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Conceptual Article

A critical reflection on the affordances of web 3.0 and artificial intelligence in life sciences education

Lindelani Mnguni

Centre for Health Sciences Education, Faculty of Health Sciences, University of the Witwatersrand, South Africa

Correspondence should be addressed to Lindelani Mnguni lindelani.mnguni@wits.ac.za
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Life Sciences Education has become increasingly important in today's rapidly changing world, as it equips students with the knowledge and skills needed to tackle complex global challenges in various biology fields. With the emergence of Web 3.0 and Artificial Intelligence (AI), numerous opportunities exist to revolutionize Life Sciences Education and enhance student learning. However, integrating these technologies into traditional teaching methods poses significant challenges. This paper aims to explore the opportunities and challenges of Web 3.0 and AI in Life Sciences Education and provide recommendations for successful integration. The opportunities of Web 3.0 and AI in Life Sciences Education include enhanced personalized learning, increased engagement, access to vast amounts of data, and innovative assessment strategies. However, ethical concerns related to AI, integration with traditional teaching methods, training and professional development for educators, and cost and accessibility issues are among the challenges. The paper also provides case studies of successful implementation and recommendations for addressing ethical concerns, professional development, funding and accessibility, and collaboration between educators and technology experts. The paper concludes with implications for future research and practice in Life Sciences Education.

Keywords: Life sciences education, web 3.0, artificial intelligence, personalized learning

1. Introduction

Life Sciences Education has become increasingly important in today's society. As technology advances rapidly, Life Sciences Education is essential for preparing students to meet the demands of the workforce and contribute to scientific and technological advancements in various fields of biology (Gonzalez & Kuenzi, 2012; National Research Council, 2011; Osborne & Dillon, 2008). However, traditional teaching methods in life sciences have often been criticized for lacking innovation and inability to engage students effectively. For instance, Gasiewski et al. (2012) contend that static, instructor-led classrooms in traditional lecture-based courses must give way to vibrant, student-centered learning environments. Some believe the lack of academic engagement in foundational life sciences courses is the leading cause of students quitting their studies. The advantages of active or student-centered learning are well documented in science regarding overall student learning and improving pass rates through better content understanding (Eddy & Hogan, 2014; Freeman et al., 2014).

Recent technological advancements, such as Web 3.0 and Artificial Intelligence (AI), offer new opportunities to revolutionize Life Sciences Education. Web 3.0 is the next generation of the internet that aims to make information more connected and accessible (Hiremath & Kenchakkanavar, 2016; Miranda et al., 2014). Web 3.0 envisions an integrated Web experience where machines can comprehend and organize data similarly to humans (Rudman & Bruwer, 2016). This will allow any data format to be shared and interpreted by any device over any network in a global data warehouse. New opportunities and challenges will arise as the Web develops. The majority of the opportunities can be categorized as the autonomous integration of data and services that expands the capabilities of Web services already in place and the development of new functionality. Artificial Intelligence (AI), on the other hand, refers to the

ability of machines to perform tasks that typically require human intelligence, such as learning, problem-solving, and decision-making (Dellermann et al., 2019; Medsker, 2012). With deep learning algorithms, AI can solve problems like object and speech recognition while incorporating other forms of computer intelligence, such as case-based reasoning (Goodfellow et al., 2016; Medsker, 2012).

The rapid developments of Web 3.0 and AI necessitates a critical reflection on the opportunities and challenges presented by these technologies to prepare Life Sciences teachers and researchers better when integrating these technologies in teaching and learning. Consequently, this paper explores the opportunities and challenges of Web 3.0 and AI in Life Sciences Education and reflects on case studies of successful implementation and the impact on student outcomes. This paper seeks to inform educators and policymakers about the potential of these technologies to revolutionize Life Sciences Education.

2. Case Studies of Web 3.0 and AI Integration in Life Sciences Education

There have been various examples of successful integration of Web 3.0 and AI in Life Sciences Education in recent years (see Table 1). These examples have demonstrated the potential of these technologies to revolutionize the teaching and learning experience.

