The impact of technological applications on creating interactive educational experiences in biology

Sstudent's' Names and Emails

Haneen Yehia Abdel Khaleq	**biology2022_e18@edu.asu.edu.eg,**
Dalia Muhammed Abdel Rehiem	**biology2022_e19@edu.asu.edu.eg,**
Ranya Samy Hussien	**biology2022_e20@edu.asu.edu.eg,**
Rahma Bahgat Abdallah	**biology2022_e21@edu.asu.edu.eg,**
Rawan Mustafa Abdel Basir	**biology2022_e22@edu.asu.edu.eg,**
Reem Ali Mahmoud	**biology2022_e23@edu.asu.edu.eg,**
Reham Reda Muhammed	**biology2022_e24@edu.asu.edu.eg**

Program

Bachelor of Science and Education (Preparatory and Secondary) Biological Sciences,

Ain Shams University, Faculty of Education

Supervisor:

Dr. Olfat Mohamed Hussien

Assistant Professor Doctor of Experimental Zoology

Journal of Applied Research in Science and Humanities

The impact of technological applications on creating interactive educational experiences in biology

Sstudents names : Haneen Yehia Abdel, Dalia Muhammed Abdel Rehiem, Ranya Samy Hussien, Rahma Bahgat Abdallah, Rawan Mustafa Abdel Basir, Reem Ali Mahmoud, Reham Reda Muhammed

Supervisor: Dr. Olfat Mohamed Hussien, Assistant Professor Doctor of Experimental Zoology

Program: Bachelor of Science and Education (Preparatory and Secondary) Biological Sciences, Ain Shams University, Faculty of Education

Abstract

Biology is a key science subject that helps students understand life processes and the natural world. However, many secondary school students face difficulties in fully grasping biological concepts due to traditional teaching methods, which often rely on memorization and lack interactive elements. These methods may not align with students' diverse learning styles, leading to reduced motivation and engagement. With the increasing role of digital transformation in education, this study explores the impact of technological applications on biology teaching and learning at the secondary level. It focuses on the use of virtual laboratories, simulations, interactive software, and multimedia presentations as tools to enhance students' understanding, motivation, and classroom participation. Data were collected using a mixed-method approach, including interviews with biology teachers, student surveys, and classroom observations. The results showed that integrating technology into biology lessons significantly improved students' academic performance, conceptual understanding, and active involvement in class activities. The research concludes that technology can play a crucial role in creating an engaging and effective biology learning environment. It recommends that schools and educators adopt modern teaching strategies that incorporate digital tools to support students' learning experiences.

Key Words: Technology in biology education, Digital learning tools, Technology integration

1. Introduction:

In today's digital era, the landscape of biology education is undergoing a significant transformation, driven by the integration of emerging technologies into classroom environments. Traditional lecture-based approaches, while foundational, often fall short in catering to the diverse needs of modern learners. In contrast, the implementation of digital tools has proven effective in fostering greater student engagement, adaptability, and retention of complex scientific concepts. As Situmorang et al. (2024) assert, digital game-based learning (DGBL) introduces an interactive framework that not only captivates student interest but also deepens their understanding of biological processes through immersive experiences.

Supporting this, research by Safitri et al. (2017) demonstrates that utilizing technology in educational settings contributes to improved academic performance, heightened motivation, and better long-term retention of information.

Among the most promising innovations is the creation of Technology-Enhanced Interactive Teaching Environments (TEITE), which offer multifaceted learning opportunities that go beyond passive content delivery. Yang, Wang, & Chiu (2015) emphasize that such environments provide students with active learning experiences, which strengthen their conceptual understanding of scientific theories.

Similarly, Liu & Chen (2015) highlight that these interactive approaches cultivate essential scientific skills such as critical analysis, problem-solving, and real-world application of biological knowledge. In addition, virtual reality (VR) has emerged as a powerful educational medium, enabling learners to engage with biological systems in a simulated, hands-on manner. Research confirms that VR enhances student interaction with course material and encourages deeper cognitive engagement, thereby fostering more meaningful learning experiences. Alhumaidan, A. (2024).

Furthermore, web-based learning platforms (WBLPs) have revolutionized biology education by offering accessible, self-paced learning that accommodates individual preferences and schedules. Khan & Riaz (2020) report that these platforms play a vital role in supporting autonomous learning and personalizing the educational journey. Beyond pedagogy, technological applications also extend into biological research and analysis. For example, Zhang et al. (2019) employed computational simulations to examine red blood cell behaviour in sickle cell disease, showcasing how digital tools can yield valuable insights into complex medical phenomena.

In essence, the fusion of technology with biology education not only enhances the way students engage with content but also equips them with the analytical and technical skills required in today's scientific landscape. As the demand for innovative educational strategies continues to rise, the integration of digital tools represents a vital step toward shaping a more effective and forward-thinking approach to teaching biology.

