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THE IMPORTANCE OF TECHNOLOGY INTEGRATION IN BIOLOGY LEARNING IN THE DIGITAL ERA

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In the context of the rapid development of information and communication technology, conventional approaches in biology learning need to be reconsidered in order to utilize the potential of existing technology. This research aims to investigate and analyze the importance of technology integration in biology learning in the digital era. This research uses a qualitative approach with descriptive methods. The research results show that the integration of technology in biology learning increases engagement and learning effectiveness. The use of simulation software, interactive videos, and learning applications motivates students and provides an immersive learning experience. Personalization of learning through digital platforms and adaptive learning improves student understanding. Online learning data provides targeted feedback, while collaborative projects and virtual interactions build collaboration skills. Overall, technology integration creates an adaptive, interactive, and relevant learning environment in the digital era.

Keywords: Technology Integration, Learning, Biology, Digital Era

1. INTRODUCTION

The integration of technology in Biology teaching has become a necessity at various levels of education, from preschool to college. Biology subject teachers are now increasingly inclined to adopt various technological tools to improve the quality of learning and provide a more interesting learning experience for students (Riani et al, 2021). By utilizing applications, interactive software, 3D simulations, and other digital resources, teachers can make learning more visual, dynamic, and relevant to students' daily lives (Ula et al., 2021).

The technology integration process not only allows educators to deliver lesson content in innovative ways, but also provides opportunities for students to develop digital skills that are important in the modern era (Anshori, 2018). The use of technology in biology learning can facilitate a deeper understanding of concepts, stimulate creativity, and encourage collaboration between students (Jayawardana & Gita, 2020).

Therefore, learning about technology integration is crucial for Biology teachers to understand how to integrate digital tools effectively, meet curriculum objectives, and prepare students to face the demands of an increasingly technologically connected future (Safitri, 2017). Thus, the Biology learning paradigm continues to develop along with technological developments, creating a dynamic and adaptive learning environment (Saragih, 2021).

In the world of modern education, technology integration has become a critical element in improving the quality of learning (Suhardiana, 2019). Teachers are no longer limited to traditional teaching methods; instead, they can utilize various technological tools such as computers, smartphones, and virtual reality devices to deepen students' understanding of course material. Technology integration is not just adding technological elements to the curriculum, but is a deep transformation in the way students learn and teachers teach (Herlambang, 2021).

The use of technology in the classroom is not just about introducing new tools, but also about increasing interactivity, student engagement, and their ability to think critically (Patandean & Indrajit, 2021). The use of computers, for example, can provide immediate access to online resources, interactive simulations, and engaging game-based learning. The application of virtual reality tools can bring students to a more in-depth and real learning experience, enriching their understanding of certain subject matter (Wardono et al, 2018).

A low student to device ratio is also key to successful technology integration. By ensuring every student has access to these devices, teachers can create an inclusive learning environment and provide equal opportunities for all students to exploit the potential of technology (Fitriyadi, 2013).

The result is a dynamic classroom, where the combination of traditional teaching methods, group collaboration, and the use of technology creates an educational experience that is holistic and relevant to students' needs in this digital era (Zubaidah, 2019).

Biology learning is an in-depth process that brings students to understand the world of life and the processes that occur in it. This scientific discipline studies life in all its forms, from microscopic organisms to complex organisms such as humans (Surata et al, 2020). The main aim of learning biology is to develop an understanding of basic biological concepts, understand the interactions of organisms with their environment, and recognize the applications of biology in everyday life (Setiawan, 2019).

Biology learning involves investigation, observation, and experimentation to understand basic principles such as cells, genetics, ecology, evolution, and anatomy (Emda, 2011). Biology teachers play a key role in presenting learning material in an interesting and relevant way, both through traditional approaches and the integration of technology. Student interaction with technological tools, such as simulation software or interactive applications, can help make complex biological concepts easier to understand (Sulastri & Rochintaniawati, 2009). Apart from that, studying biology also provides opportunities to develop practical skills such as laboratory skills, microscopic observations and data analysis. This supports understanding theoretical concepts with practical experience, creating a stronger connection between theory and real-world application (Firdaus et al, 2022).

