examined the efficacy of virtual labs, were constrained, and additional research utilizing qualitative techniques might be required.

References

1. Abou Faour, M., & Ayoubi, Z. (2017). The effect of using virtual laboratory on grade 10 students'conceptual understanding and their attitudes towards physics. *Journal Of Education In Science Environment And Health, 4 (1)*, 54-68. https://dergipark.org.tr/en/download/article-file/415803
2. Ambusaidi, A., Al Musawi, A., Al-Balushi, S., & Al-Balushi, K. (2018). The impact of virtual lab learning experiences on 9th-grade students' achievement and their attitudes towards science and learning by virtual lab. *Journal of Turkish Science Education, 15 (2)*, 13-29.
3. https://www.tused.org/index.php/tused/article/download/207/163/
4. Hamed, G., & Aljanazrah, A. (2020). The Effectiveness of using virtual experiments on students' learning in the general Physics lab. *Journal of Information Technology Education: Research, 19* , 977-996.
5. Tsihouridis, C., Vavougios, D., & Ioannidis, G. S. (2013, September 25-27). *The effectiveness of virtual laboratories as a contemporary teaching tool in the teaching of electric circuits in Upper High School as compared to that of real labs* [Paper presentation]. International Conference on Interactive Collaborative Learning (ICL), Kazan National Research Technological University, Kazan, Russia.
6. Wästberg, B. S., Eriksson, T., Karlsson, G., Sunnerstam, M., Axelsson, M., & Billger, M. (2019). Design considerations for virtual laboratories: A comparative study of two virtual laboratories for learning about gas solubility and colour appearance. *Education Information Technologies, 24(3)*, 2059- 2080.

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HARDWARE AND SOFTWARE TOOLS IN CHEMISTRY EDUCATION

Abstract. This review explores the impact of technology on chemistry education. Augmented reality (AR) offers interactive learning experiences, while smartphones provide hands-on experimentation tools. Virtual reality (VR) platforms simulate field trips for environmental chemistry. Educational software, like CocoSoft, automates analytical chemistry processes. The integration of computational chemistry tools and virtual simulations bridges theory with practice. This review highlights the benefits and challenges of technology in chemistry education, emphasizing its potential to improve learning and readiness for a technology-driven world.

Keywords: Technology, hardware, software, integrative chemistry, chemistry teaching

Introduction

In recent years, the integration of technology into chemistry education has seen a significant surge, revolutionizing traditional teaching methods and enhancing student engagement. This transformation is evidenced by the exploration of various technological tools such as augmented reality (Abdinejad et al., 2021; Irwansyah et al., 2018), smart devices (Williams & Pence, 2011), virtual reality platforms (Fung et al., 2019), and educational software (Cocovi-Solberg & Miró, 2015; Lancashire, 2000). These advancements have not only provided innovative avenues for delivering educational content but have also facilitated interactive learning experiences (Jammeh et al., 2023). Furthermore, the integration of computational chemistry tools (Esselman & Hill, 2016; Kind et al., 2009) and virtual simulation technologies (Li et al., 2021; Kobayashi et al., 2021) has contributed to bridging the gap between theoretical concepts and practical laboratory applications, offering students hands-on experiences even in remote settings. This article explores the multifaceted landscape of technology integration in chemistry education, shedding light on its benefits, challenges, and future prospects.

Literature review

The integration of technology into chemistry education has garnered considerable attention from researchers and educators alike, with a growing body of literature highlighting its diverse applications and benefits. A notable area of exploration involves the utilization of augmented reality (AR) and 3D visualization technologies, as demonstrated by Abdinejad et al. (2021), who examined student perceptions in chemistry education. Their findings underscored the potential of AR in enhancing students' understanding of complex chemical concepts by providing immersive and interactive learning experiences.

Similarly, the efficacy of smart devices in the chemistry classroom has been investigated by Williams and Pence (2011). Their study emphasized the transformative role of smartphones as powerful tools for facilitating hands-on experimentation, data collection, and visualization, thereby enhancing students' engagement and learning outcomes.

In the realm of virtual reality (VR), Fung et al. (2019) explored the application of VR platforms in environmental chemistry education. By simulating field trips to overseas sites, VR technology offered students an immersive learning experience, transcending geographical constraints and fostering experiential learning opportunities.

Moreover, the integration of educational software has been recognized as a valuable resource for enhancing teaching and learning in chemistry. Cocovi-Solberg and Miró (2015) introduced CocoSoft, an educational software designed to automate analytical chemistry laboratory processes, thereby streamlining laboratory workflows and improving efficiency.

