannot comprehend complex Biological processes, and therefore they fare poorly in theoretical tests.

This is made worse by teachers' inability to embrace such technology in their teaching practice. It is evident, 3D animation has been proved to be effective in improving students' understanding and interest in the course content, but still, many teachers in Kenya use traditional methods that do not address the individual differences of students. The causes of this reluctance are numerous and diverse and they include; lack of training and resources, resistance to change and the phobia of technology.

Studies have shown that there is rather a big gap between the technological resources that can support Biology teaching and the existing practices in Kenyan secondary schools. This gap is continuing to contribute to the poor performance of students in theory based tests and assignments because they are not given the practical, real life experience that is needed to understand these complex concepts.

Objectives of the Study

This study identified the factors that make teachers either unable or unwilling to integrate 3D computer animation in their teaching, although the tools are helpful. The specific objectives were;

- Establish the level of knowledge of Teachers of Biology on 3D computer animation
- Establish the level of 3D computer animation integration skills of Teachers of Biology
- Examine the attitude of Teachers of Biology towards 3D computer animation integration in teaching Biology Practices.

Theoretical Framework

The study was guided by the Technology Acceptance Model (TAM), which was created by Davis in 1989. This model helps forecast how individuals come to accept and use new technology. It advises that whether a technology is seen as useful and easy to use are the main factors in determining whether people will use it.

"Perceived usefulness" means how much somebody thinks using a system will advance their performance. "Perceived ease of use" refers to how easy someone thinks it will be to use a system. TAM aided this study in understanding if teachers were ready to use 3D computer animation in their teaching.

In TAM, Davis considered perceived usefulness and perceived ease of use as the things that affect whether people will accept and use new technology. In this study, the researcher used TAM to see if teachers' positive outlooks toward using 3D computer animation in teaching made them see it as useful. Also, if teachers had the skills and knowledge about using 3D computer animation, they will find it easier to integrate it into their teaching. This means they were ready to make 3D computer animation an integral part of their teaching.

