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Revitalizing Biology Learning: Innovation and Challenges in the Digital Era

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ABSTRACT

Along with the development of information technology, biology education needs to experience innovation to maintain its relevance in preparing students to face future demands. This research focuses on innovative strategies that can be applied in biology learning, taking into account the challenges that arise in the digital era. Research methods involve literature analysis, surveys, and case studies to understand the various approaches that have been taken by biology educators. The results of this research show that technology integration, curriculum development that is responsive to the latest scientific developments, and the use of online learning resources are key elements in revitalizing biology learning. Challenges identified include unequal access to technology, teacher training needs, and adapting to rapid changes in learning paradigms. Therefore, this research also explores solutions and strategies to overcome these obstacles. In conclusion, revitalizing biology learning requires a holistic approach that covers various aspects, from technology to innovative teaching strategies. By facing the challenges and taking advantage of the opportunities of the digital era, biology education can become more dynamic and relevant, preparing students to face global changes in the future.

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INTRODUCTION

The Covid-19 pandemic has become a catalyst for major changes in various aspects of life, including the world of education. Even though it has given rise to mega-dimensional challenges, this pandemic has also brought a number of lessons, one of which is related to the evolution of learning methods (Irawan et al, 2020) . As various limitations arise, teachers and lecturers around the world are forced to adopt and develop skills to organize online learning. This expertise is an urgent need, enabling them to continue carrying out the education process even in difficult conditions (Andiyanto, 2021).

One positive impact that is likely to continue to develop after the pandemic is the continuation of online learning. Educators are not only familiar with online platforms, but also aware of their benefits, such as practicality, time saving, and other aspects of feasibility (Sukmawati et al, 2022) . Thus, online learning is not only a temporary solution, but is also believed to be the dominant trend in learning modes after the Covid-19 pandemic. However, challenges such as unequal access to technology and digital skills development must still be overcome so that online learning can provide benefits equally at all levels of society (Husain & Basri, 2021).

Even though online learning has become the new norm in the world of education, there are a number of issues that need to be considered, especially when dealing with special subjects such as biology (Thahir, 2021). The unique characteristics of biology learning which focuses on hands-on activities, experiments, and contextual understanding raise critical questions. How can the element of hands-on activities, which is the essence of the science approach, be accommodated in a completely virtual online learning environment? This is not only about presenting material, but

also involves the challenge of providing direct experience for students to observe, identify and understand biological concepts in depth (Maulana, 2021).

In overcoming this dilemma, there needs to be creative thinking and solutions. Biology educators need to consider developing engaging and interactive online learning resources, including virtual simulations, online laboratories, and the use of learning software that allows students to participate in practical exploration of science (Makaborang, 2019). In addition, the integration of biology learning with real and contextual case studies can maintain the essence of hands-on activities, even in an online environment. Thus, while biology learning in the post-pandemic era may still face several obstacles, creative and innovative approaches can help ensure that the essence of science education is maintained, even through a more virtual learning mode (Argiyanti et al, 2022).

So that online learning can accommodate biology learning principles optimally, in-depth studies and collaborative discussions need to be carried out. Biology educators, curriculum developers, and educational technologists need to come together to find creative solutions that enable the biology learning experience to remain authentic in an online environment (Maghfiroh et al., 2022). One solution that can be explored is the use of recordings, imitations and animations of biological objects and problems. Through advanced technology, biological objects and phenomena can be identified, organized and utilized optimally to provide an in-depth learning experience (Wisacita, 2020).

In this context, modification of biological objects and problems becomes important. Shifting focus from hands-on activities to interesting virtual simulations can be an effective solution (Sa'adah et al, 2020). Along with this, initiatives and strengthening of new formulations for biology learning are needed that combine innovative aspects of technology with the true nature of biology learning experiences (Andarini, 2012). Active collaboration between biology education practitioners, technology experts, and policy makers will help shape the best direction for biology learning in the post-Covid-19 pandemic era, making it relevant, interactive, and educational.

