INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES
Vol 14, Issue 1, (2024) E-ISSN: 2222-6990

The Effectiveness of Blended Learning on STEM Achievement of Secondary School Students

Ali Abdullah Ali Almarzuqi, Hamidah Mat
Faculty of Educational Studies, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
Email: hamidah22605@gmail.com

To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v14-i1/20140 DOI:10.6007/IJARBSS/v14-i1/20140

Published Date: 13 January 2024

Abstract
This concept paper explores the potential of blended learning as a transformative approach to enhance STEM (Science, Technology, Engineering, and Mathematics) education in secondary schools. Blended learning, integrating online digital resources with traditional classroom instruction, promises to revolutionize the educational landscape. The concept is grounded in the premise that this hybrid model can address diverse learning styles, foster a deeper understanding of complex subjects, and cater to individual student needs more effectively than conventional methods. The paper proposes a comprehensive framework to examine how blended learning impacts student engagement, comprehension, and achievement in STEM subjects. It advocates for a balanced integration of digital tools and face-to-face interaction, emphasizing personalized learning paths, interactive content, and collaborative project-based activities. The paper also delves into the challenges and considerations of implementing blended learning, such as technological accessibility, teacher training, and curriculum design. By providing a theoretical and practical overview, this concept paper aims to guide educators, administrators, and policymakers in developing and implementing effective blended learning strategies to enhance STEM education, thereby preparing students for the demands of the 21st-century workforce. The envisioned outcome is a more engaging, relevant, and effective STEM education that not only improves academic performance but also ignites a lasting interest in these crucial fields.
Keywords: Blended Learning, STEM Education, Secondary School Students, Personalized Learning, Online Resources

Introduction
The effectiveness of blended learning on STEM (Science, Technology, Engineering, and Mathematics) achievement in secondary school students is a topic of significant interest in the educational sector (Ojaleye & Awofala, 2018; Topping et al., 2022). Blended learning, which combines online educational materials and opportunities for interaction online with traditional place-based classroom methods, offers a versatile approach to education. According to Serrano et al (2018) blended learning can increase student engagement by

providing interactive and diverse learning materials. For instance, online simulations, videos, and quizzes can make STEM subjects more engaging and easier to understand. It allows for more personalized education. Students can learn at their own pace, revisiting complex topics and accelerating through areas they find easier. This is especially beneficial in STEM education, where students often have varied levels of proficiency and interest. Several research (Fan & Yu, 2017; Lynch & Ghergulescu, 2017; Trevallion & Trevallion, 2020; Juškevičienė et al., 2021) found that many STEM subjects benefit from practical applications. Blended learning can incorporate virtual labs and simulations, allowing students to apply their knowledge in practical scenarios without the constraints of physical lab space and resources.

Furthermore, the international recognition and increasing popularity of blended learning in STEM education is evident from the growing number of articles and research focusing on technology-based learning, science education, and instructional design (Uzunboylu, 2019). This indicates a global acknowledgment of the potential of blended learning in enhancing STEM education for secondary school students. Blended Learning is a pedagogy model that combines traditional face-to-face learning with online learning elements. This model has been widely discussed as it has the potential to transform education (Eugenijus, 2023). Blended Learning is a paradigm shift that recognizes the transformative role that technology can play in the classroom while maintaining the invaluable aspects of face-to-face learning. “Blended Learning provides students with flexibility and customization,” says (Castro, 2019). “Students can access educational content in the classroom and engage in activities in the virtual realm.” When it comes to STEM education, blended learning offers a dynamic, adaptive, and interactive approach. It accommodates diverse learning needs by recognizing that STEM subjects are often complex and require a wide range of prior knowledge and skills. Blended Learning gives educators the ability to create rich and engaging learning experiences that combine theoretical foundations with real-world applications.