2. The Theoretical Framework:

At the heart of our research is a robust theoretical framework that highlights the transformative

potential of technology in enhancing biology education. Rooted in modern educational theories and supported by empirical research, this framework explores how digital tools can improve comprehension, foster engagement, and address persistent challenges in teaching biology.

A central element of this framework is TEITE, which integrate multimedia, simulations, and real-time feedback to promote active learning.

Yang, Wang, & Chiu (2015) emphasize that these environments encourage student participation and support deeper understanding of biological content.

Liu & Chen (2015) also point out that TEITE improve critical thinking, problem-solving, and knowledge retention—skills that are essential in scientific education.

Another key component is DGBL, which applies game design elements like challenges, rewards, and storytelling to the learning process. Situmorang et al. (2024) show that DGBL helps students engage with complex biological concepts in an enjoyable and interactive manner, increasing motivation and promoting conceptual understanding through practical application in simulated settings.

The framework also includes the use of web-based platforms, which have become essential tools in modern education. Khan & Riaz (2020) explain how these platforms provide flexible, on-demand access to educational content, enabling personalized and self-directed learning. By incorporating virtual labs, interactive simulations, and multimedia resources, they enhance the effectiveness of biology instruction and cater to different learning styles.

VR represents another innovative approach within this framework. According to Alhumaidan, A. (2024), VR allows students to visualize and explore biological systems in three-dimensional space, making abstract concepts more concrete. This immersive experience deepens understanding and boosts student engagement.

The integration of multiple technologies into biology education creates a more comprehensive and interactive learning environment. Safitri et al. (2017) found that combining simulations, web-based tools, and multimedia fosters better engagement and understanding of complex biological processes. Additionally, the role of computational simulations in biological research, as demonstrated by Zhang et al. (2019), highlights how technology can provide detailed insights into phenomena like sickle cell disease, connecting classroom learning with real-world scientific exploration.

This theoretical framework provides a multidimensional view of how technology can support and improve biology education, equipping students with the skills and understanding necessary for academic and scientific success

3.Methods:

This study adopted a descriptive analytical approach, which is widely used in educational research to describe phenomena as they exist and analyses the relationships between their components. This approach was chosen to describe the current use of technological applications in the teaching and learning of biology and to analyses their impact on classroom interaction, academic achievement, self-directed learning, and professional development. Data were collected from targeted samples and statistically analysed to draw conclusions and recommendations.

Study Sample

The study included two main samples:
1- Students: A questionnaire was administered to fifty students from five different secondary schools across five educational districts within Cairo Governorate. The aim was to assess the impact of technological applications on their learning of biology.
2- Teachers: A separate questionnaire was administered to twenty biology teachers from the same schools to evaluate the use and effects of technological applications in teaching the subject.
Instruments.
Two main instruments were used for data collection:
1. Student Questionnaire, which included three sections:
- The use of technological applications in learning biology.
- The impact of technological applications on interaction and participation during the lesson.
- The effect of technological applications on academic achievement and self-directed learning.
2. Teacher Questionnaire, also divided into three sections:
- The use of technological applications in teaching biology.
- The impact of technological applications on classroom interaction and student engagement.
- The effect of technological applications on academic achievement and professional development.
Additionally, personal interviews were conducted with a selected group of teachers and students to gain deeper insights into their opinions and personal experiences regarding the integration of technology in biology education.
Statistical Methods
Data was analyzed using Microsoft Excel, applying the following statistical techniques:
1- Calculation of the mean.
2- Calculation of the standard deviation.
3- Calculation of the standard error.
4- Calculation of the T-value to compare means.
5- Graphical representation of the results using bar charts to clearly illustrate trends and differences.

4. **Results**:

The results obtained from our study are shown in the following tables and figures. Tables (1) and (2) showing students and teachers questionnaire responses, respectively also mean, standard deviation, Standard error and t-value values. Figures (1), (2), (3) and (4) illustrate the data recorded in the previous tables.

Table (1): Responses to the questions in the questionnaire of students

No.of question	Response (Yes)	Response(No)	Response (Neutral)
First category: Using technological applications in learning biology			
1	38	0	12
2	34	4	12
3	30	9	11
4	32	4	14
5	35	4	10
6	44	3	3
7	40	3	7
8	40	5	5
9	22	20	8
10	30	8	12
Second category: The impact of technological applications on interaction			
11	36	4	10
12	35	4	11
13	40	3	7
14	40	4	6
15	31	9	10
16	35	10	5
17	34	5	11
18	38	2	10
19	34	7	9
20	30	6	14
Third category: The impact of technology on academic development			
21	40	2	8
22	30	7	13
23	40	3	7
24	43	2	5
25	31	4	15
26	32	5	13
27	34	7	9
28	32	6	12
29	25	9	17
30	35	3	12
Mean	34.667	5.400	9.933
Standard deviation	5.061	3.692	3.342
Standard error	0.924	0.674	0.610
T-value	29.27 the largest t-value is between yes and no		

Statistical significance: yes is significantly higher than both no and neutral with
(P-value 0.000= < 0.001)
Yes,responses are statistically significantly higher than neutral and no
Neutral responses are statistically significantly higher than no

Figure (1): **Showing the relationship between questionnaire items and students' response to them**.