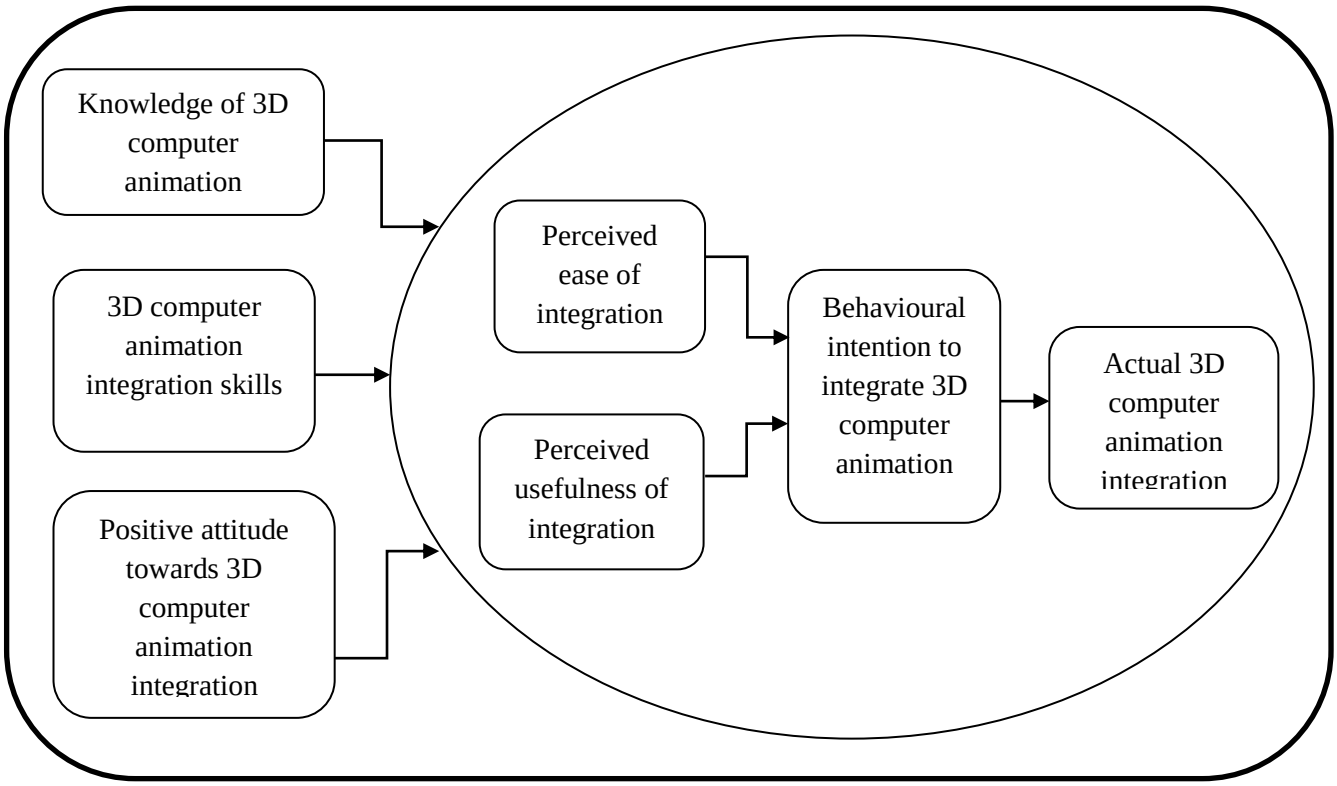

Figure 4: Technology Acceptance Model

Conceptual Framework

The study investigated teachers' preparedness to integrate 3D computer animation as the independent variable. The dependent variable was the teaching of DNA replication. The teaching of DNA replication is influenced by the teachers' competence in integrating 3D computer animation into the instruction process. The intervening variable was the use of 3D computer animation in teaching DNA replication. Figure 5 below illustrates the conceptual framework.

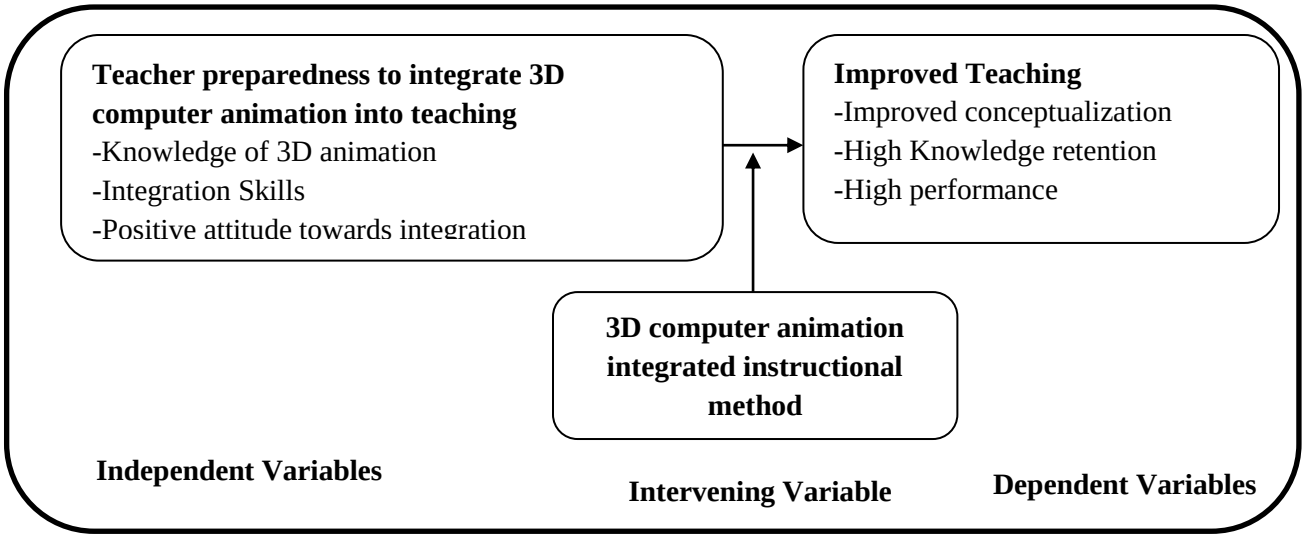

Figure 5: Conceptual Framework

Source: Developed

The study employed the TAM to explain how individuals embrace technology, specifically focusing on the acceptance of 3D computer animation among teachers. According to TAM, the perceived ease of utilizing

technology and its perceived usefulness are pivotal factors driving its implementation. Within the model, the dependent variable was the recognized usefulness, while the independent variable was the perceived ease of using the technology. In essence, the theoretical and conceptual framework sought to guide the identification of teachers' preparedness to integrate 3D computer animation in teaching, comprehend their knowledge of the technology, and explain their perspective regarding 3D computer animation.

LITERATURE REVIEW

Teachers' level of knowledge of 3D Computer Animation

The integration of 3D computer animation in teaching Biology provides a dynamic and visual representation of abstract concepts that may be difficult to grasp through traditional teaching methods. Several research studies showed that many Teachers of Biology appreciate the value and the impact of 3D computer animation in teaching. However, it is vital to note that the level of awareness and use of 3D computer animation in teaching varied depending on factors such as access to technology, ICT integration skills, professional development opportunities, and institutional support. Numerous studies were studied based on the influence of 3D animation in the teaching of Biology.

