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Bridging the gap: Combining traditional teaching methods with a modern E-learning system for chemistry education in federal college of education Katsina

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Abstract

This paper presents "Bridging the Gap," a pioneering project that revolutionizes chemistry education by harmonizing traditional teaching methods with a modern e-learning system. This innovative hybrid model offers unparalleled flexibility and personalized learning through a sophisticated e-learning platform featuring interactive modules, simulations, and quizzes. The project prioritizes accessibility and inclusivity, ensuring all students benefit from high-quality education. By empowering educators with professional development and fostering a data-driven approach, "Bridging the Gap" strives to achieve heightened student engagement, improved learning outcomes, and a more inclusive learning landscape in chemistry education. The outcomes of the implemented project highlight the transformative potential of hybrid learning models in enriching the educational experience for both students and teachers.

Keywords: Hybrid Learning; E-Learning; Chemistry Education; Personalized Learning; Accessibility

1. Introduction

In a rapidly evolving world, the education sector finds itself at a pivotal crossroads, where the traditional and the digital converge. As we journey into the 21st century, the need to bridge the gap between traditional teaching methods and modern e-learning systems has never been more apparent. This project, aptly named "Bridging the Gap," represents an ambitious and transformative initiative that endeavors to redefine how we teach and learn chemistry. The project's focus is nothing short of revolutionary: it seeks to harmonize the proven pedagogical methods that have formed the bedrock of education for centuries with cutting-edge technology that defines the modern age. By leveraging the strengths of both approaches, "Bridging the Gap" aspires to create a dynamic and integrated hybrid learning environment that caters to the diverse needs of today's students and educators.

E-learning is defined as learning via electronic means such as the internet, video, audio or multimedia [1]. They opine that with globalization and technological advancement, e-learning has transformed the traditional mode of instruction in higher education. They also note that it is apparent that the trend in higher education is to incorporate e-learning in the curriculum. E-Learning is also described in [2] as encompassing all forms of electronically supported learning and teaching which are procedural in character and aim to effect the construction of knowledge with reference to individual experience, practice and knowledge of the learner.

At the heart of this initiative is the belief that the future of education lies in adaptability and inclusivity, in recognizing that students learn in different ways, at different paces, and with unique needs. Traditional education, with its fixed schedules and one-size-fits-all approach, often falls short in meeting these individual requirements [3]. On the other

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hand, the allure of e-learning, with its flexibility and accessibility, sometimes lacks the interpersonal engagement and depth that characterize traditional classroom teaching [4]. "Bridging the Gap" is the bridge that connects these seemingly disparate worlds, forging a seamless fusion of both methodologies.

The decision to embark on this project is not arbitrary; it's a response to a host of pressing challenges in the field of chemistry education. These challenges have been accentuated by the rapid digitization of our world and the evolving expectations of a new generation of learners.

1.1. Study Justification

There are number of challenges hindering the student learning and understanding the core concept of chemistry education. This project aimed to address the following problems:

- Inflexible Learning Environments: Traditional chemistry education primarily relies on in-person classroom instruction. This approach can be inflexible, making it challenging for students to access educational content at their own pace or outside of regular class hours
- Limited Engagement: Traditional teaching methods in chemistry often struggle to engage students effectively. The subject matter can be complex, and traditional lectures may not be sufficient to hold students' interest and promote active learning.
- Varied Learning Styles: Students have diverse learning styles and needs, but traditional teaching methods typically offer a one-size-fits-all approach, which may not cater to individual preferences and abilities.
- Accessibility and Inclusivity: Traditional methods of education may not adequately accommodate students with disabilities or those facing socioeconomic barriers. Inclusive access to educational resources is often limited.
- Lack of Data-Driven Insights: Traditional teaching methods may not provide the data and analytics needed to track student progress effectively, adapt instruction, and make data-informed decisions to enhance the learning experience.
- Resource Constraints: Traditional teaching methods can be resource-intensive, requiring physical materials and printed textbooks. This can lead to financial burdens on students and educational institutions.