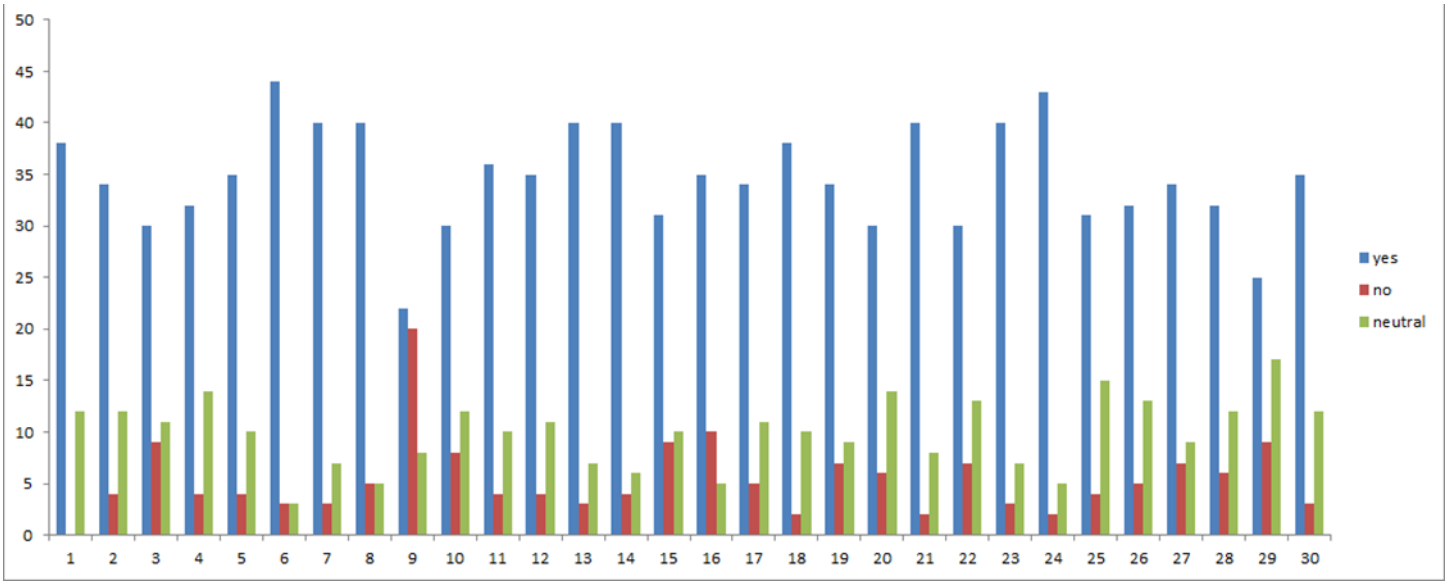


Figure (2): **Shows the standard deviation and standard error values of students' responses to the questionnaire items**.

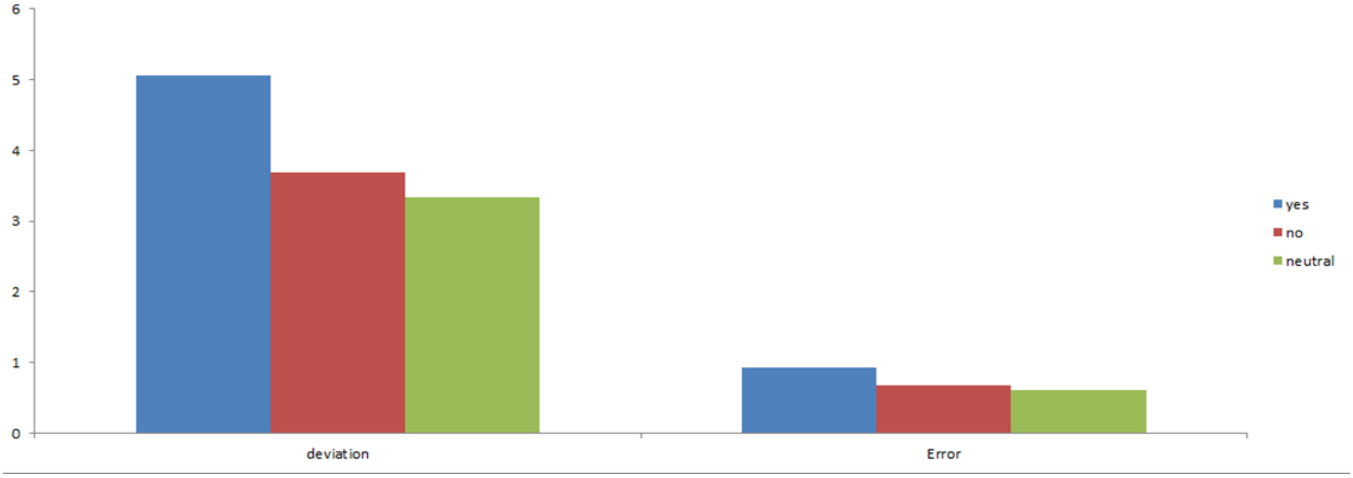


Table (2): Table (1): Responses to the questions in the questionnaire of teachers

