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The Effectiveness of Blended Learning on Critical Thinking Skills Among Secondary School Students in Chemistry Subject

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Abstract

This study examines the efficacy of blended learning in improving critical thinking abilities in chemistry among secondary school pupils. Blended learning combines traditional in-person teaching with online learning methods, creating an interactive educational approach that encourages active participation, collaborative problem-solving, and self-awareness. This study does a thorough analysis of contemporary academic literature to explore how blended learning impacts critical thinking abilities by examining theoretical frameworks such as constructivism, social cognitive theory, and cognitive load theory. The synthesis and analysis of empirical research investigate the effects of blended learning interventions on students' capacity to interpret chemical ideas, assess experimental data, and make informed judgments. Furthermore, this article examines the many elements that impact the efficacy of blended learning, such as instructional design, technology infrastructure, teacher support, and student motivation. Through the utilization of blended learning and the incorporation of evidence-based teaching methodologies, educators have the ability to enable secondary school students to engage in critical thinking, creative problem-solving, and successful application of their knowledge in the field of chemistry. This paper's findings add to the expanding body of knowledge on blended learning and offer valuable insights for educators, policymakers, and researchers who aim to improve student learning outcomes in secondary school chemistry instruction.

Keywords: Blended Learning, Critical Thinking Skills, Secondary School Students, Personalized Learning, Online Resources.

Introduction

The use of technology into teaching methods has transformed traditional educational approaches, providing new and creative ways to enhance student learning results (Al-

khresheh, 2024). Blended learning is a method that combines traditional in-person teaching with online learning methods, creating a flexible and participatory learning environment (Garrison & Vaughan, 2018). In the field of science education, specifically in chemistry, developing critical thinking abilities in secondary school students is extremely important. These skills are essential for analyzing, evaluating, and combining complicated scientific ideas (Paul & Elder, 2019).

Blended learning offers a great opportunity to improve critical thinking abilities in secondary school pupils while they study chemistry. Through the utilization of digital resources, interactive simulations, and multimedia technologies, educators have the ability to create learning experiences that actively engage the mind, foster curiosity-driven discovery, and facilitate collaborative problem-solving (Zhao, 2023). Furthermore, the adaptable nature of blended learning environments supports a wide range of learning styles and speeds, promoting customized learning experiences that respond to the specific requirements and interests of students (Bonk & Graham, 2019).

The exploration of the effectiveness of blended learning on critical thinking skills among secondary school students in the chemistry subject is of substantial importance. This study intersects critical educational domains, including pedagogical innovation, student cognitive development, and the enhancement of scientific literacy.

Blended learning combines online educational materials and opportunities for interaction online with traditional place-based classroom methods. It requires the physical presence of both teacher and student, with some elements of student control over time, place, path, or pace (Graham, 2019). This integration can transform traditional pedagogical approaches, making education more dynamic and responsive to the needs of modern learners.

Also, blended learning encourages the adoption of varied instructional strategies that can cater to different learning styles. This model supports differentiated instruction, enabling educators to personalize learning experiences and thereby enhance overall teaching effectiveness (Means et al., 2014).

Furthermore, blended learning environments foster active learning, where students engage with content interactively and collaboratively, promoting deeper understanding and retention of complex concepts (Hrastinski, 2019). In chemistry, this can translate to better grasping theoretical concepts and applying them in practical scenarios.

Also, the emphasis on both digital and hands-on learning in blended learning models helps develop students' problem-solving skills. By engaging with diverse learning activities, students can approach problems from multiple perspectives, enhancing their critical thinking abilities (Bliuc et al., 2019).

Blended learning platforms often incorporate multimedia, simulations, and interactive modules, which can significantly increase student engagement and motivation to learn (Dziuban et al., 2018). For secondary school students studying chemistry, this can make learning more appealing and accessible.

Moreover, it can empower students to take control of their own learning journey, promoting self-directed learning and autonomy. This approach can lead to higher levels of motivation and academic achievement (Kintu et al., 2017).

The blended learning model can also offer flexibility in how, when, and where students engage with course material, which can be particularly beneficial for accommodating diverse learning needs and schedules (Garrison & Kanuka, 2017). This is especially relevant in secondary education, where students often juggle multiple subjects and extracurricular activities.