Collaborative projects and discussions are often part of the blended learning approach and are essential for STEM education. Blended learning helps students build teamwork and communication skills that are important for STEM fields (Haryadi et al., 2021). Blended learning provides students with access to a wide range of resources that they may not have access to in a classroom setting. For example, blended learning can provide students with advanced research papers and interactive tools, as well as lectures from experts in their field. It also allows for more immediate, personalized feedback. With online assessments, students can get instant feedback, helping them understand their progress and where they need to improve. In addition, blended learning in STEM prepares students for college and careers, where online collaboration and digital literacy are becoming increasingly important. It can be more cost-effective than traditional methods, especially when it comes to the allocation of resources and the ability to meet the needs of larger and more diverse student populations.

Educators, on the other hand, can use data from online components to enhance their teaching methods and personalise their lessons to their students' requirements, potentially leading to improved academic accomplishment in STEM disciplines. However, problems such as guaranteeing fair access to technology, sustaining student enthusiasm, and providing enough assistance for both students and teachers in navigating the combination of online and in-person learning must be acknowledged.

In conclusion, the effectiveness of blended learning in STEM education for secondary school students is supported by its ability to improve student outcomes, provide personalized learning experiences, and integrate technology into the classroom. The growing international recognition of the importance of technology-based learning and science education further emphasizes the relevance and significance of blended learning in STEM education.

Background of STEM Education

The importance of STEM education has increased significantly because it plays a crucial role in providing students with the necessary information and skills to address the complex issues of modern society. It surpasses conventional disciplinary limits and motivates pupils to adopt a comprehensive approach to problem-solving. The foundation of STEM education lies in tackling practical challenges that frequently necessitate the integration of science, technology, engineering, and mathematics. The primary impetus for STEM education is in the acknowledgment that urgent global challenges, such as climate change, healthcare, and cybersecurity, necessitate interdisciplinary resolutions.

STEM was officially introduced in 1990 by the National Science Foundation (NSF) in the United States (Gonzalez, 2014). The general goal of the education system is to introduce STEM to raise awareness of the importance of science curriculum development in preparation for the needs of the global industry starting from the school level up to the Higher Education Institution (HEIs) level. Furthermore, STEM also received attention from the Technical and Vocational Education (TVE) department in the United States for the application of STEM for career needs. Therefore, two new topics have been introduced to meet the demand in the career industry namely Microelectronics and Pneumatics (Banks & Barlex, 2014). In line to introduce STEM and the importance of applying STEM in the education system to produce more skilled workers to contribute to economic progress and be able to meet the enrollment of skilled professional workers in the STEM field (Bacovic et al., 2022).

The STEM field is the key to employment sources and is an important agenda in the world economic policy to produce more graduates from the professional and vocational sectors of the STEM field (Gough, 2014). The selection of STEM fields in HEIs is a continuation of the formation of students' STEM career interests starting at the secondary school level. In line with that, previous studies (Chachashvili-Bolotin et al., 2016; Fadzil & Saat, 2014) assert that the appropriate time to channel information related to STEM careers among students starts from the secondary school level because at this time, students are active in building their career aspirations as well as becoming aware of learning needs. Preliminary preparations need to be carried out to see the student's progress as a result of the curriculum that has been planned. Therefore, students' awareness of the importance of science towards the formation of STEM career interest starting from secondary level is a preparation for students to continue to be consistently interested in the field of STEM studies up to the HEIs level and then be able to enter the career market.

The STEM field at HEIs level is not a major choice for every student. Some students have chosen the STEM field and changed their studies to other fields because the perception of students for the STEM field is more oriented toward mathematics and science subjects and not clear about career prospects (Denson & Hill, 2010; Wiebe et al., 2018; Baran et al., 2019). In addition, according to Bettencourt et al (2020), students who are less clear about the use of science and STEM knowledge also contribute to students' difficulties in completing coursework well. Therefore, the importance of identifying the learning needs of students from an early stage concerning the importance of science and STEM needs to be given attention so that students' development can be aligned with the needs of the career industry. According to a report from the President's Council of Advisors on Science and Technology, it is predicted that the reduction of STEM graduates will occur by one million graduates over the next decade (Domann, 2020). Therefore, the secondary level is an initial step to ensure that students are more prepared and always consistent to produce quality STEM graduates.