In a study carried out in Nigeria by Faruk et al. (2022), they found out that learners educated using 3D computer animation achieved better in genetics than their colleagues educated with the old-fashioned method. Their conclusions were derived from the observation that the majority of animations have sensory appeal, making them a versatile tool for meeting the different learning requirements of students. By using animation, some intangible genetic ideas were verified in a manner that reduced the nonfigurative imagination of students. In addition to motivational elements of computer technologies, animation stimulated learners' cognitive processes, and captured and maintained their attention, thereby enhancing their possibility of active engagement in classroom activities and retention of knowledge.

Zakirman et al. (2022), conducted a study in Indonesia with fifth-grade elementary school students, and their conclusion was that animation is a very sophisticated technological tool that can be used for educational purposes with great results. The study results confirmed the role of cartoons in mastering the material, especially when it comes to science education. The study reported the fact that the student's performance significantly improved after the use of animation in instruction and the authors linked that improved performance to increased student interest and motivation. Additionally, it was revealed that the employment of animation was able to make students' cognitive capacities much more robust as they related to understanding scientific concepts, the application of knowledge, and reasoning skills. Besides, the study showed that those students who attended science classes through animation had higher motivation towards science, as it is manifested in such indicators as self-efficacy, engagement, relevance in life, and their future perspective, in comparison to those students who received classical science instruction.

Through the findings of a research study done by Rogers et al. (2023), in Kiambu County, Kenya, it was seen that the integration of 3D computer animation is more effective in teaching abstract concepts in contrast to the approach by traditional teacher-centered methods. The study also supported the fact that it improved students' conceptual understanding of challenging concepts in Biology. Moreover, the application of 3D computer animation vividly strengthened the students' memorization of Biological vocabulary and thus, the student's ability to use such terminology accurately.

The research also showed a remarkable teacher awareness of the far-reaching benefits of integrating 3D animation in teaching Biology. Using animation as a medium, education becomes an interactive and visually stimulating process, making learning more appealing and interesting for the students. The results demonstrated the significance of 3D animation for complex subjects, giving a physical form that is beyond the usual teaching ways. With this strategy, students appeared to have a good grasp of the conceptual aspects of Biology which were often difficult.

Additionally, the study stated the multifaceted advantages of using 3D animation in the Biology classroom. Animations provided different learning styles by combining different sensory elements and also promoted active learning behaviours and engaged students more. 3D animation is a powerful tool that engages students on multiple levels due to its visual and interactive features; students find it easier to understand and remember these topics. Furthermore, Animation is a very significant part of the process that closes the gap between theoretical knowledge and practical implementation, which gives an understanding of the real-world context that, helps to make the educational value of 3D animation in biology education clear.

While there is an increasing appreciation of the use of 3D computer animation in teaching, there is still a scarcity of information on the extent of the knowledge teachers have on how to apply this technology in their classrooms. Most of the teachers, especially those in developing regions such as Murang'a County have a rudimentary understanding of 3D computer animation and lacked the advanced knowledge that is needed in order to design or even apply such tools in teaching advanced biological concepts such as DNA replication. Prior research has presented the benefits of using 3D animation in improving students' knowledge, but this research focused on the difficulties teachers experience while learning the required skills and information. This study helps to fill these gaps by evaluating the current state of knowledge of Biology teachers concerning 3D computer animation and determining the areas of their professional development needs. In this way, it offers a basis for the subsequent interventions that may help teachers to acquire the necessary knowledge and skills to improve the use of 3D computer animation in teaching.

Teachers' level of 3D computer animation integration skills

The increase of ICT use in the modern world has increasingly led to its use in different sectors and aspects of life. One of the most affected sectors is education. Due to the great importance of 3D computer animation in the teaching process, integration skills are considered to be the main. According to Alazam et al. (2013), teachers need to be competent enough to integrate 3D animation into teaching processes. Alazam et al., (2013), pointed out that in vocational education integration skills are about teaching the class with online learning tools, presenting the material, and completing the tasks.

Alazam et al., (2013), found out that the use of 3D computer animation in teaching implies the fact that teachers should use 3D animation in teaching abstract concepts in Biology. Using a sample of 1666 teachers in 81 Malaysian vocational training institutes, the researchers identified that integration skills play the most crucial role in the adoption of 3D computer animation in teaching. In a similar way, Alazam et al. (2013) reported that teachers in the vocational centres in Malaysia had relatively average training and integration skills; therefore, they had a moderate level of integration in the classroom. In the study, it was found that the factors of age and gender that were demographic did not affect the integration of 3D computer animation as a teaching tool. However, the study revealed that the ability level of integration skills was the determining factor for the integration of 3D computer animation in instruction.