By integrating online resources with traditional instruction, blended learning can also provide a more inclusive educational environment that caters to students with different learning preferences and abilities (Vaughan, 2017).
Researching the effectiveness of blended learning in developing critical thinking skills provides empirical evidence that can inform best practices and guide educational policy. This evidence base is crucial for educators and policymakers seeking to implement effective teaching strategies in STEM education (Redecker & Punie, 2017).
This study can contribute to the body of knowledge on innovative educational practices, helping to identify and disseminate successful blended learning strategies that enhance critical thinking skills in secondary school students (Hwang et al., 2015).
However, the significance of this study lies in its potential to revolutionize educational practices, enhance cognitive skills, and improve student engagement and motivation. By integrating technology with traditional instructional methods, blended learning offers a powerful framework for fostering critical thinking and preparing students for the complexities of modern scientific inquiry.
This study aims to examine the efficacy of blended learning in improving the critical thinking abilities of secondary school students in the field of chemistry. It aims to clarify the influence of blended learning interventions on different aspects of critical thinking in chemistry education. It achieves this by conducting a thorough examination of current literature, empirical studies, and theoretical frameworks. The dimensions of critical thinking that are specifically explored include analysis, inference, evaluation, and application (Alharbi, 2022; Dziuban et al., 2019; Ijirana et al., 2022).
Also, this study aims to enhance the ongoing discussion on the effectiveness of blended learning in fostering critical thinking abilities in secondary school students, specifically in the field of chemistry education, by combining real-world facts with theoretical viewpoints. The connection between blended learning methods and critical thinking skills will provide valuable insights for educators, policymakers, and curriculum developers. This knowledge will assist them in creating instructional approaches that are supported by evidence and promote comprehensive student growth in the era of digital technology.
Moreover, the study seeks to investigate the fundamental mechanisms and instructional practices utilized in blended learning settings to promote critical thinking abilities among secondary school students. These strategies may include incorporating inquiry-based learning activities, collaborative problem-solving tasks, applying chemical principles to real-world situations, and engaging students in metacognitive reflection exercises to improve their awareness of their thinking processes (Vaughan, 2019).

Background of Blended Learning

Blended learning, which combines traditional in-person teaching with online learning methods, has gained significant interest in educational research due to its ability to improve student engagement, learning results, and critical thinking abilities. In the field of chemistry education in secondary schools, the use of blended learning methods shows potential for developing students' skills in critical thinking, scientific analysis, and problem-solving (Kumar et al., 2021). This section presents a theoretical framework that explains the fundamental ideas and methods by which blended learning may successfully enhance critical thinking abilities in secondary school pupils studying chemistry. It will focus on two theories: Cognitive constructivism theory, and social constructivism theory.

Cognitive constructivism is a significant theoretical paradigm that supports the usefulness of blended learning in enhancing critical thinking abilities. According to the source, learning is a dynamic process in which knowledge is built by combining new information with pre-existing mental frameworks (Hammad et al., 2020). Blended learning environments integrate various teaching methods, including direct instruction, interactive simulations, collaborative activities, and online resources. This approach enables students to participate in meaningful learning experiences that stimulate cognitive processes such as analysis, synthesis, and evaluation (Vaughan, 2019). By actively using digital resources and interacting with peers on online platforms, students can build their understanding of chemical principles, apply their knowledge to real-world situations, and develop a metacognitive awareness of their learning processes (Bonk & Graham, 2019).

Social constructivism is another theoretical approach that contributes to the effectiveness of blended learning in enhancing critical thinking abilities. Social constructivism, based on Chatterjee & Correia's work (2020), asserts that learning is fundamentally social and takes place via interactions with others in a collaborative learning community. Blended learning environments facilitate the construction of knowledge through peer collaboration, discussion forums, and group projects. They provide chances for students to engage in debate, negotiate meaning, and collectively build understanding (Garrison & Vaughan, 2018). By engaging in collaborative problem-solving assignments, students can examine other viewpoints, provide logical justifications for their thinking, and evaluate the ideas put forth by their peers. This process helps to improve their critical thinking skills (Dziuban et al., 2019). Incorporating online learning platforms allows students to easily access a wide variety of viewpoints, resources, and multimedia materials. This creates a dynamic learning environment that promotes critical thinking and self-reflection (Eden et al., 2024).

Cognitive constructivism and social constructivism offer useful insights into how blended learning may successfully promote critical thinking abilities among secondary school students studying chemistry. Blended learning environments provide students with many opportunities to acquire knowledge, participate in critical thinking, and build self-awareness by utilizing digital resources, interactive simulations, collaborative activities, and peer contact. By basing instructional approaches on these theoretical viewpoints, educators may create blended learning experiences that enable students to engage in critical thinking, understand scientific concepts, and develop advanced problem-solving skills in the discipline of chemistry.

Issues in Blended Learning

Blended learning, which combines in-person teaching with online learning elements, has become a major educational approach in the digital era. Although blended learning has the potential to greatly improve student involvement, flexibility, and learning outcomes, it also presents problems. Blended learning settings provide several obstacles and issues, including pedagogical, technical, organizational, and logistical hurdles that educators and institutions may face.