Table 1
The examples and impact of Web 3.0 and AI tools on student outcomes

Example	*Description*	*Impact on Student Outcomes*
Virtual Reality	Using VR technology to teach complex scientific concepts through the open-source web application ProteinVR.	Improved context for understanding molecular structures.
Augmented Reality	The creation of an open-access portal called moleculARweb that provides interactive information for teaching molecular STEM.	Increased accessibility to create online AR experiences.
Gamification	The creation of Bio3D, a STEM-focused app-based gamification application that motivates students and enhances learning outcomes.	Increased motivation and engagement in traditional classroom setting.
AI Prediction	AI algorithms are used to predict students' future academic performance, allowing educators to provide targeted interventions before students fall behind.	Improved student outcomes by early interventions.
Online Collaboration	Web 3.0 technologies are used to facilitate online collaboration between students worldwide, allowing them to collaborate on STEM projects in real-time.	Increased accessibility to collaborate on STEM projects.

One innovative example of Web 3.0 and AI integration in Life Sciences Education is using virtual reality (VR) technology to teach complex scientific concepts (Reen et al., 2021; Shim et al., 2003; Zhang et al., 2019). In order to exhibit molecular structures in 3D environments, researchers (Cassidy et al., 2020) created the open-source web application ProteinVR. ProteinVR runs on a variety of virtual reality platforms and operating systems. This provides a beneficial biological context and enables users to position themselves in three dimensions. Using ProteinVR in research settings and big classrooms is ideal for developing hypotheses and educating students.

Similarly, Rodríguez et al. (2022) created an open-access portal called moleculARweb that provides interactive information for teaching molecular biology. Students, instructors, and researchers can easily access moleculARweb via smartphones, tablets, and PCs. According to Rodríguez et al. (2022), teachers were asking for more biological macromolecules to be made available. As a result, they developed a web interface that enables anyone, without any programming experience, to create online augmented reality (AR) experiences in a few simple steps starting from Protein Data Bank, AlphaFold, or custom uploaded structures, or from virtual objects or scenes exported from the Visual Molecular Dynamics program. These illustrations

highlight the critical contribution open source Web 3.0, and AI can make to advancing Life Sciences Education.

Another example of the successful integration of Web 3.0 and AI in Life Sciences Education is using gamification to enhance learning outcomes. Ibarra-Herrera et al. (2019) report on creating an app-based gamification application called Bio3D. Since iOS has a high student market share, the researchers chose it as a hosting platform. They report that after utilizing Bio3D, students felt more motivated. Due to the app's value, participating students said they would likely suggest it to others. In this context, gamification and AI have been particularly effective in engaging students who may not have been interested in traditional classroom instruction.

Some schools have used AI algorithms to predict students' future academic performance, allowing educators to provide targeted interventions before students fall behind (e.g., Albreiki et al., 2021; Alsariera et al., 2022; Tarik et al., 2021). For example, Albreiki et al. (2021) used machine learning algorithms to predict student performance in computer science courses. They found that the algorithm could predict student grades with high accuracy and that the predictions could be used to identify students who were at risk of underperforming. This allowed instructors to provide targeted support to these students and improve their overall academic performance. In addition to AI algorithms, Web 3.0 technologies are also used to facilitate online collaboration between students worldwide. These technologies allow students to collaborate on STEM projects in real time, regardless of their physical location. This can help students learn from each other and gain exposure to diverse perspectives and ideas. For instance, Alsariera et al. (2022) developed a Web 3.0-based platform for collaborative learning in chemistry. The platform allowed students from different countries to collaborate on chemistry projects and experiments, sharing resources and expertise in real-time. The platform effectively improved students' engagement, learning outcomes, and cross-cultural communication skills.