This research aims to understand the role of technology integration in biology learning in the digital era. The intent is to provide practical guidance for educators in designing curricula that are responsive to technological developments, as well as assisting policy makers in implementing technology integration programs in educational institutions. It is hoped that the research results will improve the quality of biology learning, prepare students to face challenges in an increasingly technologically connected world, and make a positive contribution to the development of relevant and effective biology learning methods in this digital era.

2. METHOD

The approach used in this research is a qualitative approach. The goal of qualitative research is to gain a deeper understanding of human perception of reality. Qualitative research can take many forms, but most of them are flexible and aim to preserve the full context of the data when analyzing it. Descriptive analysis according to Sugiyono (2011) is a research technique used to draw meaningful conclusions from data. This research uses observation, documentation and technical interviews. Using data reduction and technical triangulation, researchers collect data then delete and verify it.

3. RESULTS AND DISCUSSION

Technology Integration in Education

In the integration of technology in education there are four levels. Experts often use the acronym SAMR, which stands for substitution, augmentation, modification, and redefinition, to represent the four levels of technology integration. Here's what the different levels include:

a. Substitution

At the substitution level of technological integration, the approach to using technology in learning is still limited to replacing traditional tools with digital tools without changing the substance of the learning objectives or activities carried out. For example, teachers may replace pen and paper with a word processing program to write student essays, but the essence of the task remains the same. Likewise, digital textbooks without interactive features or deeper content links may be considered a substitute, as they simply present the same information as the print version. This approach can be considered a first step in integrating technology in learning, especially suitable for classes with a large number of students and different levels of access to technology.

Although the degree of substitution still focuses on leveraging technology in place of traditional tools, this move could pave the way to deeper integration in the future. Teachers and students can begin to become familiar with the use of technology in learning contexts, while the infrastructure and related skills develop. With time and experience, next steps in technology integration, such as learning

augmentation and transformation, can be explored to improve the quality and effectiveness of learning in the digital era.

b. Augmentation

This augmented level of technology integration represents a more advanced step in the use of technology in learning. At this level, teachers not only replace traditional tools with digital tools, but also add additional features or resources to enhance students' learning experiences. For example, in word processing programs, teachers can use spell checking and grammar correction tools, giving students instant access to language correction in their writing without modifying the essence of the assignment.

Although the learning plan objectives and activities may remain the same, the level of augmentation allows students to utilize additional content through technology delivery methods. To illustrate, the digital version of a math textbook may contain the same text and activities as the print version, but students using the digital version can click on the link around the example problem and watch a video explaining how to solve the problem. Thus, the augmentation level provides an opportunity to enrich the student's learning experience through the use of technology, while maintaining continuity with the established learning objectives.

c. Modification

At the modification level of technology integration, educators have the ability to change several aspects of learning activities to be more in line with the advantages of technological media. For example, a teacher can modify a peer-review exercise by using document sharing software. Using this tool, students can easily ask questions about their peers' work or highlight passages of text that need attention, resulting in a more efficient and collaborative editing process.

Additionally, technological modifications can be used to adapt face-to-face activities into remote or mixed media formats. For example, the use of video conferencing software can facilitate student and teacher interaction through chat and poll features. This feature not only allows students to ask questions anonymously, but also creates space for more open and inclusive discussions. By utilizing technological modifications, educators can expand learning potential, creating experiences that are more interactive and responsive to student needs in this digital era .

d. Redefinition

The level of redefinition in technology integration reaches the point where teachers can design learning activities and create learning plans that would not be possible without technology support. This level requires conditions in which students have uniform access to digital tools and educators have significant expertise in the use of technology for instructional purposes. For example, a fourth grade class in California and a similar class in Mongolia could form an educational partnership through the use of video chat and translation software. Through this partnership, both classes can teach each other about their cultures and geography, creating an immersive and global learning experience.