An important difficulty in blended learning is to ensure that the training is coherent and aligned across the face-to-face and online components (Garrison & Kanuka, 2017). To ensure consistency in curriculum delivery, assessment techniques, and learning objectives across various modes, meticulous planning and coordination are necessary. Furthermore, educators have a tremendous problem in finding the right balance between utilizing technology and

implementing effective teaching methods to encourage active learning and student involvement (Vaughan, 2019).

Furthermore, the implementation of blended learning programs is hindered by significant technological obstacles. Technical malfunctions, compatibility difficulties, poor infrastructure, and digital literacy gaps among students and teachers might hinder the smooth incorporation of technology into teaching methods (Graham, 2017). It is essential for the success of blended learning programs to provide access to dependable internet connectivity, suitable hardware and software resources, and technical support services (Picciano, 2017).

Furthermore, organizational issues refer to the obstacles posed by institutional hurdles and administrative restraints that might impede the successful execution of blended learning programs (Bates, 2019). Organizational issues commonly encountered by educational institutions aiming to implement blended learning models include resistance to change, insufficient institutional support, bureaucratic obstacles, and limitations in resources (Rumble, 2017). To overcome these problems, it is necessary to have effective leadership, strategic planning, and active involvement of stakeholders to get support from the organization and promote a culture of innovation and cooperation (Garrison & Vaughan, 2018).

Logistical problems in mixed learning contexts refer to practical aspects such as organizing schedules, managing workers, and allocating resources (Oliver, 2019). Ensuring the smooth coordination of synchronous and asynchronous learning activities, effectively managing teacher workload, offering sufficient training and professional development opportunities, and guaranteeing equal access to learning materials are logistical problems that require meticulous consideration (Graham et al., 2019). Furthermore, educators have practical difficulties when it comes to dealing with student motivation, engagement, and responsibility in online learning environments (Vaughan, 2017).

To summarize, blended learning has the capacity to significantly change instructional methods and improve student learning encounters. Nevertheless, it is crucial to tackle the numerous difficulties and problems that are inherent in mixed learning settings in order to guarantee its efficacy and long-term viability. By recognizing and actively dealing with the pedagogical, technological, organizational, and logistical difficulties, educators and institutions may utilize the advantages of blended learning to encourage student achievement and stimulate innovation in education.

The Effectiveness of Blended Learning

The efficacy of blended learning may be comprehended through several theoretical frameworks, such as constructivism, social cognitive theory, and cognitive load theory (Oliver, 2019). Constructivist theories highlight the importance of learners actively constructing knowledge through their engagement with content and peers. They suggest that blended learning environments, which integrate face-to-face interactions with online activities, can enhance deep learning and knowledge construction (Garrison & Kanuka, 2017). Social cognitive theory emphasizes the influence of observational learning and social interaction on learning outcomes. It suggests that blended learning environments, through encouraging collaboration and peer interaction, can enhance the development of critical thinking and problem-solving abilities (Graham et al., 2019). Cognitive load theory highlights the significance of effectively managing cognitive load to enhance learning. It suggests that blended learning environments, through the provision of self-paced learning and multimedia

instruction, can assist learners in effectively managing their cognitive resources (Picciano, 2017).
Empirical research investigating the efficacy of blended learning has produced inconclusive results. Some studies have observed favorable outcomes in terms of student learning and academic accomplishment, while others have discovered no notable distinction when compared to conventional classroom instruction (Graham & Borup, 2019). The success of blended learning is influenced by several factors, including the design of learning activities, the incorporation of technology, the quality of teacher assistance, and student characteristics such as motivation and prior knowledge (Vaughan & Garrison, 2018). The efficacy of blended learning relies on meticulous instructional design, continuous evaluation, and alignment with learning objectives, as stated by (Garrison and Vaughan, 2018). Blended learning has the capability to improve student engagement and enable active learning.
Blended learning is an educational strategy that blends the advantages of in-person teaching with online learning methods. The efficacy of blended learning depends on several elements, such as instructional design, technical infrastructure, and student characteristics. While it has the potential to improve student learning outcomes and engagement, these factors play a crucial role in determining its success. Additional study is required to have a deeper understanding of the circumstances in which blended learning is most successful and to determine the optimal methods for implementing it in various educational settings.