No.of question	Response (Yes)	Respone(No)	Response (Neutral)
First category: Using technological applications in teaching biology			
1	16	0	4
2	13	3	4
3	15	0	5
4	11	4	5
5	13	3	4
6	11	4	5
7	11	5	4
8	15	3	2
9	6	10	4
10	5	9	6
Second category: The impact of technological applications on interaction and participation			
11	12	3	5
12	15	2	3
13	12	2	6
14	11	4	5
15	13	3	4
16	13	2	5
17	14	2	4
18	11	4	5
19	8	5	7
20	12	2	6
Third category: The impact of technological applications on Professional development			
21	12	2	6
22	12	4	4
23	14	3	3
24	12	3	5
25	9	6	5
26	13	3	4
27	13	3	4
28	14	0	6
29	13	2	5
30	14	2	4
Mean	12.100	3.267	4.633
Standard deviation	2.496	2.196	1.066
Standard error	0.456	0.401	0.195
T-value	17.0 the largest the largest t-value is between yes and no		

Statistical significance: yes is significantly higher than both no and neutral with
(P-value 0.000= < 0.0001)
Yes responses are statistically significantly higher than neutral and no
The difference between neutral and no was statistically significant but to a lesser degree

Figure (3): Showing the relationship between questionnaire items and teachers' response to them.

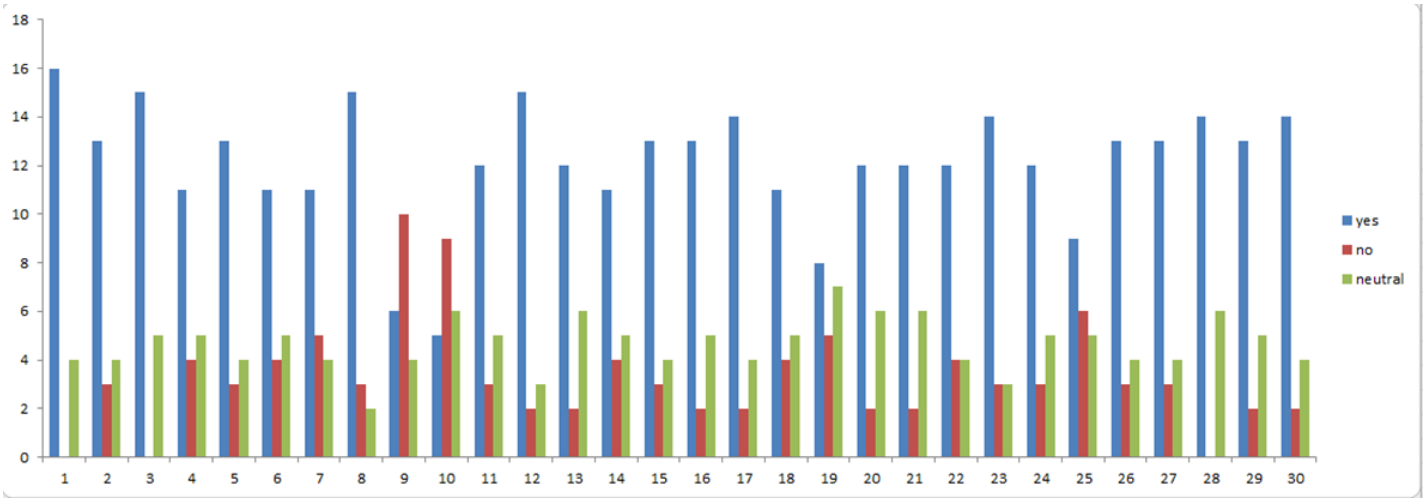
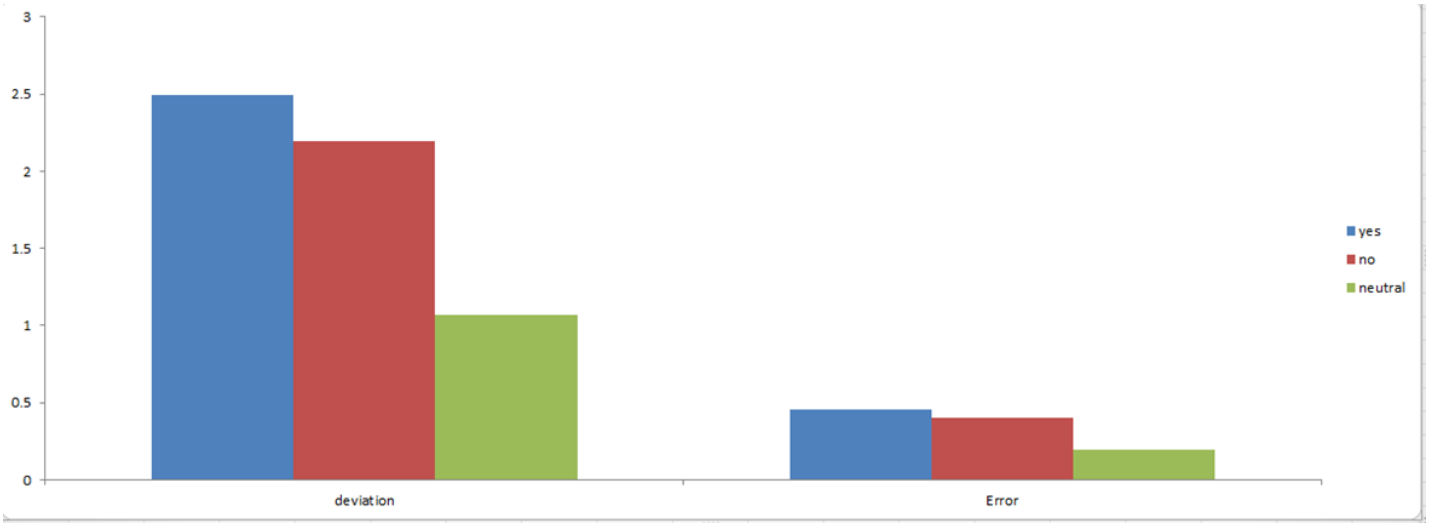