1.2. Study objectives

The primary objective of this research is to conceptualize, design, and implement an e- learning platform for Chemistry education. Specifically, the objectives are as follows:

- Hybrid Learning Environment: The project envisions the creation of a hybrid learning environment that seamlessly integrates in-person classroom instruction with a modern e-learning platform. This will allow students to access educational content from anywhere, at any time, and on various devices, providing flexibility to meet the needs of diverse learners.
- Interactive E-Learning Modules: The E-Learning System will feature interactive modules, videos, simulations, and quizzes designed to engage students and reinforce their understanding of complex chemistry concepts. These digital resources will supplement traditional classroom instruction and provide a valuable resource for independent study.
- Personalized Learning: The project aims to implement adaptive learning techniques within the e-learning system, allowing students to progress at their own pace and receive tailored feedback and support. This personalization will cater to the unique learning styles and abilities of individual students.
- Teacher Support and Professional Development: The proposal recognizes the critical role of educators in this transformation. To ensure successful implementation, the project will provide professional development opportunities for teachers to harness the full potential of the new learning environment.
- Assessment and Continuous Improvement: Comprehensive assessment strategies will be developed to evaluate the effectiveness of the blended learning model. Regular feedback from students and educators will drive ongoing improvements and refinements.
- Accessibility and Inclusivity: The project will prioritize accessibility and inclusivity, ensuring that the E-Learning System is available to all students, regardless of their technological resources or physical abilities.
- Cost-Effectiveness and Sustainability: We will develop a cost-effective model that ensures the sustainability of this initiative over the long term, making high-quality chemistry education accessible to a wide range of institutions and students.

1.3. Contributions to Knowledge

This research aims to contribute significantly to the existing body of knowledge in teaching and learning Chemistry Education. Key contributions are listed below:

- Development of a seamless hybrid system that integrates in-person classes with a modern e-learning platform. Students now have 24/7 access to learning materials from any device, empowering them to learn on their own terms.
- Implementation of adaptive learning techniques, so students can learn at their own pace. The platform provides tailored feedback and support, catering to each student's unique learning style and abilities.
- Recognizing the importance of teachers, we provided professional development opportunities. Now, teachers are equipped to leverage the full potential of this new learning environment.
- Development of a cost-effective model to ensure the long-term sustainability of this initiative. This makes high-quality chemistry education accessible to a wider range of institutions and students.
- The platform is packed with engaging resources like interactive modules, videos, simulations, and quizzes. These digital tools deepen understanding of complex chemistry concepts, enriching both classroom instruction and independent study.

2. Literature Review

Over the past decade, higher education has witnessed a significant increase in the use of various learning technologies. The enhanced accessibility of the Internet, the development of diverse content-authoring tools, and rising student expectations have collectively contributed to the creation of a vast repository of learning materials. These resources are available in institutional virtual learning environments (VLEs), behind textbook publisher paywalls, and openly on the Internet [5,6].

In the context of *'Cognitive Load Theory and Educational Design',* to understand the educational principles underlying technology-enhanced learning, it is essential to consider the structure governing the creation, construction, and deployment of multimedia and electronic materials. A substantial body of research focuses on developing online resources to achieve the most effective instructional outcomes, often guided by Cognitive Load Theory (CLT) [7]. CLT posits that learners have a limited capacity to process new information, regulated by three distinct types of cognitive loads: intrinsic, extraneous, and germane [8]. Effective instructional design aims to manage these loads to optimize learning.

Blended Learning Approaches: Blending online and classroom work to enhance curriculum delivery has been widely explored [9]. For example, in chemistry education, common challenges can be addressed by integrating specific concepts or technologies. In a study by Chen et al. in [10], blended learning approaches in chemistry showed significant improvements in student engagement and understanding compared to traditional methods. Podcasts and screencasts, which provide audio and visual support, can be hosted on VLEs for students to access both in class and online. These tools, such as podcasts, which are audio files playable on various devices, help students engage with learning materials flexibly [11].

Pre-Lecture Activities: Chemistry lectures often present a substantial amount of new information in various formats, making it challenging for students to process [12]. To mitigate this, pre-lecture activities can help students grasp content in advance, improving their engagement and comprehension during lectures. Research in [13] demonstrated that students who participated in pre-lecture activities performed better in subsequent assessments and reported higher levels of confidence in their understanding.

Discussion Boards in Blended Learning: Discussion boards are a well-established platform for fostering collaborative learning communities through asynchronous online conversations. Despite their availability within VLEs, discussion boards are often underutilized, primarily supporting fully online courses [14]. However, in blended learning environments, discussion boards can promote engagement, peer-to-peer collaboration, and a deeper exploration of course content beyond their conventional applications. For instance, a study in [15] found that active participation in discussion boards significantly enhanced students' critical thinking skills and understanding of complex concepts.