The aim of this research is to identify innovative solutions that can accommodate biology learning principles in an online learning environment in a digital era and post-Covid-19 pandemic. Through in-depth study and collaborative discussions, this research aims to formulate a new formulation that allows biology educators to make optimal use of recordings, imitations and animations of biological objects and problems. By identifying modifications to biological objects and problems that can be applied in online learning, this research seeks to create an approach that combines innovative aspects of technology with the authentic nature of biology learning. The benefits of this research involve a significant contribution to the development of biology learning practices in the post-pandemic era, helping to ensure that students' learning experiences remain substantial, interactive, and relevant to the principles and nature of science learning.

METHOD

In this research, the application of qualitative descriptive methods is the main approach. In accordance with the opinion of Moleong (20 14), descriptive research aims to explain phenomena using descriptive words rather than numbers, so that narrative explanations become the main focus. Qualitative methods, as defined by Bogdan & Taylor in Moleong (20 14), produce descriptive data in the form of written or spoken words obtained through direct observation of individuals and behavior. The choice to use this type of descriptive research with a qualitative approach is based on the belief that this method is more supportive in exploring issues that are relevant to the research focus . The data collection process in this research was carried out through interviews and documentation. In analyzing data, research uses an interactive model where the collected data is analyzed, abstracted, structured and validated for its validity. The final stage

involves interpreting the data to gain a deep understanding of the research topic which focuses on the biology learning revolution in the digital era.

RESULTS AND DISCUSSION

An innovative solution for revitalizing Biology Learning in the Digital Era

Revitalizing online biology learning in the digital era requires innovative solutions to ensure students' learning experiences remain meaningful and authentic. Some innovative solutions to explore include:

a. Virtual Reality (VR) and Augmented Reality AR) Simulation

VR and AR are two things that are almost similar. AR can seem like VR, and vice versa. AR simulates artificial objects in a real environment. Meanwhile, VR creates an artificial environment that can be inhabited. Specifically, the application of VR and AR in the world of education and/or learning is related to the ability of this technology to help students understand material/procedures, according to their capacity (in a more democratic way), help students understand abstract concepts, simulate phenomena or procedures, and provide students with the experience of using high technology in learning without physical space and equipment (Neuberger & Egger, 2018).

Virtual Reality (VR) is a breakthrough digital technology that is capable of creating interactive simulations in a three-dimensional environment. In contrast to the experience of viewing objects on a screen, VR allows students to surf and interact with virtual worlds that are designed in such a way as to stimulate as many senses as possible, including sight, hearing, taste/touch, and even smell VR technology creates the sensation of physical presence in the environment virtual, allowing users to feel as if they are really in it (Mustaqim, 2016). The simulations produced by VR not only include immersive visualizations, but also allow users to actively participate in the experience.

In the context of biology learning, VR opens up great opportunities to describe and simulate various biological phenomena and processes interactively. Simulations can include interactions between ecosystem components, energy flows, material cycles in an ecosystem, and even the movement of gamete cells, blood cells, intercellular molecules, and ions between cell organelles. Fernandez (2017) states that simulations in VR can be built based on research facts, theories, or the imagination of experts and practitioners, opening up space for more dynamic and in-depth biology teaching. Thus, the integration of VR in biology learning can provide a more real and immersive learning experience, facilitating the understanding of biological concepts in an innovative and interesting way for students.

Different from VR, AR is a type of digital technology that combines the real world with the virtual world, is interactive in real time, and takes the form of three-dimensional animation (Azuma, 1997). In almost similar language, Valino (1998) also said that AR is a digital technology that combines two or three-dimensional virtual objects and then projects them in real time. Thus, it can be defined that AR is a digital technology that is capable of combining virtual objects in two or three dimensions into a real context and then displaying them in real time. Combining the virtual world with the real world through AR is intended to produce clearer and more interesting information that originates from the system on real objects. In its development, AR is able to create interactions between the real world and the virtual world, all information can be added so that the information is displayed in real time, as if the information were interactive and real.