It is also important to note that the impact of these technologies on student outcomes may vary depending on the context in which they are implemented. Therefore, it is essential to carefully evaluate the effectiveness of any new technology before it is widely adopted in the classroom. Integrating Web 3.0 and AI in Life Sciences Education can revolutionize the teaching and learning experience. By leveraging these technologies, educators can provide personalized, engaging, and effective instruction that meets the needs of every student. However, to fully realize the benefits of Web 3.0 and AI in Life Sciences Education, researchers must continue to innovate, evaluate, and refine their approaches to ensure that they provide students with the best possible learning experience.

3. Opportunities of Web 3.0 and AI in Life Sciences Education

The emergence of Web 3.0 and AI has provided educators with new tools and resources to enhance teaching and learning in these subjects. Several opportunities are presented by Web 3.0 and AI, including enhanced personalized learning, increased engagement and motivation, access to vast amounts of data, facilitating collaboration and communication, and innovative assessment strategies.

The affordances of AI in life sciences are particularly useful as students are expected to learn complex phenomena that exist at the microscopic and molecular levels (Mnguni, 2014). In this regard, AI-generated visual models could be a crucial tool for learning abstract concepts in life sciences, particularly in studying molecular structures and processes. These concepts are often too small or complex to be visualized using traditional teaching methods, such as lectures or textbooks. AI can generate interactive and 3D visualizations of molecular structures and processes that are dynamic and engaging. These visualizations can be customized to show different levels of detail. Students can manipulate them to explore the structures and functions of molecules and how they interact with each other. For example, students can use AI-powered visualizations to rotate, zoom in or out, and manipulate the molecule's orientation to see it from different perspectives. They can also interact with the visualization by clicking on different molecule parts to learn more about their properties and functions.

Another significant opportunity presented by Web 3.0 and AI in Life Sciences Education is the ability to provide enhanced personalized learning experiences for students (Balakrishnan, 2018; Chassignol et al., 2018; Peirce et al., 2008). These technologies allow educators to create tailored learning experiences adapted to each student's needs. This means that students can work independently and receive feedback and support specific to their learning needs. AI-powered adaptive learning systems can analyze a student's performance and progress in real-time and adjust the difficulty and pace of the learning material accordingly (Delgado et al., 2020; Pokrivčáková, 2019). This approach can be instrumental in Life Sciences Education, where students struggle with complex concepts. By identifying and addressing these areas of difficulty, educators can help students to build stronger foundational knowledge.

Web 3.0 and AI can also help to increase student engagement and motivation in Life Sciences Education (Hussain et al., 2018; Sinatra et al., 2015). This is because these technologies provide educators with new tools, such as virtual simulations and augmented reality experiences, to make learning more interactive and engaging. These tools can help to bring abstract biological concepts to life and make them more accessible and relatable to students. Additionally, AI-powered tools can provide students with immediate feedback about their progress in grasping these concepts, which can help to keep them motivated and engaged in their learning (Hussain et al., 2018). Gamification techniques, such as point systems and badges, can encourage students to engage with the material and complete tasks and assignments (Barata et al., 2013; Glover, 2013; Tan & Hew, 2016).

Another significant opportunity Web 3.0 and AI present in Life Sciences Education is the ability to access and analyze vast amounts of data (Jordan & Mitchell, 2015; Sarker, 2021). These technologies can help educators gather and analyze student performance data, which can be used to identify areas of strength and weakness and to develop targeted interventions. Additionally, Web 3.0 technologies allow educators to access and integrate data from various sources, including online databases and educational resources (Rudman & Bruwer, 2016). This can give students a broader range of learning materials and resources, enhancing their understanding of complex concepts.

Web 3.0 and AI can facilitate collaboration and communication in Life Sciences Education (Lal, 2011; Miranda et al., 2014; Pattnayak & Pattnaik, 2016). These technologies can connect students and educators, regardless of their geographic location. This is particularly useful when fieldwork, remote learning, and work-based learning are used. For example, online discussion forums and collaborative tools can facilitate peer-to-peer learning and collaboration. AI-powered chatbots and virtual assistants can also provide students with on-demand support and guidance, which can be particularly helpful for students learning remotely or needing additional support outside of regular class hours.