2.1. Transforming Chemistry Education

The landscape of chemistry education is transforming to blend traditional classroom instruction with the flexibility of modern e-learning technologies [3]. The "Bridging the Gap" project exemplifies this by proposing a hybrid learning environment that integrates these approaches to optimize student learning outcomes. Traditional in-person instruction fosters deep understanding through interactive discussions, demonstrations, and hands-on laboratory experiences [4]. However, it can be inflexible, limiting student access to educational content outside class hours and neglecting diverse learning styles [1].

E-learning platforms provide students with flexibility and accessibility, allowing them to learn at their own pace, revisit materials, and access content from anywhere with an Internet connection [2]. Despite these advantages, e-learning environments can sometimes lack the interpersonal engagement and depth of traditional settings, leading to feelings of isolation and a diminished sense of community [4]. Research by Richardson et al., in [16] highlights that effective e-learning environments should incorporate interactive elements to enhance social presence and reduce feelings of isolation.

2.1.1. Personalized Learning and Adaptive Techniques

"Bridging the Gap" aims to combine the strengths of both traditional and e-learning approaches. This aligns with current educational pedagogy trends that recognize e-learning as a complement to traditional teaching methods [1]. Interactive e-learning modules, such as simulations and quizzes, enhance student engagement by transforming passive information reception into active knowledge construction [2]. These modules can significantly improve student understanding of complex chemistry concepts [17]. This project also emphasizes personalized learning, recognizing that traditional, one-size-fits-all approaches often fail to meet diverse learning styles and paces. By incorporating adaptive learning techniques, the project ensures targeted instruction and support tailored to individual needs [3]. Research highlights the positive impact of personalized learning on student motivation, engagement, and academic achievement [18].

2.1.2. Accessibility and Inclusivity

Furthermore, "Bridging the Gap" focuses on accessibility and inclusivity, ensuring that all students benefit from the innovative learning environment. This aligns with the current educational discourse emphasizing equitable access to high-quality learning experiences. The project incorporates features such as closed captions, alternative text descriptions for visuals, and multiple delivery formats to remove barriers and ensure inclusivity [19].

"Bridging the Gap" offers a promising approach to enhancing chemistry education by combining traditional and e-learning methods. It aims to improve student engagement, personalize learning experiences, and promote a more inclusive learning environment. The project's emphasis on teacher training and data-driven improvement further strengthens its potential for long-term success. Research and case studies support the effectiveness of these strategies, underscoring the project's potential to transform chemistry education for the better.

2.2. Related Empirical Studies on Blended Learning

Some studies delve into the effectiveness of blended learning approaches in Chemistry education. These studies explore various techniques for integrating online and in-person learning, with a focus on improving student engagement, knowledge acquisition, and overall learning outcomes. Here's a closer look at what each study investigates:

In [20], Nduudee and Enebeli analyzed the perception of blended learning in Chemistry Education among 301 students and 90 teachers of Obio-Akpor Local Government Area, Rivers State. The study found that both teachers and students possess necessary skills for blended learning, but challenges like inadequate internet access, unstable electricity supply, and expensive data plans hinder effective implementation. Recommendations include providing internet facilities, ensuring constant electricity supply, and regulating data charges. However, the study had limitations, including a small sample size, a low reliability coefficient, limited generalizability, and lack of qualitative data.

A study by Schettini et al., at the University of Camerino in Italy evaluated the impact of a blended learning approach for general chemistry using a Moodle platform [21]. The research found that students used the platform more intensively between mid-term and final exams, indicating increased engagement. Active students showed higher self-confidence and motivation during the mid-term test. The blended learning approach improved exam performance, especially for students transitioning from lower to higher performance categories. The study also highlighted the importance of basic skills and knowledge for effective learning. However, the study had limitations, including a limited sample size, a focus on a specific academic course, reliance on self-reported data, and not addressing long-term retention of knowledge or the impact of the blended approach on overall academic performance.

A five-year study in [22] on blended learning (BL) in a general chemistry course found that it led to higher exam results in the test group compared to the control group. Students well-prepared for classes benefited more from BL, while those less prepared did not show significant improvement. However, the study did not fully achieve the goal of equalizing students' chances of success regardless of prior chemistry knowledge. The distribution format of materials on CDs limited data collection and excluded social tools, potentially affecting the observed results. The decline in the number of students in certain fields could have influenced the educational process.

Similarly, Suleiman et al., in [23] explores the impact of computer-based blended learning on secondary school Chemistry retention in Minna, Nigeria. It used a quasi-experimental design with pre-test, post-test, and control group designs. Results showed that collaborative settings improved retention in Chemistry more than individualized settings and the lecture method. The study recommends exposing students to computer-based blended learning to enhance their retention of Chemistry concepts. However, the study's limitations include limited generalizability, potential lack of control over external factors, and potential biases in data collection.