Issues in STEM Education

STEM education faces several critical issues that have garnered attention in recent research. The integrative STEM initiative, which seeks to blend science, mathematics, and engineering with technology education, has emerged as a central focus in the current paradigm shift in education (Karakaş & Hidiroğlu, 2022). This approach aims to address the interdisciplinary nature of real-world problems and prepare students for the complexities of modern challenges. Additionally, the role of students' worldviews in decision-making within the context of socio-scientific issue-based instruction through integrated STEM education has been highlighted as a significant factor influencing students' final science-related decisions (Wahono et al., 2021). This underscores the importance of considering diverse perspectives and societal implications in STEM education to foster informed decision-making and critical thinking skills.

Moreover, the integration of environmental education into STEM education, known as E-STEM, has been identified as having a crucial impact on students' perceptions and their understanding of the engineering design process related to environmental issues (Koculu & Girgin, 2022). This highlights the potential of E-STEM to cultivate students' awareness and knowledge regarding environmental challenges such as plant growth, acid rain, pollution, and sustainable agriculture. By incorporating environmental considerations into STEM education, students can develop a holistic understanding of the interconnectedness between scientific, technological, engineering, and mathematical concepts and their environmental implications.

The importance of STEM receives attention in the education system, especially the emphasis on student awareness to generate students' ability to fill the needs of the future career industry (Gottfried et al., 2016; MOE, 2015). However, the number of student participation in science streams at the high school level continues to decline (Jensen & Sjaastad, 2013; MOE, 2013; Welch et al., 2015; Miller et al., 2018; Sahin & Yilmaz, 2020). The decline in the number of science stream students becomes increasingly critical when the global education system also experiences a decline in the number of students from the secondary level up to the HEIs level (Blankenburg et al., 2016). In line with the report of Akademik Sains Malaysia (2016) showing a declining trend in science students until 2015 (Table 1) further straying from the curriculum development section setting of 60:40 science students to literature students.

Table 1
The ratio of science students to literature students

Aim	Science	Literature
	60	40
1986	31	69
1993	20	80
2001	29	71
2004	36	64
2011	44	56
2014	21	79
2015	30	79

(Source : Akademi Sains Malaysia report, 2016)

These issues underscore the need for a transdisciplinary approach in STEM education that integrates technology, societal perspectives, and environmental considerations. By addressing these critical issues, STEM education can better prepare students to tackle real-world challenges and contribute to sustainable and innovative solutions.

The Concept of Blended Leaning in STEM Education

Blended learning, which integrates face-to-face and online instruction, has become increasingly prevalent in higher education, often referred to as the "new traditional model" or the "new normal" in course delivery (Dziuban et al., 2018). In the context of STEM education, blended learning has shown consistently better effects on knowledge outcomes compared to traditional learning in health education (Vallée et al., 2020). This instructional model has been identified as a promising approach to transforming STEM instruction, as it combines face-to-face instruction with online activities (Owston et al., 2020). Furthermore, it has been associated with improved student performance in STEM subjects, particularly in the context of the Fourth Industrial Revolution (Naidoo & Singh-Pillay, 2020). Blended learning has also been found to be influential in vocational education, demonstrating its versatility across different educational domains (Krismadinata et al., 2020).

In the specific context of STEM, the implementation of blended learning involves a compositional combination of full-scale experiments with the use of digital laboratories, cloud services, and Bring Your Device (BYOD) technologies, highlighting the integration of technology into STEM education (Martyniuk et al., 2021). However, challenges have been identified, particularly in higher education, where the effectiveness of blended learning in physical education is still an area requiring further research and analysis (Wang et al., 2023; Fernández et al., 2021). Despite these challenges, the potential of blended learning in a multidisciplinary but independent curriculum has been recognized, emphasizing the need for pedagogy redevelopment to leverage its benefits fully (Tan et al., 2022).

The COVID-19 pandemic has further emphasized the importance of blended learning, with recommendations for thorough preparation in infrastructure, educator skills, and student readiness to ensure the quality of the learning process and outcomes (Setiadi et al., 2022). Additionally, the effectiveness of blended learning in enhancing critical thinking skills has been demonstrated, particularly when incorporating a STEM education approach (Ardianti et al., 2019). Blended learning has been described as a strategic instructional model developed to meet the challenges of the Fourth Industrial Revolution, aligning with the evolving educational landscape (Noni et al., 2019).