Web 3.0 and AI can provide educators with new tools and strategies for assessing student learning (Ali & Abdel-Haq, 2021; Zawacki-Richter et al., 2019). These technologies can be used to develop more innovative and effective assessment strategies, such as adaptive testing and real-time performance monitoring. Adaptive testing allows educators to adjust the difficulty of the assessment based on the student's performance, ensuring that the assessment is challenging but not too difficult. Real-time performance monitoring allows educators to track student progress in real-time and provide immediate feedback on areas of strength and weakness.

Overall, Web 3.0 and AI present significant opportunities for enhancing teaching and learning in Life Sciences Education. By providing personalized learning experiences, increasing engagement and motivation, facilitating collaboration and communication, and providing access.

4. Challenges of Web 3.0 and AI in Life Sciences Education

While Web 3.0 and AI technologies can potentially revolutionize teaching and learning in Life Sciences Education, several challenges must be addressed to integrate these technologies into traditional teaching methods successfully.

One of the most pressing challenges is related to ethical concerns surrounding the use of AI in education (Du & Xie, 2021; Marshan & Marshan, 2021; Stahl & Wright, 2018). AI algorithms are designed to learn and make decisions based on the data they are fed, but this raises questions about the accuracy and bias of the data being used. For example, if an AI algorithm is trained on a dataset that contains racial or gender biases, it may perpetuate those biases in its decision-making processes. Educators must be careful when selecting and using AI tools in the classroom, ensuring they are not perpetuating harmful biases. Furthermore, ethical considerations must be prioritized when selecting and using AI tools in the classroom. This requires a careful analysis of the data being used and the potential biases that may be present. Educators should also consider using AI tools designed specifically for education and have undergone rigorous testing to ensure accuracy and fairness.

Another challenge is the integration of Web 3.0 and AI technologies with traditional teaching methods. Life Sciences Education has traditionally relied on lecture-style teaching and rote memorization, but using Web 3.0 and AI technologies requires a more hands-on, interactive approach (Eddy & Hogan, 2014; Freeman et al., 2014; Gasiewski et al., 2012). This requires educators to shift their teaching styles and adopt new pedagogical methods, which can be challenging and time-consuming. This means educators may require additional training and skills development to effectively identify and use Web 3.0 and AI technologies in their teaching. Therefore, training and professional development for educators is a significant challenge. Many educators may lack the necessary skills and knowledge to effectively integrate Web 3.0 and AI technologies into their teaching practice (Ferdig et al., 2022; Wang et al., 2021). In order to address this, professional development programs should be offered to help educators learn how to use these technologies in the classroom effectively. Additionally, innovative programs should be developed that emphasize hands-on, experiential learning. Educators should be encouraged to experiment with new pedagogical methods and to share their experiences and best practices with other educators.

Cost and accessibility issues are also challenging when integrating Web 3.0 and AI in Life Sciences Education (Rudman & Bruwer, 2016). These technologies can be expensive, and not all schools, educators, and students have the necessary resources. In addition, accessibility issues may arise for students with disabilities or for those who do not have access to the necessary technology at home. These challenges must be addressed to ensure all students have equal access to the benefits of Web 3.0 and AI technologies in Life Sciences Education. One of the solutions would be integrating Web 3.0 and AI technologies with traditional teaching methods in a way that enhances, rather than replaces, existing teaching practices. This may involve using AI tools to supplement lectures and readings or incorporating interactive activities and games that allow students to apply their knowledge more hands-only. Furthermore, schools should explore creative solutions such as partnerships with technology companies, grant opportunities, and shared resources. Educators should also work to ensure that all students have equal access to the necessary technology and should consider using low-cost or free tools that are widely available.

While there are challenges associated with integrating Web 3.0 and AI technologies into Life Sciences Education, many innovative solutions can be employed to overcome these challenges by prioritizing ethical considerations, adopting new pedagogical methods, and providing professional development opportunities.