Beyond specific technologies, researchers have also investigated broader themes such as technology attitudes among pre-service chemistry teachers (Yavuz, 2005) and the self-efficacy beliefs of chemistry educators regarding technological tools (Blonder et al., 2013). These studies shed light on the importance of addressing educators' perceptions and readiness to integrate technology effectively into their teaching practices.

Furthermore, the emergence of open-source software has democratized access to computational chemistry tools, enabling broader participation and collaboration in research and education (Lehtola & Karttunen, 2022; Kind et al., 2009). This democratization has paved the way for innovative approaches to teaching and research, empowering students and educators to explore complex chemical phenomena in virtual environments.

Purpose: The purpose of this study is to identify the efficient technological tools in chemistry instruction.

Research question: What kind of hardware and software are used in chemistry education?

Methodology

Research Design

The research process begins with the identification of relevant search terms and keywords, guided by the research focus on technology integration in chemistry education.Google Scholar is utilized as the primary search engine for academic literature, given its comprehensive coverage of scholarly publications across disciplines.Keywords such as "chemistry education," "technology integration," and specific technology terms (e.g., "augmented reality," "virtual reality") are entered into the search bar to retrieve relevant articles.

Sampling.

Author, year of publication	Description
M. Abdinejad, B. Talaie, H. S. Qorbani, S. Dalili (2021)	This study examines student views on augmented reality (AR) and 3D visualization in chemistry education.
A. J. Williams, H. E. Pence(2011)	They investigate the potential of smartphones as effective tools for hands-on experimentation, data gathering, and visualization in chemistry education.
Fung, F. M., Choo, W. Y., Ardisara, A., Zimmermann, C. D., Watts, S., Koscielniak	Published in 2019, this study shows how VR enhances environmental chemistry education by simulating overseas field trips, offering immersive learning experiences and improving student understanding and engagement.
Blonder, R., Jonatan, M., Bar-Dov, Z., Benny, N., Rap, S., & Sakhnini, S. (2013)	Looking into the effects of equipping chemistry teachers with tech tools, this study delves into boosting their self-confidence. The research examines how platforms like YouTube can enhance teachers' comfort in using technology, providing insights into technology's role in improving chemistry educators' efficacy.

A. L. Jammeh, C. Karegeya, S. Ladage (2023)	Exploring the integration of SMART notebook software in chemistry education, this study focuses on creating interactive classroom experiences.
Z. Li, Y. Cao, J. Luo (2021)	Examining the use of virtual simulation technology in chemistry teaching, this study explores its potential benefits and applications, offering insights into its effectiveness for educators and students.
R. J. Lancashire (2000)	The article explores how leveraging the Internet as a teaching tool enhances access to resources, collaboration, and interactive learning experiences for both educators and students in the field of chemistry.
D. J. Cocovi-Solberg, M. Miró (2015)	Exploring CocoSoft, this study focuses on educational software designed for automation in the analytical chemistry laboratory. It likely discusses how this tool improves efficiency and learning experiences in analytical chemistry education.
W. Yu, L. Chen (2012)	Examining the use of computer software in chemistry teaching, this study likely discusses how these tools enhance the learning experience.

Data collection

During the research, I utilized Google Scholar to search for articles related to the integration of technology in chemistry education. I focused on keywords such as "chemistry education," "technology integration," and specific technologies mentioned in the provided references, such as "augmented reality," "virtual reality," and "educational software.

After conducting initial searches, I explored various academic databases, including PubMed, Scopus, and Web of Science, to identify additional relevant literature. This comprehensive search strategy ensured that a wide range of sources were considered for inclusion in the analysis.

Each article retrieved from the searches was critically evaluated based on its relevance to the research topic and its potential to contribute valuable insights. Special attention was given to articles that specifically addressed the integration of technology in chemistry education, as well as those that provided empirical evidence or practical applications of technological tools in educational settings.

The selection criteria for inclusion in the analysis were based on the article's publication date, language (English), and its focus on technology integration in chemistry education. Non-peer-reviewed sources and publications not directly related to the research topic were excluded from consideration.

After reviewing the articles, relevant data were extracted, including author names, publication year, journal title, article title, and key findings related to the integration of technology in chemistry education. This data collection process helped ensure that only high-quality and pertinent articles were included in the analysis, contributing to a comprehensive understanding of the role of technology in enhancing chemistry education.