Some AR applications are designed to provide users with more detailed information from real objects. An example is Ultrasonography (USG) to see the condition of a woman's womb, and the movements being made by the fetus which are displayed on a screen directly and in real time using ultrasonic technology. A similar approach also makes things easier for surgeons. The

surgeon can directly and simultaneously feel the patient's soft tissue and examine it in three dimensions with projections (Mustaqim, 2016).

b. Developing an Interactive learning Platform

In the ever-growing digital era, creating an interactive online learning platform is a must to improve the quality of learning. One of the important features in this platform is the discussion forum, which gives students the opportunity to participate in dialogue and share their understanding of the learning material. These online discussions can help build a learning community among students, enriching their experience through the exchange of ideas and diverse points of view (Hasriadi, 2022).

Apart from that, the integration of online quizzes is also an important aspect of the learning platform. Quizzes can be directed to measure student understanding of learning material and provide instant feedback. The formative use of online quizzes can help teachers to identify areas that require further understanding, while students can use quizzes as an effective tool to test their own knowledge.

Furthermore, collaboration spaces within the platform can give students and teachers a place to work together on group projects or more complex assignments. Through this feature, students can collaborate, share ideas, and solve problems together, similar to real-life teamwork experiences. Collaboration spaces also enrich interactions between teachers and students, creating opportunities for more personalized and in-depth learning.

Thus, the development of interactive online learning platforms not only creates a dynamic learning environment, but also expands the space for student participation and increases their involvement in the teaching and learning process. By utilizing features such as discussion forums, online quizzes, and collaboration spaces, learning becomes more engaging, focuses on developing collaborative skills, and fosters a spirit of exploration and active learning among students.

c. Utilization of digital resources

The use of diverse digital resources can provide a new dimension to biology teaching methods, creating a dynamic and engaging learning environment for students. One very effective digital resource is learning videos. Through videos, biological concepts can be explained visually and narratively, helping students understand the material in a more comprehensive way. Videos also provide an opportunity to present biological phenomena that are difficult to replicate in the classroom directly, providing an immersive visual experience (Liriwati, 2023).

Furthermore, interactive simulations become an invaluable tool in teaching complex biological concepts. Simulations can create virtual environments in which students can experiment, observe, and understand biological phenomena in an interactive way. This provides space for open-ended exploration, allowing students to encounter scenarios and situations that may be difficult to access in traditional learning contexts. With interactive simulations, biology learning not only becomes more fun, but also more in-depth.

In addition, the use of special biology learning applications can provide experiences tailored to student needs. These applications can present learning material in an engaging format, often complemented by gamification or other interactive elements that can increase student engagement. Biology-specific learning applications can also provide challenges and assignments appropriate to students' level of understanding, creating a personalized and adaptive learning experience.

By integrating these digital resources in biology teaching methods, teachers can create variety in learning approaches. This opens up opportunities for students to access the material in a way that suits their individual learning styles. Thus, the use of videos, interactive simulations, and biology-specific learning applications not only enriches teaching, but can also motivate students to become more active and participate in their learning process.

Challenges of revitalizing Biology Learning in the Digital Era

The revitalization of biology learning in the digital era, although full of innovative potential, is also faced with a number of challenges that need to be overcome. Some key challenges include:

a. Technology Gap

The gap in access to technology is one of the main challenges in efforts to revitalize biology learning in the digital era. Across the world, there are significant disparities in the availability and accessibility of electronic devices and internet connectivity among students. Students from underprivileged sections of society or areas with limited infrastructure may have difficulty accessing necessary devices or face limitations in stable internet connectivity. Thus, the creation of this access gap could potentially increase the participation gap in online biology learning.

The impact of access gaps is not only limited to physical device and connectivity issues, but also includes aspects of the learning experience. Students who lack access may feel isolated from digital resources and are less able to follow developments in biology learning material optimally. They may miss opportunities to participate in online discussions, quizzes, or collaborative projects that may be an integral part of online learning.