In this example, technology becomes a catalyst that enables collaborative learning activities and changes traditional dynamics in learning. Students not only learn from their teachers, but also from peers in different countries, opening up opportunities for cross-cultural understanding and broader perspectives. With this level of redefinition, education is no longer limited by geographic or traditional boundaries, but rather evolves into a learning experience that is connected, innovative, and includes global dimensions.

In addition to the SAMR levels, there are various technology integration frameworks that can help educators or school administrative teams effectively incorporate technology into teaching. Here are two general frameworks for technology integration in education:

a. TPACK

TPACK, or technology pedagogy content knowledge framework, is a technology integration framework that focuses on areas of knowledge for educators. TPACK features three key areas of knowledge for teachers:

- Content knowledge involves core subject matter, such as works of 17th-century English poetry or biological processes.

- Pedagogical knowledge includes the methods and strategies used in the process of teaching content, such as discussions or interactive activities.
- Technological knowledge refers to an understanding of various digital tools that teachers can utilize in the teaching process, such as laptops or smartphones.

This framework emphasizes the relationships between the three areas of knowledge. According to this framework, educators who have strong knowledge in all three areas can create effective plans for technology integration.

b. Three E's

Developed in 2011, the Triple E framework helps educators measure the effectiveness of current technology use in the classroom. This framework focuses on three areas of technology integration:

- Engagement refers to the extent to which technology strategies succeed in attracting students' interest in the learning material.
- Enhancement describes the extent of added value provided by a particular technology in a learning context.
- Extension measures the extent to which technology strategies provide effective assistance for students in building knowledge and skills outside the scope of the classroom.

The Triple E framework gives teachers a way to evaluate the success of technology strategies and create new lesson plans that effectively incorporate digital tools.

The importance of technology integration in Biology Learning in the Digital Era

The integration of technology in biology learning in the digital era has several significant interests. First, the use of technology in biology learning has a significant positive impact on student engagement. Tools such as simulation software allow students to directly engage in virtual experiments, visualize abstract concepts, and observe biological phenomena that are difficult to access in the real world. By presenting material in an engaging and interactive format, simulation software creates a deep and memorable learning experience, piquing students' curiosity about the world of biology.

Additionally, interactive videos and learning applications add a visual and multimedia dimension to biology learning. Videos can realistically present biological processes, while learning apps provide direct access to up-to-date information and learning activities that can be accessed anytime and anywhere. By stimulating more than one sense, technology creates a multisensory learning experience, increasing the appeal and relevance of biology material for students. Thus, the use of technology not only makes the material more engaging, but also provides a more dynamic and responsive approach to students' diverse learning preferences, which in turn, increases their overall learning motivation.

Second, technology integration brings the potential for revolutionary personalization of learning. Through the use of digital platforms, teachers have access to present learning materials that can be adapted to the level of understanding and individual needs of students. Adaptive learning software, for example, can automatically adjust the difficulty of assignments or provide additional material based on each student's learning abilities and progress. With this approach, each student can overcome their own learning challenges, fill gaps in understanding, or even be given challenges appropriate to their ability level.

Additionally, technology integration allows teachers to track and analyze student performance in greater detail. Learning data collected from online activities, digital exams, or interactions with digital materials allows teachers to identify student learning patterns and provide more targeted feedback. By understanding students' learning styles and preferences, teachers can design learning experiences that better suit and support each individual's development. By utilizing personalized learning through technology, educators can create an inclusive environment and support the optimal development of each student, ensuring that learning is no longer one size fits all, but rather adapts to the uniqueness of each student.