Figure (4): Shows the standard deviation and standard error values of teachers' responses to the questionnaire items



5. Interpretation of Results:

From table (1) and figures (1) and (2):

The statistical analysis of student responses to the questionnaire reveals a compelling trend in Favor of integrating technological applications into the teaching and learning of biology at the secondary level. The mean number of affirmative ("Yes") responses was 34.67, which is significantly higher than both neutral and negative responses, with a p-value < 0.001, indicating strong statistical significance. This suggests a high level of student acceptance and perceived effectiveness of technology-enhanced biology instruction.

A particularly notable outcome is the overwhelming agreement on several core items. For example, 44 students affirmed their use of apps to watch explanatory biology videos, while 43 students agreed that these technologies provide the flexibility to review lessons at any time and from any location. In addition, 40 students indicated that technology effectively bridges the gap between theoretical knowledge and its practical applications in biology. These findings align closely with the work of Situmorang et al. (2024), who demonstrated that digital game-based learning and interactive platforms significantly enhance student engagement, motivation, and retention of scientific content in biology education.

Furthermore, the data reveal that a substantial proportion of students believe that technological tools contribute to the development of critical thinking, foster self-assessment, and promote independent learning. These findings are reinforced by Yang et al. (2015), who reported that technology-enhanced learning environments not only boost conceptual understanding but also encourage active student participation and curiosity within biology classrooms.

However, responses were more varied when students were asked whether technology could replace the teacher's role. Only 22 students agreed, while 20 disagreed, and 8 remained neutral. This indicates that although students appreciate the supportive role of technological applications, they do not see them as a substitute for the teacher's presence, guidance, and explanation — especially for complex biological concepts. This perspective is supported by Safitri et al. (2017), who emphasized that technology is most effective when integrated in harmony with traditional teaching methods, rather than as a replacement.

The low standard deviation and standard error values across responses reinforce the consistency and reliability of the student responses. Moreover, the high t-value observed between the "Yes" and "No" groups ($t = 29.27$) further confirm the strength of the statistical difference.

The analysis underscores a growing enthusiasm among students for the use of technology in biology education. The applications are not only seen as tools for enhancing academic performance but also as means for enriching the overall learning experience. These insights offer valuable implications for curriculum designers, educators, and policymakers, encouraging the adoption of more interactive and technology-driven pedagogical strategies to support student-centred learning in biology.

From table (2) and figures (3) and (4):

The analysis of the questionnaire responses reveals a multifaceted set of challenges encountered by biology teachers when attempting to integrate technology into their instructional practices. Despite a consensus among teachers regarding the potential benefits of educational technology—such as enhancing student engagement, deepening conceptual understanding, and fostering critical thinking—several structural and pedagogical barriers remain evident, These findings resonate with existing literature that underscores the need for holistic support systems to ensure the effective use of ICT in education Khan & Riaz (2020).

Firstly, the results clearly point to a significant gap in both pedagogical and technological training. Many teachers reported that they had either limited or no exposure to professional development programs that focus on the integration of digital tools into lesson planning and delivery. This lack of training limits their ability to design interactive lessons or adopt student-centred strategies supported by technology. Without a strong foundation in digital pedagogy, even the most motivated teachers may struggle to implement effective practices in the classroom .