The integration of 3D computer animation into teaching requires proper training for teachers as per Belay et al. (2020). A study conducted in Eritrea demonstrated that teacher integration skills represented the fundamental element which enabled effective technology integration in teaching. Belay et al. (2020) define teacher preparedness in modern classrooms as the ability to determine effective technology usage timing and methods. Teachers with comprehensive technology integration understanding tend to implement technological methods in their classroom instruction while teachers with limited technology integration understanding do not. The combination of 3D computer animation with teaching methods creates positive outcomes for teaching integration skills (Belay et al., 2020).

The achievement of this success depends on teacher experience and expertise because it requires them to use 3D computer animation. Based on research surveying 221 participants the researchers confirmed that teaching staff who lack sufficient proficiency cannot effectively implement 3D computer animation for classroom instruction (Belay et al., 2020). During Biology instruction the Teachers of Biology avoided using 3D

computer animation as a teaching tool. The participating teachers demonstrated strong computer skills yet lacked essential equipment and specialized knowledge to implement 3D computer animation properly in their Biology instruction. According to Belay et al. (2020) Biology teachers require specific abilities to use 3D computer animation for their educational purposes.

The research team suggested a teacher training initiative to provide teachers with necessary integration skills for implementing 3D computer animation systematically in their teaching practice. Research findings presented by Alazam et al. (2013) and Belay et al. (2020) indicate that teaching integration of 3D computer animation depends directly on educator proficiency with this tool. Educational staff need specialized training to develop their integration abilities that will enhance their technological implementation in instructional delivery.

Most researchers in the reviewed studies examine teacher skill acquisition without further analysis. The present research aimed to measure how proficient teachers were in terms of integration skills. The proficiency and experience of individuals determined the different levels at which they integrated 3D computer animation. The research examined four levels which describe how much teachers use 3D computer animation during their educational practice.

- Basic level: Teachers at this level have a basic understanding of 3D computer animation and they can retrieve and use pre-existing 3D animation or models in their teaching or presentations but may not be involved in creating them.
- Intermediate level: Teachers at this level can create simple 3D computer animation, by use of basic principles of animation such as movement and timing.
- Advanced level: Teachers at this level have advanced skills in creating complex 3D computer animation. They can customize existing animation or create animation tailored to specific objectives.
- Expert level: Teachers at this level contribute to the creation of cutting-edge 3D computer animation, using the latest technologies and trends. They take on leadership roles, advocating for the widespread adoption of 3D computer animation in the instructional process.

Teachers' attitude towards 3D computer animation integration in teaching

In India, which compares to Kenya as a developing country, the use of 3D computer animation in teaching has been a growing trend. However, Rastogi and Malhotra (2013) argued that there was little or no focus on the friction caused by the shift towards the use of new technologies in education. The authors argued that while teaching has become technologically oriented, there is a mismatch with the pedagogic values and ideas of the teachers. Rastogi and Malhotra (2013) acknowledged that integrating technology in teaching enhanced the quality of teaching and transformed the education environment. Nonetheless, the researchers argued that possession of integration skills by the teachers is not enough to change the teaching practice.

The benefits of the use of 3D computer animation in teaching are recognized when the teachers understand the value of the technology in boosting their teaching process (Rastogi and Malhotra, 2013). Until the attitude of the teachers towards the use of technology is changed, its positive implication on learning cannot be realized. Rastogi and Malhotra (2013) argued that teachers need to feel that the use of technology is vital in teaching. In the hasty implementation of technology in education, the teacher's attitude towards the technology is ignored.

In developing countries, technology is not part of the education culture. Consequently, its introduction in schools may not go well with teachers who have long been used to the traditional ways of teaching and may perceive the use of technology in education as an added burden. Rastogi and Malhotra (2013) indicated that the mismatch between the use of technology and the teacher's perception of the technology resulted in the inefficient use of technology in teaching. Integration of 3D computer animation in the pedagogical process is therefore hindered by the teacher's attitude towards the use of technology. Rastogi and Malhotra (2013),

argued that to change the attitude of teachers towards technology, the integration skills of the teachers should be improved and active motivation to embrace the technology encouraged.

The use of technology in education in the 21ST century is an on-going trend across the world. Nonetheless, it remains unclear whether teachers have the right attitude and support to integrate technology into teaching. In a research that involved 161 teachers in West Virginia, it was noted that the attitude held by the teachers was a core determinant of whether they adopted the technology in teaching. Kale and Goh (2014), argued that the adoption of Web 2.0 in learning was influenced by the age, workload, beliefs, and perceptions of the technology. The study indicated that in the adoption of modern technology in teaching, the perceptions or attitudes of the teacher are core determinants of whether the technology is to be implemented in teaching. Kale and Goh (2014), highlights important gaps in the process of implementing technology in teaching. Recognizing the teachers' opinions and perspectives about technology is the key point of enabling technology in learning.