Overcoming this access gap requires a holistic approach involving a number of stakeholders, including government, schools and non-profit organizations. Initiatives could involve providing subsidized devices and internet access to disadvantaged students, as well as creating hotspot zones or public internet facilities in remote communities. Apart from that, there is a need to develop biology learning content that can be accessed offline to overcome connectivity problems. The importance of equal access to biology learning in the digital era underscores the need for community empowerment and investment in inclusive educational technology infrastructure. Only through joint efforts focused on balancing technology and educational justice can we ensure that all students have equal and fair access to learning opportunities in the digital world.

b. Development of adequate teacher training

The migration to learning in the digital era places new demands on the teacher's role, requiring special skills to effectively manage learning. The main challenge faced by many teachers is the lack of adequate training in the use of digital tools and technology. Some teachers may not be fully familiar with learning software and applications, so they may experience self-doubt in designing and presenting biology learning materials online. These challenges are exacerbated by the continued speed of technological development. Teachers need to keep their knowledge up to date on the latest tools and applications that can enhance students' learning experiences. Lack of training and support in this case can be an obstacle in adopting new learning methods that are more interactive and technology-based.

In addition, concerns about technical and logistical issues can also be detrimental to teachers. Insufficient understanding of technical settings, hardware maintenance, or handling technical problems can make it difficult for teachers to deliver online biology lessons smoothly. This can create frustration and confusion that affects teaching effectiveness. The importance of ongoing and in-depth training for teachers in integrating technology in the classroom cannot be overstated. Relevant and focused training initiatives can help improve teachers' skills in using digital tools to present material, communicate with students, and support a variety of learning styles.

In this context, a collaborative approach between schools, educational institutions and other related parties is very important. Providing training tailored to teacher needs, providing reliable technical support, and creating inclusive learning environments will help overcome these challenges, giving teachers the confidence and skills necessary to reach the full potential of biology learning in the digital age.

c. Changes in Learning and Teaching Paradigms

The migration to digital-based biology learning not only involves changes in tools and technology, but also encourages a paradigm shift in the mindset of teachers and students. Educators need to understand that digital-based learning is not just the application of technology, but a deep transformation in learning approaches. The main challenge lies in changing the traditional mindset that tends to be linear and teacher-centered into a mindset that is more open to innovation, collaboration and active student involvement.

Some teachers may feel constrained or reluctant to move away from proven, traditional teaching methods for a more interactive and collaborative approach. These changes can raise concerns about control over the classroom, quality of learning, and adapting to technological developments. Therefore, adequate support and training are crucial in helping teachers overcome resistance to change and facilitating their adaptation to more innovative learning models.

On the student side, adopting digital-based biology learning also requires a change in mindset. Students must be actively involved in the learning process, develop independent learning skills, and become active participants in collaborative learning. This shift may require students to take a more proactive role in managing time, devising learning strategies, and contributing to online discussions or collaborative projects. The importance of this approach is not only related to technology, but also to preparing students to face challenges in the digital era. Teachers need to create a learning atmosphere that motivates and stimulates students' curiosity, encourages independence in learning, and builds the collaborative skills they will need in an ever-changing, digitally connected world.

By openly facing this paradigm shift, teachers and students can utilize the potential of digital-based biology learning more optimally. Awareness of the value of this approach, along with ongoing support and training, will help overcome barriers and create a dynamic and adaptive learning environment.

CONCLUSION

Revitalizing biology learning in the digital era faces significant challenges, but also presents innovative solutions to improve the student learning experience. Innovative solutions such as the use of Virtual Reality (VR) and Augmented Reality (AR) technology, the development of interactive learning platforms, and the integration of digital resources such as videos and simulations, open up new opportunities in biology teaching. However, a number of challenges, such as gaps in technology access, lack of teacher training, and paradigm shifts in learning mindsets, need to be overcome to ensure the successful implementation of digital-based learning. The technology access gap is a major concern, and resolving it requires collaboration between various parties, including governments, schools, and non-profit institutions, to ensure that all students have equal access to digital learning. Teacher training is also a key factor in optimizing the potential of biology learning in the digital era, so ongoing support and training initiatives are very necessary. Changes in learning and teaching paradigms also need to be faced with an open attitude, allowing teachers and students to adapt themselves to changes towards more interactive, collaborative and adaptive learning. By overcoming these challenges, the biology learning revolution in the digital era can create an inclusive, innovative and competitive learning environment. Equal access, in-depth teacher training, and acceptance of changes in learning paradigms are the keys to success in utilizing the potential of technology to improve the quality of biology education. Through joint efforts and commitment to the development of educational technology, we can shape the future of biology learning that is more dynamic and relevant in facing the demands of the digital era.

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