Types of Blended Learning

Blended learning involves combining in-person teaching with online learning methods to create interactive and stimulating learning environments. This approach covers several models and designs. Through comprehending the attributes, benefits, and difficulties linked to various forms of blended learning, educators may make well-informed choices about instructional design and implementation to cater to the requirements of diverse learners and educational settings.
However, there are four main models of blended learning, rotation model, flex model, a La Carte Model and enriched Virtual Model. The rotation model is a methodical timetable in which students alternate between several modes of learning, including in-person instruction, online education, and self-directed study (Yonchai et al., 2023). There are several versions of the rotation model, such as the station rotation, lab rotation, and flipped classroom models. Each of these models focuses on distinct mixes of in-person and online activities to achieve educational objectives (Picciano, 2017).
Conversely, the flex model empowers students to have autonomy over the timing, location, and speed of their education through the provision of online resources and customized learning routes (Bates, 2019). Within the flex model, students frequently engage in self-directed or collaborative work, while teachers assume the role of facilitators and mentors instead of providing direct teaching (Graham et al., 2019).
The a la carte approach enables students to supplement their traditional face-to-face education with online courses or modules, providing them with increased options and flexibility in choosing and scheduling their courses (Vaughan, 2019). The utilization of this paradigm is prevalent in higher education, enabling students to enhance their learning through online courses that may not be accessible on campus (Garrison & Kanuka, 2017).
The enhanced virtual approach combines traditional in-person teaching with online learning, offering students a mix of scheduled classroom instruction and autonomous online study

(Oliver, 2019). This strategy facilitates individualized learning experiences while ensuring consistent communication with educators and classmates (Graham & Borup, 2019).

The Impact of Blended Learning on Critical Thinking Skills

Empirical research investigating the influence of blended learning on critical thinking abilities has shown inconclusive results. Some studies have found favorable benefits on different facets of critical thinking, including argumentation, problem-solving, and metacognitive awareness (Graham et al., 2019). The success of blended learning in promoting critical thinking abilities is influenced by several factors, including the design of learning activities, the incorporation of technology, the quality of teacher assistance, and student characteristics such as motivation and prior knowledge (Garrison & Vaughan, 2018). The efficacy of blended learning in increasing critical thinking abilities relies on meticulous instructional design and alignment with learning objectives, notwithstanding the opportunities it provides for active involvement, individualized learning experiences, and real-world application of information (Dumitru et al., 2023).

Blended learning shows potential as a successful teaching method for developing critical thinking abilities in secondary school pupils (Hasanah, & Malik, 2020). Empirical data indicates that blended learning can enhance critical thinking abilities. However, further study is necessary to comprehend the specific circumstances in which blended learning is most successful and to determine the optimal methods for implementing it in various educational settings. Through the utilization of blended learning and the integration of evidence-based teaching methodologies, educators have the ability to enable students to engage in critical thinking, evaluate information, and effectively solve intricate issues in the digital world (Kumar et al., 2021).

Figure 1 shows the combination of blended learning theories.

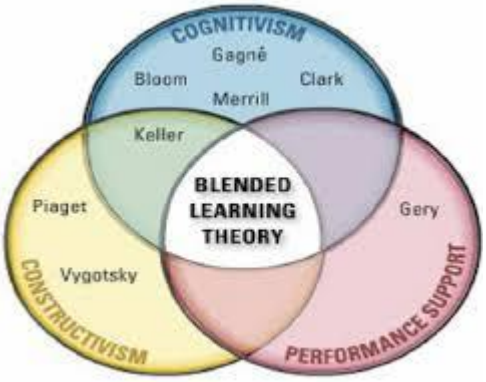

Figure 1: *The Combination of Blended Learning Theories.*
Source: Carman (2005).

Blended learning theories offer a theoretical framework for comprehending the fundamental concepts and mechanisms that contribute to its efficacy. By utilizing theoretical frameworks like constructivism, social cognitive theory, and cognitive load theory, educators may create and execute blended learning environments that encourage significant learning experiences and enhance student achievement.

Conclusion

Overall, incorporating blended learning into secondary school education, specifically for chemistry instruction, shows potential for improving students' critical thinking abilities. This study has examined contemporary scholarly literature and empirical data to demonstrate the potential of blended learning in developing critical thinking abilities, including analysis, evaluation, inference, and reflection. Empirical studies have produced conflicting results on the effectiveness of blended learning in enhancing critical thinking abilities. However, there is agreement that well-planned instructional methods, which are in line with learning goals and teaching principles, are essential for harnessing the transformative power of blended learning.

Theoretical frameworks, such as constructivism and social cognition theory, offer useful insights into how blended learning affects critical thinking abilities. Blended learning settings foster the growth of critical thinking skills by offering chances for active participation, collaboration, and thoughtful contemplation. The efficacy of blended learning is contingent upon several elements such as instructional design, technology infrastructure, instructor support, and student motivation.

In order to fully understand the most effective ways to enhance critical thinking abilities through blended learning, it is necessary to do more study on the ideal design principles, instructional tactics, and technical tools. Long-term research investigating the lasting impacts of blended learning interventions on the development of critical thinking, together with comparison studies of various models and approaches, might offer useful insights into the most effective methods for implementation.

Through the utilization of blended learning and the incorporation of evidence-based teaching methodologies, educators have the ability to enable secondary school students to engage in critical thinking, examine material, and effectively solve intricate issues in the field of chemistry and other areas.

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