The contradicting results of research in Tanzania however showed that the teachers in the region had a positive attitude towards the use of technology, yet the integration of technology in teaching was poor (Ndibalema, 2014). Unlike the positive link between positive attitude and the good impact of technology on teaching and the negative association between negative attitude and the poor impact of technology on teaching, the study had a contrary result. The gap in teachers' understanding and teaching abilities was the first barrier to the implementation of the technology.

Teachers hold either a favourable or unfavourable view on the integration of 3D computer animation in the teaching process, according to the studies analyzed. This thinking can be a potential factor that influences classroom practices and the quality of teaching. An optimistic demeanour clearly shows the teachers' positive attitude, which in turn depicts their enthusiasm, readiness, and belief in the abilities of 3D computer animation to improve the outcomes of teaching and learning. This type of teacher is more likely to be more in favour of digital technologies, to look up professional development opportunities, and to seek out new ways to integrate 3D computer animation into their instruction.

However, the negative orientation is mostly related to such concepts as mistrust or reluctance to apply technological solutions in teaching. Teachers can hold negative views toward the integration of 3D computer animation into their classes, and they may perceive the 3D integration as troublesome, time-wasting, or irrelevant to their teaching goals. The result might be the reluctance to experiment with and use 3D computer animation and may result in an incomplete integration and a lack of opportunities for enriching the learning experiences of their students. Institutions of education and all key actors need to set and eliminate negative attitudes using special training, support, and awareness programs which will create a positive and supportive environment for successful technology integration in the learning process.

While the importance of 3D computer animation in teaching is gradually being understood, there are still many gaps in the way teachers use this tool in their work. Most of the surveys have targeted the general perception of teachers towards technology but few have targeted the challenges that hinder the integration of technology in learning especially in the area of Biology. Furthermore, although positive attitudes towards 3D animation have been reported, the degree to which such attitudes are put into practice in the classroom is not well defined. To address these gaps, this study seeks to examine not only the attitudes of Biology teachers towards 3D computer animation but also their actual integration skills and the difficulties they encounter. In this way, the study will offer specific recommendations that will help to design professional development programs and policy measures that will enhance the use of 3D animation in Biology teaching.

METHODOLOGY

This research study used a descriptive research design to establish the extent of preparedness of teachers of biology to integrate 3D computer animation in their teaching. The research employed both qualitative and quantitative data collection techniques (mixed method) to ensure that a broad data was collected. The research focused on both the independent and dependent variables in order to determine the correlation between the teachers' preparedness and the efficiency of the use of 3D computer animation in teaching Biology. This study was carried out in Murang'a County, Kenya. Murang'a County, situated in central Kenya, is known for its diverse geography, featuring a mix of rolling hills, valleys, and highland areas.

The target population for this study included all individuals eligible to participate, specifically focused on the use of 3D computer animation in teaching Biology in secondary schools within Gatanga Sub-county. The study targeted Biology teachers across the thirteen public secondary schools in the sub-county. The target population included approximately seventy teachers of biology, who teach students in various forms, ranging from Form 2 to Form 4. These teachers were pivotal in the study, as their experiences and insights helped to evaluate the effectiveness of integrating 3D computer animation into the Biology curriculum. Purposive sampling was used to only sample the schools that have ICT resources and were being used in Classroom instruction. Purposive sampling was used to sample thirteen public schools in Gatanga sub-county from the target population of thirty-six public secondary schools. The research instruments that were used for this study were questionnaires, interview schedules, and lesson observation schedules. The selected teachers of Biology were issued with questionnaires that had a set of open-ended questions.

The research instruments that were used included questionnaires, interviews and lesson observations. Surveys were used to collect both qualitative and quantitative data on the teachers' knowledge, skills and attitudes regarding 3D computer animation. Semi-structured interviews provided more detailed information about teachers' experiences, while lesson observations evaluated the effectiveness of using 3D animation in the classroom. The data analysis was done using both qualitative and quantitative methods. The interviews and the open-ended questionnaire responses were analysed through content analysis in which the data was grouped according to the frequency of the themes and patterns that emerged. This assisted in finding out the perception and experience of the teachers on 3D computer animation. The data gathered from the questionnaires was analyzed using descriptive and inferential statistics. Descriptive statistics in the form of frequency distributions were used to summarize the data. This way the researcher had a more rounded view of the perceived and actual impacts of the integration of 3D animation in the teaching of Biology.

FINDINGS

Teachers of Biology Professional Qualifications

The academic qualifications of the teachers of Biology were presented in Figure 6.