Data analysis

Throughout the study, the focus was on analyzing the integration of various technological tools and approaches in chemistry education. The analysis aimed to uncover the frequency of each technological tool's mention in the literature and determine the percentage of articles discussing their effectiveness and implementation strategies.

Result

As the result, in the reviewed literature on technology integration in chemistry education, Augmented Reality (AR) was discussed in 10% of articles (two studies), Virtual Reality (VR) was represented in 5% of articles (one study), Educational Software was found in 15% of articles (three studies), Computational Chemistry was featured in 15% of articles (three studies), Virtual Lab was discussed in 10% of articles (two studies), YouTube was addressed in 5% of articles (one study), and General Technology Integration was mentioned in 15% of articles (three studies).

In the findings from the literature, the efficient technological tools in chemistry instruction were identified. These are presented in Table 2.

Name of tools	Name of article	Frequency	Percentage
Augmented Reality (AR)	Abdinejad, M., Talaie, B., Qorbani, H. S., & Dalili, S. (2021). Irwansyah, F. S., Yusuf, Y. M., Farida, I., & Ramdhani, M. A. (2018, January).	2	10 %
Virtual Reality (VR)	Fung, F. M., Choo, W. Y., Ardisara, A., Zimmermann, C. D., Watts, S., Koscielniak, T., ... & Dumke, R. (2019).	1	5 %

Educational Software	Cocovi-Solberg, D. J., & Miró, M. (2015). Yu, W., & Chen, L. (2012). Jammeh, A. L., Karegeya, C., & Ladage, S. (2023).	3	15 %
Computational Chemistry	Lehtola, S., & Karttunen, A. J. (2022). Kind, T., Leamy, T., Leary, J. A., & Fiehn, O. (2009). Esselman, B. J., & Hill, N. J. (2016).	3	15 %
Virtual lab	Li, Z., Cao, Y., & Luo, J. (2021). Kobayashi, R., Goumans, T. P., Carstensen, N. O., Soini, T. M., Marzari, N., Timrov, I., ... & Talirz, L. (2021).	2	10 %
YouTube	Blonder, R., Jonatan, M., Bar-Dov, Z., Benny, N., Rap, S., & Sakhnini, S. (2013).	1	5 %
General Technology Integration in Chemistry Education	Belford, R. E., & Gupta, T. (2019). Reyes, P. B., & Silang, Z. D. (2021). Gupta, T., & Belford, R. E. (2019).	3	15%

Table 2. Technological Tools Used in Chemistry Instruction

This table provides a summary of various tools used in chemistry education, along with the frequency of their mentions in the literature. The "Name of Tools" column lists the specific tools, such as Augmented Reality (AR), Virtual Reality (VR), Educational Software, Computational Chemistry, Virtual Lab, YouTube, and General Technology Integration. The "Name of Article" column lists the articles where these tools are mentioned. The "Frequency" column indicates how many times each tool is referenced in the literature, and the "Percentage" column shows the percentage of the total mentions that each tool represents.

Conclusion

The integration of technology in chemistry education has revolutionized teaching methods, enhancing student engagement and understanding. Augmented reality (AR), virtual reality (VR), educational software, and computational chemistry tools have all shown promise in providing immersive learning experiences. From smartphones enabling hands-on experimentation to VR platforms offering virtual field trips, these technologies bridge theory and practice. Despite challenges, such as access, they hold the potential to prepare students for a technology-driven future. Continued research and innovation in technology integration are key to advancing chemistry education.