Secondly, the findings highlight a critical deficiency in school-level infrastructure, which severely restricts the practical application of educational technologies. Respondents emphasized issues such as unreliable internet connectivity, insufficient access to smartboards or multimedia projectors, and outdated equipment. These infrastructural weaknesses not only hinder teachers' ability to deliver technology-enhanced lessons but also demotivate them from planning such activities in the first place.

As confirmed by prior research, a supportive and well-equipped school environment is crucial for the sustainable integration of ICT tools in teaching Khan & Riaz (2020).

Thirdly, the study reveals that excessive teaching workloads are a considerable obstacle. Teachers are often responsible for delivering content to multiple grade levels, across several schools in some cases, which leaves them with limited time and energy to explore or implement digital innovations. This situation is exacerbated by a lack of tangible incentives—either financial or professional—to reward the adoption of new teaching methods.

Consequently, some educators default to traditional, lecture-based instruction despite acknowledging the pedagogical value of technological tools .

Finally, and perhaps most promisingly, most teachers expressed a strong willingness to improve their digital competencies, provided that appropriate support systems and training opportunities are made available. This enthusiasm reflects an underlying readiness for change, which can be leveraged by educational leaders and policymakers to develop strategic initiatives aimed at empowering teachers through continuous professional development and investment in school infrastructure.

while the path to fully integrating technology into biology instruction is fraught with challenges, the findings suggest a clear roadmap: targeted teacher training, enhanced school infrastructure, reduced teaching burdens, and systemic support can collectively foster a more effective and engaging educational experience for students.

6. Conclusion:

It was concluded that the integration of technological applications into biology teaching

has a positive and effective impact on enhancing students' understanding, engagement, and motivation.

The study showed that using tools such as virtual labs, simulations, multimedia presentations, and interactive platforms support both teachers and learners in making the educational process more dynamic and meaningful. However, there are still some challenges that may limit the effective use of technology in the classroom, such as the lack of ,adequate infrastructure, limited teacher training and unequal access among students.

We recommend the following useful suggestions:

1.Providing continuous training courses for biology teachers to enhance their skills in using modern technological tools and application

2.Integrating technology-based resources into the biology curriculum in a structured and purposeful way.

3.Supporting schools with the necessary infrastructure, including internet access and modern devices, to facilitate the use of educational technology.

4.Raising awareness among parents and students about the benefits of educational technology and how to use it effectively.

5.Addressing the digital divide by ensuring equal access to digital tools for all students, regardless of socio-economic background.

6.Encouraging innovation and creativity in teaching methods to make biology learning more interactive and student centered.

7. Acknowledgement:

First and foremost, we would like to express our deepest appreciation to our supervisor, Dr. Olfat Mohamed, for her efforts and cooperation with us throughout the entire research process.

Also, deep thanks and gratitude to: Prof. Dr. Hanan Helmy Latif, Head of the Department of Biological and Geological Sciences for her constant support to us and all students of the department.

My greetings also to Mr. Mohsen Adly, the headmaster of the school, Mr. Walid Ebrahim, the class teacher, and Mr. Taher Muhammed, the educational supervisor of the school for their guidance and assistance.

References:

Alhumaidan, A. (2024). Exploring the virtual frontier: The impact of virtual reality on undergraduate biology education at the American University in Dubai. International Journal of Information and Education Technology, 14(5), 421–426. https://www.ijiet.org/vol14/IJIET-V14N5-2092.pdf

Khan, M. J., & Riaz, M. A. (2020). Students' perception on web-based technology in teaching biology. International Journal of Emerging Technologies in Learning (iJET), 15(2), 142–151. Retrieved from https://files.eric.ed.gov/fulltext/EJ1348879.pdf

Liu, M., & Chen, Z. (2015). Study the effectiveness of technology-enhanced interactive teaching environment on student learning of junior high school biology. ResearchGate. Retrieved from https://www.researchgate.net/publication/281962207_Study_the_Effectiveness_of_Technology-Enhanced_Interactive_Teaching_Environment_o

n_Student_Learning_of_Junior_High_School_Biology

Safitri, M., Riandi, R., Widodo, A., & Nasution, W. R. (2017). Integration of various technologies in biology learning. Journal of Physics: Conference Series, 895(1), 012145. https://doi.org/10.1088/1742-6596/895/1/012145

Situmorang, R. P., Suwono, H., Munzil, Susanto, H., Chang, C.-Y., & Liu, S.-Y. (2024). Learn biology using digital game-based learning: A systematic literature review. EURASIA Journal of Mathematics, Science and Technology Education, 20(6), Article em2459. https://doi.org/10.29333/ejmste/14658

Yang, K.-T., Wang, T.-H., & Chiu, M.-H. (2015). Study the effectiveness of technology-enhanced interactive teaching environment on student learning of junior high school biology. Eurasia Journal of Mathematics, Science and Technology Education, 11(2), 263–275. https://doi.org/10.12973/eurasia.2015.1327a