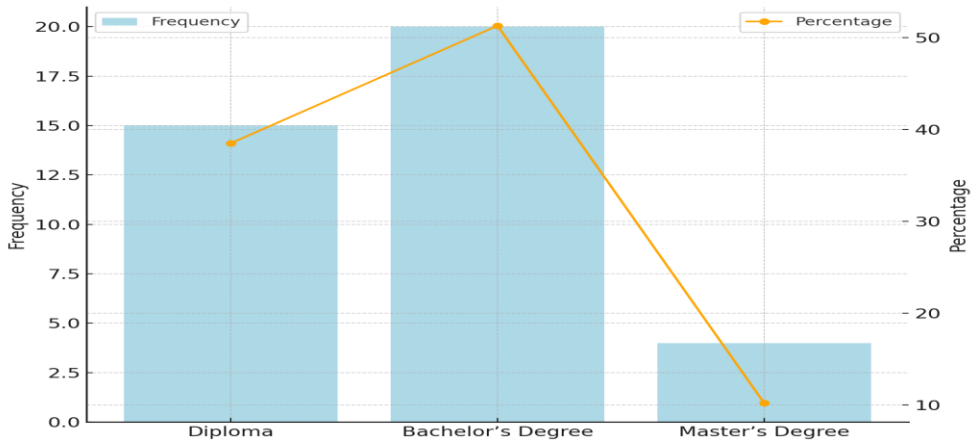

Figure 6: Teachers of Biology professional Qualification

Teachers' professional qualifications directly affect their ability to implement 3D computer animation as an innovative teaching method in Biology classrooms. The study data shows that Bachelor's degree holders make up the largest group (51.3%) while Diploma holders follow at (38.5%) and Master's degree holders form the smallest group (10.2%). The data shows that educational training has been completed by most teachers yet their advanced qualifications remain scarce which might contain educational technology or digital tool specializations. Teachers who possess Bachelor's and Master's degrees tend to have experienced pedagogical strategies that use technology while Diploma holders received less exposure to such training. Although few in number teachers with advanced degrees play an important role by providing guidance to their colleagues about implementing 3D animation in Biology instruction. All teachers require on-going professional development to fill digital literacy gaps so they can successfully use 3D animation to improve student DNA replication comprehension regardless of their qualification level. The research results demonstrate that teachers need specific training to acquire essential abilities for deploying 3D computer animation in educational settings.

Awareness of 3D Computer Animation

The awareness on 3D Computer Animation is presented in Figure 7.

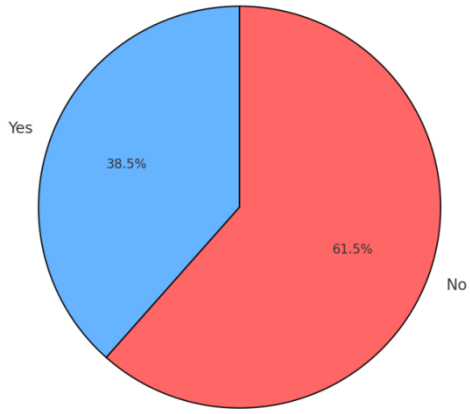

Figure 7: Teachers of Biology awareness of 3D computer animation

The research examined how much knowledge teachers of biology possessed about using 3D computer animation. The research data showed that 38.5% of participants knew about 3D computer animation yet 61.5% of them were completely unfamiliar with this technology. Most teachers of Biology in the study region lack experience with digital teaching aids thus creating barriers to successful 3D animation integration in their classroom instruction. The insufficient training opportunities combined with limited digital resource access and institutional support for technology-enhanced learning explains the lack of awareness. The absence of 3D animation knowledge among teachers prevents them from finding or supporting its utilization which results in students missing out on better understanding of complex biological processes such as DNA replication. Professional development workshops and technology-based training programs and institutional encouragement for 3D animation will help teachers of Biology adopt this teaching method. The successful use of innovative teaching methods requires awareness as an initial step which must be addressed because it enables proper implementation.

Frequency of Using 3D Animation in Teaching

Table 1 summarizes the frequency of 3D animation use in Biology instruction.

Table 1: Frequency of using 3D animation in Biology instruction

Frequency of Use	Frequency	Percentage
Frequently	4	10.2%
Rarely	10	25.6%
Never	25	64.1%

The research investigated the frequency of 3D computer animation usage in Biology teaching by teachers. The survey results show that 10.2% of participants use 3D animation often but 25.6% use it occasionally and 64.1% have never integrated it into their Biology teaching practices. The current use of 3D animation in Biology instruction stands at a very low level. The low implementation of 3D computer animation stems from various reasons including; teachers resistance to change, insufficient training, limited access to technological resources and lack of awareness. The teaching methods of teachers who avoid 3D animation primarily consist of textbook material, diagram drawings and chalkboard illustrations yet these traditional methods lack effectiveness when teaching dynamic biological processes such as DNA replication.