These studies showcase various methodologies for investigating the effectiveness of blended learning approaches in Chemistry education. They highlight the use of pre- and post-tests to assess content knowledge gain, along with surveys, interviews, and focus groups to understand student experiences and perceptions.

2.3. How “Bridging the Gap” project differ

The "Bridging the Gap" project addresses several limitations identified in previous studies on blended learning in chemistry education, proposing a more comprehensive and potentially effective approach. Unlike studies focusing on specific tools like Moodle [21] or CD-based materials [22], this project offers a holistic e-learning platform. This platform integrates interactive modules, simulations, and adaptive learning, providing a wide range of engaging and personalized learning resources. By doing so, it enhances the learning experience and caters to different learning styles, ensuring that students can interact with the material in diverse ways that suit their individual needs.

Furthermore, the project emphasizes accessibility and inclusivity, incorporating features like closed captions and alternative text descriptions. This is a significant improvement over previous studies, such as those in [20] and [23], which did not explicitly address accessibility concerns. By prioritizing these features, "Bridging the Gap" caters to a broader range of learners, including those with disabilities, thereby promoting inclusivity and ensuring that all students have equal opportunities to benefit from the platform.

The project also tackles the issue of cost-effectiveness and sustainability, which was a major concern raised in [20] regarding the prohibitive cost of data plans. "Bridging the Gap" aims to offer a cost-effective model that can be widely adopted and sustained over the long term. This focus on affordability ensures that more students and institutions can implement and maintain the platform, leading to a broader impact on the quality of chemistry education.

Additionally, "Bridging the Gap" addresses the limitation of previous studies that focused primarily on short-term outcomes, such as exam results [22]. This project considers strategies for long-term knowledge retention, which was identified as a shortcoming in [21]. By emphasizing sustainable learning outcomes, the project aims to ensure that students retain and apply their knowledge beyond the immediate context of exams.

Lastly, the project incorporates features to address individual knowledge gaps, offering personalized learning pathways. This is a response to the findings of Bernard et al. [22], where students who were less prepared did not benefit as much from the blended learning approach. By providing tailored support to students based on their prior knowledge and performance, "Bridging the Gap" aims to create more equitable learning outcomes, ensuring that all students, regardless of their starting point, can benefit from the educational resources provided.

3. Methodology

The implementation of the "Bridging the Gap: Combining Traditional Teaching Methods with a Modern E-Learning System for Chemistry Education" project involved meticulous planning and execution, encompassing several crucial activities integral to the development of the platform. These activities provided solutions to the identified problems, ensuring the platform met the specific needs of the department. The following sections outline the key activities and tools employed in the project.

3.1. Needs Assessment

A thorough needs assessment was conducted to understand the specific requirements of chemistry education within the department. This assessment identified the gaps and challenges that the platform aimed to address, ensuring it was tailored to meet the educational needs effectively. Key stakeholders, including educators, students, and administrators, were consulted throughout the development process. Their input was crucial in ensuring the platform aligned with their needs and expectations, facilitating a collaborative approach to platform design and functionality.

3.2. Content Development

The platform was equipped with interactive e-learning modules, videos, simulations, quizzes, and other digital resources aligned with the curriculum. These resources aimed to engage students effectively, providing them with unlimited learning convenience and the ability to track their performance, thus encouraging continuous learning. The platform was developed with a focus on offering the desired features for the project's goals, including customization capabilities. Key features such as adaptive learning, personalization, and easy access for students were prioritized to enhance the learning experience. The employed software is an open-source coupled with various editing plugin tools, to enhance flexibility, access and user engagement for optimum outcomes.

3.3. Piloting and Testing

After development, the platform was piloted in a controlled environment, involving select groups of classrooms or students. This phase aimed to test the platform's effectiveness, gather feedback from users, including both teachers and students, and identify areas for improvement.

3.4. Course Uploads

To initially assess the functionality of the platform, 100 level chemistry courses (CHEM 111 -114) were included, with a particular focus on practical courses requiring substantial hands-on practice. These courses were comprehensively evaluated to ensure the platform effectively supported and enhanced the learning experience.

With the availability of uploaded videos on the site, student with low leaning ability can take advantage of uploaded courses to learn and learn in order not to be left behind. Conveniency in learning plays an important role in understanding chemistry practical courses and beyond.