Zhang, X., Caruso, C., Lam, W. A., & Graham, M. D. (2019). Flow-induced segregation and dynamics of red blood cells in sickle cell disease. arXiv. https://arxiv.org/abs/1912.10101

الملخص العربي

تُعدّ مادة الأحياء من المواد العلمية الأساسية التي تساعد الطلاب على فهم العمليات الحيوية والعالم الطبيعي. ومع ذلك، يواجه العديد من طلاب المرحلة الثانوية صعوبات في استيعاب المفاهيم البيولوجية بشكل كامل بسبب اعتماد طرق التدريس التقليدية، التي غالبًا ما ترتكز على الحفظ وتفتقر إلى العناصر التفاعلية. ولا تتماشى هذه الأساليب مع أنماط التعلم المتنوعة لدى الطلاب، مما يؤدي إلى انخفاض الدافعية والمشاركة.

تهدف هذه الدراسة إلى استكشاف تأثير التطبيقات التكنولوجية على تدريس وتعلّم مادة الأحياء في المرحلة الثانوية. وتركز الدراسة على استخدام المعامل الافتراضية، والمحاكاة، والبرمجيات التفاعلية، والعروض التقديمية متعددة الوسائط كأدوات لتعزيز فهم الطلاب، وزيادة دافعيتهم، ومشاركتهم داخل الصف .تم جمع البيانات باستخدام منهجية متعددة الأساليب، شملت مقابلات مع معلمي الأحياء، واستبيانات للطلاب. أظهرت النتائج أن دمج التكنولوجيا في دروس الأحياء ساهم بشكل كبير في تحسين الأداء الأكاديمي للطلاب، وفهمهم للمفاهيم، ومشاركتهم الفعالة في الأنشطة الصفية.

وتخلص الدراسة إلى أن التكنولوجيا يمكن أن تلعب دورًا محوريًا في خلق بيئة تعلم أحياء تفاعلية وفعالة. كما توصي بأن تعتمد المدارس والمعلمون استراتيجيات تعليمية حديثة تُدمج فيها الأدوات الرقمية لدعم تجربة التعلم لدى الطلاب.

Questionnaire on the Impact of Technological Applications on the Interactive Learning Experience in Biology

Dear Student,

This questionnaire aims to assess the impact of technological applications on your learning experience in biology. Your answers will help us improve teaching methods. Please answer the following questions honestly. There are three response options: Yes – No – To Some Extent.

Section One: The Use of Technological Applications in Learning Biology

1. Do you use technological applications in studying biology?
□ Yes □ No □ Neutral

2. Do you find that technological applications make it easier to understand complex concepts in biology?
□ Yes □ No □ Neutral

3. Do you prefer using technological applications over traditional study methods?
□ Yes □ No □ Neutral

4. Do applications help you recall information easily during revision?
□ Yes □ No □ Neutral

5. Do you think that learning through interactive applications is more enjoyable than using textbooks?
□ Yes □ No □ Neutral

6. Do you use educational applications to watch explanatory biology videos?
□ Yes □ No □ Neutral

7. Do technological applications help you connect theoretical knowledge with practical applications?
□ Yes □ No □ Neutral

8. Do you find that applications provide you with additional sources of information more quickly?
□ Yes □ No □ Neutral

9. Do you think technological applications can replace the teacher in explaining some lessons?
□ Yes □ No □ Neutral

10, Do you have the ability to use technological applications easily in your studies?
□ Yes □ No □ Neutral

Section Two: The Impact of Technological Applications on Engagement and Participation in the Lesson

11. Do technological applications make you more engaged during learning?
□ Yes □ No □ Neutral

12. Do interactive applications motivate you to search for additional information in biology?
□ Yes □ No □ Neutral

13. Do you feel that using technology in the classroom makes lessons more interesting?
□ Yes □ No □ Neutral

14. Do applications provide you with opportunities to solve questions and exercises in a more interactive way?
□ Yes □ No □ Neutral

15. Do you prefer discussing interactive application content you're your classmates?
□ Yes □ No □ Neutral

16. Do you think technological applications facilitate collaboration with your classmates on school projects?
□ Yes □ No □ Neutral

17. Do applications help you improve your critical thinking and problem-solving skills?
□ Yes □ No □ Neutral

18. Do you feel that interacting with educational content through technology helps you gain a deeper understanding?
□ Yes □ No □ Neutral

19. Do you believe that using technological applications makes classroom lessons more productive?
□ Yes □ No □ Neutral

20. Do you think teachers use technological applications effectively in the classroom?
□ Yes □ No □ Neutral

Section Three: The Impact of Technological Applications on Academic Achievement and Self- Learning

21. Do you think that using technological applications has contributed to improving your academic performance in biology?
□ Yes □ No □ Neutral