Educational institutions that provide digital resources together with administrative backing motivate teachers to adopt innovative approaches. Greater teacher use of 3D animation requires three main actions which include specialized training programs along with adequate technological equipment and changes to curricula that strengthen digital resources utilization. The regular application of 3D animation in education leads to better student participation and clearer understanding of difficult biological material.

Teachers' Skills in Using 3D Computer Animation

Table 2 provides findings on the respondents' proficiency in various aspects of 3D computer animation.

Table 2: Respondents' proficiency in various aspects of 3D computer animation

Skill Area	Excellent	Good	Fair	Poor
Searching for 3D Animation	1	3	5	30
Retrieving 3D Animation	1	2	3	33
Using 3D Animation for Teaching	0	2	3	34
Creating 3D Animation	0	1	2	36
Uploading 3D Animation to the Internet	0	0	1	38

The research evaluated teachers of Biology skills in different aspects of 3D computer animation integration which demonstrated overall weak proficiency levels. Most teachers displayed inadequate abilities throughout the entire evaluation process from searching for and retrieving 3D animation and their subsequent use and creation and upload functions. One teacher considered excellent at searching for appropriate 3D animation but 30 teachers demonstrated poor abilities in this task. The results revealed poor skills in retrieving appropriate 3D animation because 1 teacher rated their abilities as excellent but 33 teachers rated themselves as poor.

Out of the 39 teachers who participated in the study, 87.2% identified their skills as poor when it comes to using 3D animation for teaching purposes despite their knowledge of the technology. The skill of creating 3D animation proved to be the most challenging since 36 teachers 92.3% rated their abilities as poor and only 3 teachers rated their skills as fair. The majority of teachers demonstrated limited abilities to upload 3D animation to the internet since 38 teachers (97.4%) assessed their skills as poor.

Most Biology teachers demonstrate insufficient technical capabilities for successful integration of 3D animation in their teaching practice. The teachers' poor proficiency in digital teaching tools stems from inadequate training programs and insufficient exposure to digital teaching tools and insufficient institutional support for technology adoption. The lack of sufficient skills prevents teachers who understand 3D animation benefits from successfully integrating it into their educational activities. The successful integration of 3D

animation in Biology instruction demands specialized professional development programs alongside capacity-building workshops and digital literacy training incorporated into teacher education curricula. Education stakeholders together with schools need to supply teachers with accessible 3D animation software and educational resources which will help teachers build their skills in using this technology. The successful implementation of 3D computer animation in Biology education depends on developing teachers' digital competencies.

Link between Levels of Knowledge

This study confirms previous research findings presented in Chapter 2 about teachers' understanding of 3D computer animation. Teachers who received training in technology and ICT demonstrated better chances of integrating 3D computer animation in their classroom instruction. Most teachers in this study did not have sufficient understanding about 3D computer animation as 61.5% reported being unaware of it while only 10.2% frequently used it during their teaching sessions.

According to Rogers et al. (2023), Kenyan teachers who had limited exposure to ICT struggled to effectively use digital teaching resources. Additionally, Faruk et al. (2022) proved that animated instruction improves student comprehension however this benefit decreases when teachers do not possess the required technical competencies. The study results confirm this situation because teachers who admitted to having little knowledge also showed weak integration abilities resulting in 92.3% of them unable to modify or create instructional 3D animation.

The difference between theoretical knowledge and practical application requires specialized teacher training programs to develop necessary skills for effective 3D animation implementation. Teachers who understand animation benefits will stay unable to deliver successful classroom implementation without proper training.

Teacher's Attitude Towards 3D Computer Animation

Table 3 provides findings on the teachers' of Biology attitude towards 3D computer animation.

Table 3: Teachers' of Biology attitude towards 3D computer animation

		Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
(a)	It is easy to integrate 3D computer animation in teaching DNA replication	1	3	5	10	20
(b)	Integration of 3D computer animation improves the quality of my teaching	0	2	3	7	28
(c)	Integration of 3D computer animation makes the DNA replication concept understandable to the learners	0	1	20	10	8
(d)	3D computer animation integration helps in improving learners' performance	1	3	18	10	7
(e)	Teachers should always integrate 3D computer animation into teaching to make learning exciting	1	5	15	10	8
(f)	Teachers should frequently attend workshops that emphasize 3D computer animation integration in teaching	5	15	7	8	4
(g)	Integration of 3D computer animation training should be included in teachers' training curriculum	7	15	5	9	3

The study evaluated teacher attitudes regarding 3D computer animation integration through assessments of its practical value and implementation simplicity and adoption readiness. The survey showed a mostly optimistic response since 56.4% of teachers believed animation enhances both teaching quality and student understanding of DNA replication processes. The data showed that 3D animation use in lessons was rare although teachers held positive attitudes toward its benefits.