Third , in the midst of the era of digital transformation, the integration of technology in learning provides personalization opportunities that change the conventional learning paradigm. With the

digital platform, teachers can deliver learning material flexibly according to the needs and level of understanding of each student. The use of adaptive learning software is one prominent innovation, allowing automatic adjustment of the difficulty level of assignments or provision of additional material based on the specific needs and learning progress of each student.

Furthermore, technology integration facilitates the collection and analysis of learning data. Through online activities, digital tests, and interactions with digital materials, teachers can track student progress in greater detail. By understanding individual learning patterns and preferences, teachers can provide more targeted feedback, supporting students' development according to their needs. This approach creates an inclusive learning environment, where each student receives special attention, and education is no longer generic. Technology integration paves the way to complete personalization of learning, ensuring that every student can overcome challenges, develop their potential, and achieve success in the ways that are most effective for them. Top of Form

fourth, technology integration opens up opportunities to create more interactive and collaborative learning experiences in the context of biology learning. With online projects, students can engage in exploration and research activities that involve the use of digital resources. For example, students can participate in collaborative projects to create multimedia presentations on specific biology topics or utilize online platforms to design experimental simulations. These kinds of activities not only deepen students' understanding of biological material, but also build critical skills such as research, data analysis, and presentation.

Furthermore, technology integration facilitates virtual collaboration between students, allowing them to interact without geographic boundaries. Through digital communication tools, such as online forums or discussion platforms, students can share ideas, exchange information, and discuss biological concepts in real-time. This creates a dynamic learning environment, where students are not only recipients of information, but also active actors in the formation of knowledge. Engagement in collaborative learning processes like this not only prepares students for the challenges of academia, but also builds essential collaboration skills in everyday life and in the workplace of the future.

Thus, the integration of technology in biology learning not only increases learning effectiveness, but also helps create a learning experience that is more fun, personalized and relevant to the demands of the digital age.

4. CONCLUSION

The integration of technology in education, especially in biology learning, has a progressiveness that is reflected in the four levels of the SAMR model: substitution, augmentation, modification, and redefinition. At the substitution level, technology is used as a substitute for traditional tools without changing the substance of learning. Augmentation involves adding features to enhance the learning experience, while modification allows adapting learning activities to the advantages of technological media. The redefinition level is the pinnacle of integration, where technology enables learning that would not be possible without technological support. Two frameworks, TPACK and Triple E, provide guidance for educators in effectively integrating technology. TPACK emphasizes the relationship between content, pedagogical, and technological knowledge, while Triple E focuses on engagement, enhancement, and extension as measures of the effectiveness of technology use. In the context of biology learning, technology integration has a significant positive impact. First, technology increases student engagement through simulations, interactive videos, and learning applications. Second, the revolutionary potential of personalized learning allows teachers to present material that suits students' individual needs. Third, technology integration opens up opportunities for collecting and analyzing learning data, allowing educators to provide more targeted feedback. Fourth, the learning experience becomes more interactive and collaborative through online projects and virtual collaboration. Overall, technology integration not only increases learning effectiveness, but also creates a learning experience that is more enjoyable, personalized, and relevant to the demands of the digital age. By harnessing the potential of technology, biology education can become more dynamic and responsive to student needs, opening up

opportunities for critical skills development, global collaboration, and student preparation for a challenging future in the digital era.