22. Do applications help you organize your study time more effectively?
□ Yes □ No □ Neutral

23. Do you think technological applications make you more independent in learning biology?
□ Yes □ No □ Neutral

24. Do applications allow you to review lessons anytime and anywhere?
□ Yes □ No □ Neutral

25. Do you think learning through applications increases your focus during studying?
□ Yes □ No □ Neutral

26. Do you feel that technological applications boost your confidence in answering biology questions?
□ Yes □ No □ Neutral

27. Do applications allow you to assess yourself and identify your weaknesses in biology?
□ Yes □ No □ Neutral

28. Do you find that applications offer a personalized learning experience that suits your pace and style?
□ Yes □ No □ Neutral

29. Do you think using technological applications reduces your reliance on private tutoring?
□ Yes □ No □ Neutral

30. Do you believe that technological applications will be essential for the future of learning biology?
□ Yes □ No □ Neutral

Questionnaire on the Impact of Technological Applications on the Interactive Learning Experience in Biology – For Teachers

Dear Teacher,

This questionnaire aims to measure the impact of using technological applications in teaching biology and how effective they are in improving student interaction and learning. We kindly ask you to answer the following questions honestly. There are three response options: Yes – No – Neutral.

Section One: Using Technological Applications in Teaching Biology

1. Do you use technological applications in teaching biology?
☐ Yes ☐ No ☐ Neutral

2. Do you think that technological applications make it easier for you to explain complex concepts to students?
☐ Yes ☐ No ☐ Neutral

3. Do the apps provide you with effective visual and audio means to support classroom explanation?
☐ Yes ☐ No ☐ Neutral

4. Do technological applications help reduce the time required to prepare lessons?
☐ Yes ☐ No ☐ Neutral

5. Do you think that technological applications can be an alternative to some traditional teaching tools?
☐ Yes ☐ No ☐ Neutral

6. Do technological applications help you track student progress more accurately?
☐ Yes ☐ No ☐ Neutral

7. Do you use apps to create online tests or interactive activities for students?
☐ Yes ☐ No ☐ Neutral

8. Do you find that using technological applications increases the efficiency of the classroom?
☐ Yes ☐ No ☐ Neutral

9. Do you think all students have easy access to technology applications?
☐ Yes ☐ No ☐ Neutral

10. Do you think there is sufficient support from the administration for the use of technology in teaching?
☐ Yes ☐ No ☐ Neutral

Section Two: The Impact of Technological Applications on Classroom Interaction and Participation

11. Do you notice an increase in student engagement when using technology applications in teaching?
☐ Yes ☐ No ☐ Neutral

12. Do you think using apps makes students more motivated to participate in the lesson?
☐ Yes ☐ No ☐ Neutral

13. Do you think that interactive applications help students think critically and solve problems?
☐ Yes ☐ No ☐ Neutral

14. Do you find that technology provides greater opportunities for discussion and interaction among students?
☐ Yes ☐ No ☐ Neutral

15. Do technological applications help make the classroom more interesting and engaging for students?
☐ Yes ☐ No ☐ Neutral

16. Do you think students understand the material more deeply when using interactive applications?
☐ Yes ☐ No ☐ Neutral

17. Do you think that technological applications help provide feedback to students faster?
☐ Yes ☐ No ☐ Neutral

18. Do apps help you manage your classroom more organized?
☐ Yes ☐ No ☐ Neutral

19. Do applications contribute to improving students' collaboration and teamwork skills?
☐ Yes ☐ No ☐ Neutral

20. Do you feel that students rely more on technology rather than developing self-research skills?
☐ Yes ☐ No ☐ Neutral

Here is the revised **Section Three** with every instance of **"to some extent"** changed to **"Neutral"**, consistent with the format of previous sections:

Section Three: The Impact of Technological Applications on Academic Achievement and Professional Development

21. Have you noticed an improvement in student performance as a result of using technology applications?
☐ Yes ☐ No ☐ Neutral

22. Do you think technology makes students more independent in their learning?
☐ Yes ☐ No ☐ Neutral

23. Do you think using apps makes it easier for you to provide personalized lessons that suit each student's needs?
☐ Yes ☐ No ☐ Neutral

24. Do you rely on apps to provide additional resources to support student learning?
☐ Yes ☐ No ☐ Neutral

25. Do you feel that technology helps bridge the gap between different levels of students?
☐ Yes ☐ No ☐ Neutral

26. Do you find that using technological applications makes the evaluation process more accurate and effective?
☐ Yes ☐ No ☐ Neutral

27. Does technology help improve your communication with students and parents?
☐ Yes ☐ No ☐ Neutral

28. Do you find that the use of technology in teaching requires ongoing training for you as a teacher?
☐ Yes ☐ No ☐ Neutral

29. Do you see technological applications as an essential element in the future of biology teaching?
☐ Yes ☐ No ☐ Neutral

30. Do you feel that technology helps develop your professional skills as a teacher?
☐ Yes ☐ No ☐ Neutral