According to Kale & Goh (2014), positive digital tool attitudes create adoption potential yet practical implementation faces obstacles from external factors like training deficiencies and institutional support limitations. Teachers in developing countries view technology as more trouble than help for instruction according to Rastogi & Malhotra (2013) because they lack confidence in their digital abilities.

Teachers who identified their technical skills as inadequate showed the lowest rates of animation integration even though they supported its educational value. Teachers identified three main obstacles which included insufficient ICT infrastructure together with limited training opportunities and insufficient time for integration. The research demonstrates a clear need for structured workshops together with administrative support because these elements help teachers move from positive attitudes to practical classroom implementation.

CONCLUSIONS AND RECOMMENDATIONS

The research demonstrates that teachers of Biology across Murang'a County see the value of 3D computer animation, yet their integration capacity stays restricted because they lack knowledge and technical skills and sufficient resources. The research indicates that teachers need appropriate professional development programs to master animation integration skills effectively. The lack of formal training programs means teachers will likely stick to conventional teaching approaches which might not deliver optimal conceptual learning results.

Educational technology adoption requires strong institutional backing, according to the study results. The absence of proper ICT infrastructure together with insufficient administrative support makes it difficult for schools to implement digital learning tools despite teacher willingness to adopt them. A collective partnership between educational policymakers, school administrators, and teachers needs to work together to provide enough resources and training programs for barrier elimination.

The research demonstrates the necessity of changing current methods used to develop teacher professionals. Single-time educational workshops combined with brief training periods fail to develop enduring competence for technology integration among teachers. The development of continuous capacity-building programs along with peer collaboration and mentorship should replace current approaches because they help teachers learn practical skills for classroom animation usage.

The study's identified challenges that require implementation of several proposed recommendations. The teaching profession requires immediate implementation of complete professional development programs, which teach teachers of Biology essential skills to integrate 3D computer animation into their instruction. The training programs should follow a structured format while maintaining continuous delivery to meet teacher requirements through the combination of theoretical learning and practical animation tool experience. Educational institutions, including teacher training colleges and universities, must establish ICT integration courses as part of their curriculum to train future teachers about digital teaching approaches.

Schools need to invest in ICT infrastructure which enables the use of 3D animation in educational settings after implementing training programs for teachers. The implementation requires schools to acquire computers and projectors along with internet access and animation software in addition to making these resources available to teachers. The education policy must allocate sufficient funding to support technological improvements in educational settings, especially in Biology classes because visual educational tools boost students' understanding of difficult scientific concepts.

School administrators must provide direct backing for teachers who want to integrate technology by eliminating restrictive systems and supporting them as they try new educational approaches. The support system should modify lesson plans to let teachers investigate animation-based teaching methods while creating a professional development framework that supports continuous learning. The successful implementation of 3D computer animation by teachers should lead to their selection as mentors to guide their colleagues in adopting innovative teaching approaches through shared learning experiences.

The Ministry of Education (MoE) needs to modify the national curriculum by adding digital tools into science education across the board. The establishment of policies supporting technology-enhanced learning must include both necessary equipment for schools and sufficient teacher support. The development of partnerships between educational institutions and technology companies and software developers should establish methods to provide budget-friendly animation tools accessible to schools.

Recommendations for Further Research

- Long-term assessments need to investigate whether animation-based teaching produces superior results in Biology student achievement than regular classroom methods.
- Comparative research that evaluates how different digital teaching tools integrate across multiple educational fields and geographical areas would generate comprehensive insights about effective technology-enhanced learning practices.
- Research needs to study how school administrators support ICT integration because their backing determines whether teachers will adopt new instructional technologies.
- Research on how school policies, funding allocation methods, and leadership styles impact digital tool adoption will identify essential systemic adjustments for technology-based educational approaches.

In conclusion, this study has underlined the major knowledge gaps, skill deficiencies, and resource constraints hindering the integration of 3D computer animation in Biology instruction in Murang'a County. Despite the teachers having a positive attitude towards using animation in teaching, lack of training, technological infrastructure, and institutional support poses major challenges. Addressing these issues requires a multi-faceted approach involving teacher training, increased investment in ICT infrastructure, administrative support, and policy reforms. By implementing these recommendations, the education sector can harness the potential of 3D computer animation to enhance Biology teaching, improve student engagement, and ultimately foster better learning outcomes in Kenyan secondary schools.

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