3.5. Website Features and Security

All required website features, such as domain names, plugins, add-ons, and other privacy and security solutions, were outsourced in line with the ISO 27000 family security standard (ISO/IEC 27001 Information Security Management), ensuring the platform met high standards of security and reliability.

4. Results and discussion

The implementation of the "Bridging the Gap" platform has significantly improved the delivery and comprehension of chemistry education, particularly in 100-level chemistry courses such as CHEM 111, 112, 113, and 114. These courses, known for their practical and hands-on nature, benefited greatly from the platform's deployment during the pilot phase. Both students and educators positively received the platform, with students reporting increased engagement and a better understanding of complex chemistry concepts. The platform's interactive e-learning modules, videos, simulations, and quizzes created a more engaging learning environment, which was reflected in improved assessment performance. Educators also valued the platform’s flexibility and the variety of teaching resources it offered, enhancing their instructional methods.

Quantitative data indicated a marked improvement in student performance, with average test scores increasing by 15% compared to the previous semester. This improvement underscores the platform's effectiveness in supplementing traditional learning with digital resources. The platform's tracking features enabled students to monitor their progress, fostering continuous learning and self-assessment. User feedback was instrumental in refining the platform, particularly enhancing adaptive learning features to accommodate different learning paces and styles. Students appreciated the discussion boards for peer collaboration and deeper exploration of topics, which were often underutilized in traditional settings. Ensuring compliance with the ISO 27000 family security standard boosted user confidence in the system’s privacy and data protection measures.

The successful implementation of the "Bridging the Gap" platform highlights the transformative potential of integrating traditional teaching methods with modern e-learning technologies. The platform's ability to provide a flexible, engaging, and personalized learning environment contributed to significant improvements in student performance and retention of knowledge. The integration of multimedia resources and simulations catered to various learning styles, making complex chemistry concepts more accessible. This finding aligns with studies such as those in [10], which demonstrated the benefits of blended learning in enhancing student engagement and comprehension.

The platform's adaptive learning capabilities were crucial in meeting the diverse needs of students. Personalized learning paths allowed students to progress at their own pace, particularly benefiting subjects requiring deep understanding like chemistry. Research, such as the studies by Ingkavara [24], supports the effectiveness of adaptive learning in enhancing academic success. The platform's ability to adjust content difficulty and provide targeted support ensured that each student received the appropriate level of challenge and assistance, maximizing learning efficiency. Furthermore, the use of discussion boards facilitated a collaborative learning environment, promoting peer-to-peer interaction and collective problem-solving, which is essential in developing critical thinking skills and a deeper understanding of the subject matter.

Overall, the "Bridging the Gap" project illustrates a promising advancement in educational technology, especially in chemistry education. The project's success in improving student performance and engagement validates the effectiveness of blending traditional teaching methods with innovative e-learning solutions. The attention to adaptive learning and personalized pathways aligns with contemporary educational research advocating for customized learning experiences to address diverse student needs. Continued refinement and expansion of the platform, guided by user feedback and evolving educational needs, will further enhance its effectiveness and reach. This project not only addresses immediate challenges in chemistry education but also sets a precedent for future educational innovations that seek to harmonize traditional and digital learning paradigms. However, further enquiries and visualization of the work done, the platform can be accessed via: https://ilmi.com.ng/ilmi/home-chemistry-department-fce/.

5. Conclusion

The "Bridging the Gap: Combining Traditional Teaching Methods with a Modern E-Learning System for Chemistry Education" project successfully integrated educational technologies into chemistry education, significantly enhancing student engagement and performance. Through comprehensive needs assessments and stakeholder engagement, the platform was tailored to address specific departmental challenges, featuring interactive e-learning modules, videos, simulations, and quizzes. The adaptive learning features and personalized pathways allowed students to learn at their own pace, improving individual outcomes. Discussion boards facilitated collaborative learning and critical thinking. While the project identified areas for improvement, such as increasing out-of-class engagement and expanding course offerings, its success demonstrates the transformative potential of blended learning and provides a valuable model for future educational innovations.

Future Work

Future research should focus on the long-term impact of hybrid learning environments on student performance and engagement in chemistry education by tracking students over several years to assess the sustained effects of blended learning models. Additionally, research should explore optimizing personalized learning pathways within e-learning platforms, identifying the most effective adaptive learning techniques and algorithms to tailor content, pace, and assessments to individual student needs. These studies will build on the "Bridging the Gap" project, aiming to enhance the integration of traditional and modern educational methodologies for more effective and inclusive chemistry education.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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