5. Recommendations for Integrating Web 3.0 and AI in Life Sciences Education

Integrating Web 3.0 and AI in Life Sciences Education can revolutionize teaching and learning. However, it also presents some significant challenges, including ethical concerns, the need for professional development, funding, and accessibility issues, and the need for collaboration between educators and technology experts.

One of the most significant challenges associated with integrating Web 3.0 and AI in Life Sciences Education is ethical concerns related to the use of these technologies. To address these concerns, institutions of learning and regulatory bodies should take a proactive approach to ethics

education in the classroom. This might include incorporating discussions of ethics and responsible technology use into lesson plans, encouraging teachers and students to explore the ethical implications of their projects and research, and engaging in ongoing dialogue with students about the ethical implications of emerging technologies.

Another critical challenge associated with integrating Web 3.0 and AI in Life Sciences Education is the need for professional development for educators. Many educators are not yet familiar with these technologies and may lack the training and support they need to effectively incorporate them into their teaching. To address this challenge, teacher training institutions should prioritize professional development for educators, offering ongoing training and support to help them stay up-to-date with emerging technologies and develop the skills they need to integrate them into their teaching effectively.

Integrating Web 3.0 and AI in Life Sciences Education can also present significant funding and accessibility challenges. For example, some institutions and schools may lack the resources to purchase the necessary hardware and software or the infrastructure needed to support these technologies. To address these challenges, authorities should explore innovative funding models, such as public-private partnerships or grant programs, to help fund the purchase of necessary technology. Additionally, they should work to ensure that all students have access to these technologies, including those from low-income or underrepresented communities.

Furthermore, to fully realize the potential of Web 3.0 and AI in Life Sciences Education, there needs to be a strong collaboration between educators and technology experts. Educators bring deep knowledge of pedagogy and learning theory, while technology experts bring expertise in emerging technologies and the technical skills needed to implement them effectively. By working together, educators and technology experts can develop innovative solutions to the challenges of integrating Web 3.0 and AI in Life Sciences Education. One way to facilitate this collaboration is to create interdisciplinary teams, including educators and technology experts. These teams can work together to develop innovative curricula and teaching strategies that incorporate emerging technologies and provide ongoing training and support to educators. Additionally, institutions can partner with technology companies or organizations to bring external expertise and resources.

6. Conclusion

In conclusion, this paper has explored the opportunities and challenges of Web 3.0 and AI in Life Sciences Education and highlighted the need for careful consideration and thoughtful integration of these technologies in teaching and learning. The opportunities presented by Web 3.0 and AI in Life Sciences Education are numerous and significant, ranging from enhanced personalized learning to innovative assessment strategies. However, the challenges of ethical concerns related to AI, integration with traditional teaching methods, training and professional development for educators, and cost and accessibility must be addressed to realize the potential benefits fully.

Case studies of successful integration of Web 3.0 and AI in Life Sciences Education have demonstrated the potential impact on student outcomes and offer insights into best practices for implementation. These examples suggest that collaboration between educators and technology experts, professional development for educators, and funding and accessibility considerations are critical factors for successfully integrating Web 3.0 and AI in Life Sciences Education.

As we move forward, it is clear that Web 3.0 and AI will continue to play a significant role in Life Sciences Education. Further research is needed to understand the implications for teaching and learning fully. Future research should explore innovative ways to integrate Web 3.0 and AI in Life Sciences Education, including developing new instructional strategies, assessment techniques, and learning environments. Additionally, it is essential to continue to address ethical concerns related to AI in education and to develop guidelines and policies for the responsible use of these technologies.

In conclusion, the integration of Web 3.0 and AI in Life Sciences Education has the potential to revolutionize teaching and learning but requires careful consideration of the opportunities and challenges presented by these technologies. By collaborating and innovating, educators and

technology experts can collaborate to create a brighter future for Life Sciences Education and equip students with the skills and knowledge needed to succeed in a rapidly changing world.

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