REFERENCES

1. Anshori, S. (2018). Pemanfaatan teknologi informasi dan komunikasi sebagai media pembelajaran. *Civic-Cu lture: Jurnal Ilmu Pendidikan PKn Dan Sosial Budaya*, *2*(1).
2. Emda, A. (2011). Pemanfaatan media dalam pembelajaran biologi di sekolah. *JURNAL ILMIAH DIDAKTIKA: Media Ilmiah Pendidikan Dan Pengajaran*, *12*(1), 149-162.
3. Firdaus, Z., Izza, J. N., Aruna, A., Novaldi, M. D., & Setiawan, D. (2022). Pengembangan mikroskop online interaktif pada materi biologi sel guna revitalisasi pembelajaran praktikum daring. *JINoP (Jurnal Inovasi Pembelajaran)*, *8*(1), 95-105.
4. Fitriyadi, H. (2013). Integrasi teknologi informasi komunikasi dalam pendidikan: potensi manfaat, masyarakat berbasis pengetahuan, pendidikan nilai, strategi implementasi dan pengembangan profesional. *Jurnal Pendidikan Teknologi dan Kejuruan*, *21*(3).
5. Herlambang, Y. T. (2021). *Pedagogik: Telaah Kritis Ilmu Pendidikan Dalam Multiperspektif*. Bumi Aksara.
6. Jayawardana, H. B. A., & Gita, R. S. D. (2020, August). Inovasi pembelajaran biologi di era revolusi industri 4.0. In *Prosiding Seminar Nasional Biologi* (Vol. 6, No. 1, pp. 58-66).
7. Patandean, Y. R., & Indrajit, R. E. (2021). *Flipped classroom: Membuat peserta didik berpikir kritis, kreatif, mandiri, dan mampu berkolaborasi dalam pembelajaran yang responsif*. Andi.
8. Riani, S., Al Hakim, R. R., & Sukmarani, D. (2021, December). Pemanfaatan teknologi pembelajaran berbasis multimedia untuk pembelajaran biologi: mini-review. In *Prosiding Seminar Nasional Pendidikan Biologi*.
9. Safitri, M. (2017). *Analisis integrasi teknologi dalam tpack guru pada pembelajaran biologi di SMA* (Doctoral dissertation, Universitas Pendidikan Indonesia).
10. Saragih, D. F. (2021). *Profil Keterampilan Abad 21 Mahasiswa Pada Mata Kuliah Metodologi Penelitian Program Studi Pendidikan Biologi Angkatan 2018 Universitas Negeri Medan* (Doctoral dissertation, UNIMED).
11. Setiawan, A. R. (2019). Efektivitas pembelajaran biologi berorientasi literasi saintifik. *Thabiea: Journal of Natural Science Teaching*, *2*(2), 83-94.
12. Sugiyono, P. (2011). Metodologi penelitian kuantitatif kualitatif dan R&D. *Alpabeta, Bandung*, 62-70.
13. Suhardiana, I. P. A. (2019). Peran teknologi dalam mendukung pembelajaran bahasa Inggris di sekolah dasar. *Adi Widya: Jurnal Pendidikan Dasar*, *4*(1), 92-102.
14. Sulastri, Y., & Rochintaniawati, D. (2009). Pengaruh penggunaan pembelajaran kooperatif tipe jigsaw dalam pembelajaran biologi di SMPN 2 Cimalaka. *Jurnal pengajaran MIPA*, *13*(1), 15-22.
15. Surata, I. K., Sudiana, I. M., & Sudirgayasa, I. G. (2020). Meta-analisis media pembelajaran pada pembelajaran biologi. *Journal of Education Technology*, *4*(1), 22-27.
16. Ula, S., Afifa, A. N., & Azizah, S. A. (2021). Pengaruh penggunaan teknologi di masa pandemi covid-19 terhadap hasil belajar pada mata pelajaran biologi di man 2 jember. *ALVEOLI: Jurnal Pendidikan Biologi*, *2*(1), 54-66.
17. Wardono, W., Waluya, B., Kartono, K., Mulyono, M., & Mariani, S. (2018). Literasi matematika siswa smp pada pembelajaran problem-based learning realistik edmodo schoology. In *PRISMA, Prosiding Seminar Nasional Matematika* (Vol. 1, pp. 477-497).
18. Zubaidah, S. (2019, September). STEAM (science, technology, engineering, arts, and mathematics): Pembelajaran untuk memberdayakan keterampilan abad ke-21. In *Seminar Nasional Matematika Dan Sains, September* (pp. 1-18).

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