The effectiveness of blended learning in STEM education for secondary school students is supported by its ability to improve student outcomes, provide personalized learning experiences, and integrate technology into the classroom. Additionally, the sustainability of teachers' positive emotions and their perceptions of STEM education contribute to the successful implementation of STEM education in schools.

In summary, blended learning has emerged as a significant instructional model with the potential to enhance student outcomes, particularly in STEM education. Its integration of technology and traditional approaches, along with its adaptability to various educational domains, positions it as a valuable tool for addressing the evolving needs of education in the 21st century.

The Types of Blended Learning in STEM Education

The types of blended learning in STEM education for secondary school students encompass various instructional models that combine traditional face-to-face instruction with online learning resources. Blended learning has been described as an approach that utilizes digital and online resources in addition to conventional face-to-face instruction (Damoah & Omodan, 2022). It involves a combination of direct education (face-to-face), independent learning, and independent online learning (Nurwakhidah & Suganda, 2022). Furthermore, it is an instructional approach where traditional face-to-face instructional time and computer-mediated learning are combined (Sepehri et al., 2018). Blended learning can be course-specific or program-specific, and it is presented as a midway between full face-to-face and online instruction modalities (Achieng' et al., 2021; "Towards an optimal blended learning model during disrupted education periods", 2022). Additionally, it is an educational concept in which a student acquires knowledge both independently online and in person with a teacher (Martyniuk et al., 2021).

Blended learning in STEM (Science, Technology, Engineering, and Mathematics) education involves integrating traditional face-to-face instruction with online learning components. This approach allows for flexibility, personalized learning, and the incorporation of technology to enhance the STEM learning experience. The flipped classroom is an example of the blended learning approach. In a flipped classroom model, traditional lecture and homework elements are reversed (Yavuz & Ozdemir, 2019; Ajmal & Hafeez, 2021). Students engage with pre-recorded video lectures or online resources at home, and class time is dedicated to hands-on activities, discussions, and problem-solving. This model is particularly effective in STEM subjects where practical application is crucial (Lawson et al., 2019).

Another type of blended learning is the Rotation Model. The rotation model involves students moving between different learning modalities, such as face-to-face instruction, online instruction, and small-group activities (Singh et al., 2021). In a STEM context, one rotation might involve direct instruction on a specific concept, another rotation might involve interactive online simulations or labs, and a third rotation might involve collaborative problem-solving.

On the other hand, Station Rotation is also known as one type of blended learning. Like the rotation model, the station rotation model designates specific areas or "stations" in the

classroom for different activities. Students rotate through these stations, engaging in various learning modalities. Stations can include hands-on experiments, online research, group discussions, and teacher-led instruction (Fazal & Bryant, 2019; Rembach et al., 2019). Furthermore, STEM education often involves laboratory work. In a blended learning setting, virtual labs or simulations can be integrated into online components, allowing students to conduct experiments and explore scientific concepts in a digital environment. This provides flexibility in terms of time and resources.
The effectiveness of blended learning in STEM education has been highlighted, with studies indicating its potential to improve student outcomes, provide personalized learning experiences, and integrate technology into the classroom. Blended learning has been recognized as influential in vocational education and has shown promise in transforming STEM instruction (Krismadinata et al., 2020; Owston et al., 2020). Moreover, it has been emphasized that the sustainability of teachers' positive emotions and their perceptions of STEM education contribute to the successful implementation of blended learning in schools.

The process of autonomous learning in blended learning settings has become increasingly important and has changed considerably in the face of new challenges. Autonomous learning and working with the assistance of new information technologies in blended learning contexts have become integral features of societies and their educational systems all over the world.

In conclusion, the type of blended learning in STEM education for secondary school students encompasses a diverse range of instructional models that integrate traditional and online learning modalities. The potential of blended learning to enhance student outcomes and transform STEM instruction underscores its significance in modern education.