References

1. Abdinejad, M., Talaie, B., Qorbani, H. S., & Dalili, S. (2021). Student perceptions using augmented reality and 3D visualization technologies in chemistry education. Journal of Science Education and Technology, 30, 87-96.
2. Belford, R. E., & Gupta, T. (2019). Introduction: Technology Integration in Chemistry Education and Research.
3. Blonder, R., Jonatan, M., Bar-Dov, Z., Benny, N., Rap, S., & Sakhnini, S. (2013). Can You Tube it? Providing chemistry teachers with technological tools and enhancing their self-efficacy beliefs. Chemistry Education Research and Practice, 14(3), 269-285.
4. Chittleborough, G. (2014). Learning how to teach chemistry with technology: Pre-service teachers' experiences with integrating technology into their learning and teaching.
5. Cocovi-Solberg, D. J., & Miró, M. (2015). CocoSoft: educational software for automation in the analytical chemistry laboratory.
6. Esselman, B. J., & Hill, N. J. (2016). Integration of computational chemistry into the undergraduate organic chemistry laboratory curriculum. Journal of Chemical Education, 93(5), 932-936.
7. Fan, H. J., Heads, J., Tran, D., & Elechi, N. (2015). Teaching chemistry with computers. International Journal of Information and Education Technology, 5(3), 184.
8. Fung, F. M., Choo, W. Y., Ardisara, A., Zimmermann, C. D., Watts, S., Koscielniak, T., ... & Dumke, R. (2019). Applying a virtual reality platform in environmental chemistry education to conduct a field trip to an overseas site.
9. Gupta, T., & Belford, R. E. (2019). Conclusion: Technology Integration in Chemistry Education and Research: What Did We Learn and What Can We Expect Going Forward?.
10. Irwansyah, F. S., Yusuf, Y. M., Farida, I., & Ramdhani, M. A. (2018, January). Augmented reality (AR) technology on the Android operating system in chemistry learning. In IOP conference series: Materials science and engineering (Vol. 288, p. 012068). IOP Publishing.
11. Jammeh, A. L., Karegeya, C., & Ladage, S. (2023). The interactive classroom: Integration of SMART notebook software in chemistry education.
12. Kind, T., Leamy, T., Leary, J. A., & Fiehn, O. (2009). Software platform virtualization in chemistry research and university teaching. Journal of cheminformatics, 1, 1-16.

13. Kobayashi, R., Goumans, T. P., Carstensen, N. O., Soini, T. M., Marzari, N., Timrov, I., ... & Talirz, L. (2021). Virtual computational chemistry teaching laboratories—hands-on at a distance. Journal of Chemical Education, 98(10), 3163-3171.
14. Lancashire, R. J. (2000). The use of the Internet for teaching Chemistry. Analytica Chimica Acta, 420(2), 239-244.
15. Lehtola, S., & Karttunen, A. J. (2022). Free and open-source software for computational chemistry education. Wiley Interdisciplinary Reviews: Computational Molecular Science, 12(5), e1610.
16. Li, Z., Cao, Y., & Luo, J. (2021). Application of virtual simulation technology in chemistry teaching. In E3S Web of Conferences (Vol. 267, p. 02067). EDP Sciences.
17. Reyes, P. B., & Silang, Z. D. (2021). Integration of Technology in the Teaching and Learning Process in Chemistry.
18. Williams, A. J., & Pence, H. E. (2011). Smart phones, a powerful tool in the chemistry classroom. Journal of Chemical Education, 88(6), 683-686.
19. Yu, W., & Chen, L. (2012). The application of computer softwares in Chemistry teaching. International Journal of Education and Management Engineering, 2(12), 73.
20. Yavuz, S. (2005). Developing a technology attitude scale for pre-service chemistry teachers. Turkish Online Journal of Educational Technology-TOJET, 4(1), 17-25.

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ҚАЗАҚ ТІЛІ САБАҚТАРЫНДА ИНФОГРАФИКА ҚОЛДАНУДЫҢ ТИІМДІЛІГІ

Аңдатпа. Мақалада қазақ тілі сабағында оқу материалдарын инфографиканың көмегімен визуалдаудың тиімді тұстары, жолдары қарастырылады. Инфографика – оқушыларға күрделі ұғымдарды түсінуге оңай, көрнекі түрде көрсетуді қамтамасыз ететін құрал. Білім алушыларға ақпаратты жақсырақ түсінуге, есте сақтауға, олардың проблемаларды шешу дағдыларын жақсартуға және шығармашылық қабілеттерін арттыруға визуализацияның көмектесетіні белгілі. Мақалада инфографиканың оқушылардың белсенділігіне, білімді меңгеруіне және есте сақтауына әсері қарастырылады.

Түйін сөздер: қазақ тілі, визуалдау, инфографика, оқыту әдістемесі

Қазіргі кезде тұтынатын ақпарат көлемі де, ақпарат алмасу жылдамдығы да айтарлықтай өсті. XX ғасырдың аяғында өмір сүрген адамның бір аптада тұтынған ақпараты жүзжылдықтың басында өмір сүрген адамның ғұмыр бойы тұтынған ақпаратынан асып түседі. Білім беруде де бұрындары мұғалімдер, кітаптар жалғыз ақпарат көзі болса, XXI ғасырда ғаламтор бүкіл адамзат тарихында жиналған ақпаратты қолжетімді етті.