The Impact of Blended Learning on STEM Education

Blended learning has been widely studied and practiced as an effective method for improving learning experiences and outcomes in higher education (Huang & Lee, 2022). In the context of vocational education, it is highly influential, demonstrating its versatility across different educational domains (Krismadinata et al., 2020). Furthermore, teachers' perceptions of using blended learning for STEM-related subjects have been recognized as relevant, particularly in the context of the Fourth Industrial Revolution (Naidoo & Singh-Pillay, 2020). The educational direction of STEM in the implementation of blended teaching of physics highlights the integration of technology into STEM education, emphasizing the potential of blended learning in this domain (Martyniuk et al., 2021). Additionally, the use of a blended learning approach based on STEM education has been shown to improve critical thinking skills in students (Ardianti et al., 2019). Moreover, blended learning in the science classroom has been identified as a tool for developing 21st-century skills, such as critical thinking and problem-solving, which are essential for students in various contexts (Washington, 2020).

Conversely, blended learning frequently integrates multimedia components, simulations, and interactive material, enhancing student engagement during the learning process. Online components enable students to advance at their own speed, accommodating unique learning styles and interests (El-Sabagh, 2021). In addition, blended learning offers a diverse range of resources, including films, simulations, and interactive modules, which cater to various learning styles and enhance comprehension through several modes of learning. In addition, blended learning facilitates the broader availability of a plethora of educational resources, empowering students to delve into supplementary materials that might augment their comprehension of STEM ideas. Online components encompass tangible illustrations, case studies, and pragmatic implementations, facilitating students in bridging academic knowledge with real-life situations.

Furthermore, blended learning allows students to easily access materials and resources from any location, promoting flexibility and accommodating various learning schedules (Alkhatib, 2018). Many blended learning platforms utilise adaptive technology to personalise information according to each student's proficiency, ensuring that they are provided with appropriate challenges and support. Blended learning often integrates collaborative tools that facilitate communication and collaboration among students, fostering a feeling of community (Al-Samarraie & Saeed, 2018). Online systems enable improved teacher-student interaction by utilising discussion boards, chat sessions, and video conferencing. Online examinations and quizzes provide immediate feedback to students, helping them to identify their areas of weakness and allowing teachers to tailor their instruction accordingly (Xiong & Suen, 2018). Teachers can employ data analytics obtained from online platforms to track student progress and adjust teaching methods based on individual or group performance. The effectiveness of blended learning depends on intentionally integrating online and in-person components, ongoing professional development for teachers, and thoughtful consideration of the distinct needs and characteristics of the student population. Moreover, ongoing research is being carried out in this domain, and the impact of blended learning may vary based on the specific implementation and context.

Theoretical suggestions related to blended learning
Intrinsic Motivation Theory (Amabile, 1996)
Intrinsic motivation theory, as proposed by Amabile (1996), emphasizes the importance of internal drives and personal enjoyment in fostering creativity and innovation in organizational settings. This theory aligns with the concept of means-ends fusion (Locke & Schattke, 2019), which suggests that intrinsic motivation arises from the perceived alignment of an activity with its associated goal. Furthermore, the MEF theory expands the understanding of intrinsic motivation beyond traditional engagement, highlighting its various manifestations (Kruglanski, 2018).

Amabile's theory also underscores the detrimental effects of extrinsic motivators on creativity, emphasizing the positive impact of intrinsic motivation on employee creativity (Nili & Tasavori, 2022). This aligns with the cognitive evaluation theory, which suggests that external events can shape intrinsic motivation (Siddiqui & Rida, 2019). Additionally, the Self-Determination Theory (SDT) is considered comprehensive for understanding intrinsic motivation, addressing the shortcomings of need theories, and predicting behavior through intrinsic motivation (Takeda et al., 2018; Nientied & Toska, 2019).

The role of intrinsic motivation in driving performance, particularly in project management, has gained attention, with research exploring its connection to the Self-Determination Theory (Szulawski et al., 2021). Moreover, the cognitive evaluation theory has operationalized extrinsic and intrinsic motivation as perceived usefulness and enjoyment, respectively (Lamanauskas et al., 2021). Amabile's componential model of organizational creativity emphasizes the contextual components essential for fostering creativity, such as autonomy, freedom, and organizational support (Hirudayaraj & Matić, 2021). This is further supported by the recognition of the value creation process and its link to the creative environment in organizations (Boisjoly, 2021; Timotheou & Ioannou , 2021).

The function of motivation is essential in determining the success of students in STEM areas. Intrinsic motivation refers to the innate drive to acquire knowledge and actively participate in STEM disciplines driven by personal fulfilment and curiosity. Research conducted by Ahmed et al. (2018) and Gottfried (2020) demonstrates a robust correlation between intrinsic drive and academic performance, particularly in STEM disciplines. This stems from extrinsic rewards or external pressures, such as high academic achievements or professional ambitions. Although not as preferable as intrinsic motivation, extrinsic incentive can nevertheless promote involvement and exertion, as evidenced by studies such as Reeve and Deci's (2018) research. Inquiry-based learning, which involves open-ended inquiries that encourage students to investigate, question, and discover, can enhance intrinsic motivation by harnessing their innate curiosity and sense of agency (Aydogdu & Yalvac, 2022). Project-based learning involves engaging students in real-world projects that aim to solve issues or generate solutions. This approach encourages students to recognise the practicality of STEM subjects in their daily lives and apply their knowledge in meaningful ways. As a result, it enhances both their intrinsic and extrinsic motivation (Martins et al., 2021). An affirming classroom atmosphere that promotes safety, support, and inclusivity cultivates students' self-assurance and desire to engage in challenging tasks, hence bolstering their motivation (Patrick et al., 2023). Facilitating mentorship and providing role models for students in STEM areas offers them inspiration, advice, and a sense of potential, especially for marginalised groups (Hernandez et al., 2022). Customised education that adapts instruction to the specific needs and interests of individuals enhances the level of engagement and relevance in learning, hence promoting intrinsic motivation (Rathore et al., 2021). It is imperative to motivate secondary school students in order to enhance their achievement in STEM. Educators can foster a passion for STEM and enhance academic performance, increase engagement, and promote a promising future in these critical fields by comprehending various forms of motivation and implementing successful techniques such as inquiry-based learning and creating positive classroom atmospheres.

In summary, Amabile's intrinsic motivation theory, in conjunction with related theories such as the Self-Determination Theory and means-ends fusion, provides a comprehensive framework for understanding the impact of intrinsic motivation on creativity and innovation in organizational settings.

The Cognitive Theory of Multimedia Learning (Mayer & Moreno, 2002)

The Cognitive Theory of Multimedia Learning (CTML) is a result of merging the cognitive load theory with constructivist learning theory, as proposed by Mayer and Moreno in 2002. The cognitive theory of multimedia learning elucidates the process by which individuals acquire knowledge from both written and visual information, drawing upon the dual coding theory, which encompasses the visual and verbal models (Mayer, 2010). Nevertheless, cognitive load theory posits that the human brain has a limited capacity to process information from various mental channels (Sepp et al., 2019; Ba et al., 2021).

As per the cognitive paradigm of multimedia learning, meaningful learning occurs when students can verbally or visually choose relevant material and begin to reorganise it in their working memories (Callahan et al., 2019; Ginting et al., 2021). The integration of visuals and written content should enhance the multimedia presentation and assist students in simplifying complex subjects. Therefore, this combination ultimately enables pupils to merge their newly acquired information with their existing knowledge. Ultimately, a novel condition of understanding is established, which will bestow a fresh significance upon the existing circumstance. The correlation between verbal and visual representation can enhance learners' ability to remember material in their long-term memory for an extended period. Figure 1 shows The Combination of Intrinsic motivation theory and Cognitive Theory of Multimedia Learning.

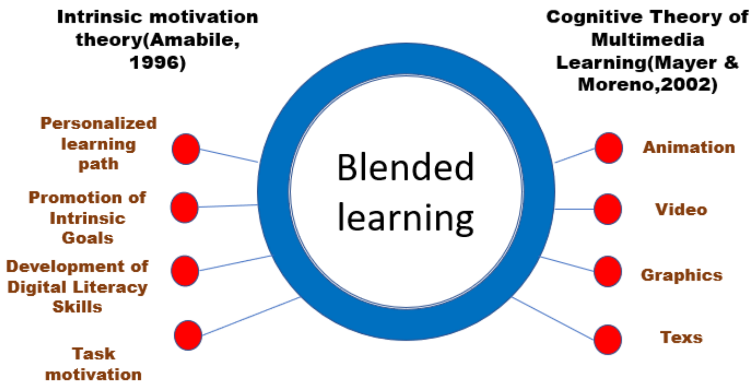

Figure 1: *The Combination of Intrinsic motivation theory and Cognitive Theory of Multimedia Learning*

Combining multimedia cognitive theory and intrinsic motivation theory in the context of blended learning can have several significant impacts, enhancing the overall educational experience. Blended learning typically involves a mix of traditional face-to-face instruction and online learning components. According to Serrano et al (2019) multimedia elements, when integrated into both face-to-face and online components, can increase engagement levels. Interactive multimedia content, such as videos, simulations, and interactive presentations, can captivate learners' attention and maintain interest. Moreover, blended learning inherently provides a degree of flexibility, allowing students to engage with content at their own pace and time (Glazer, 2023). The integration of multimedia supports this flexibility, offering learners autonomy in choosing how they interact with the material. Not only that, leveraging multimedia in both online and offline settings aligns with cognitive theories that suggest presenting information through multiple channels enhances learning and information processing. Students can benefit from a variety of multimedia resources during both in-person and online sessions.

On the other hand, blended learning, combined with multimedia elements, enables the creation of personalized learning paths. Students can access multimedia content that aligns with their preferences and learning styles, contributing to intrinsic motivation (Ali, et al., 2023). Multimedia content can be used to reinforce concepts introduced during face-to-face sessions. For instance, online modules with multimedia elements can serve as resources for review and practice, providing continuous engagement with the material. Furthermore, blended learning can be designed to emphasize the intrinsic value of learning (Cronje, 2020). Multimedia elements can contribute to creating a positive and enjoyable learning experience, aligning with intrinsic motivation principles. Blended learning environments also can integrate multimedia elements into assessment methods. For example, students might create multimedia projects to demonstrate their understanding, fostering creativity and intrinsic motivation. Multimedia resources can be made accessible online, allowing students to revisit content as needed. This accessibility supports the principles of both theories by providing resources that can be engaged with at any time, reinforcing learning and motivation.

Conversely, blended learning, particularly when incorporating multimedia elements, contributes to the development of digital literacy skills. Students learn to navigate and critically evaluate multimedia content, aligning with cognitive development and intrinsic motivation. Multimedia can be used to bridge the gap between theoretical concepts covered in face-to-face sessions and real-world applications (Jalinus, 2021). Blended learning can integrate multimedia case studies, simulations, or virtual experiences that enhance the relevance and practicality of the content. In summary, the combination of multimedia cognitive theory and intrinsic motivation theory in blended learning creates a dynamic and engaging educational environment. However, successful implementation requires careful consideration of instructional design principles, learner preferences, and the integration of multimedia resources that align with the learning objectives.

Conclusion

Blended Learning offers an innovative approach to STEM education that aligns with the needs and expectations of modern learners. This instructional technique is distinguished by its dynamic and adaptable nature, which allows educators to actively engage students, foster interdisciplinary learning, and provide them with the essential skills and knowledge to confront future challenges and opportunities. By employing innovative techniques in Blended Learning, educators, institutions, and researchers may collectively contribute to the progress and enhancement of STEM education.

Acknowledgement

The authors are thankful to all those who participated in the study and helped to accomplish the research process.

Corresponding Author

Hamidah Mat

Faculty of Educational Studies, University Putra Malaysia, Malaysia

Email : hamidah22605@gmail.com

References

Ahmed, S., Minnaert, A., & Van de Wyer, M. (2018). Intrinsic motivation, task value, and achievement in secondary STEM education. Learning and Instruction, 56, 81-97.

Ajmal, S. F., & Hafeez, M. (2021). Critical Review on Flipped Classroom Model Versus Traditional Lecture Method. International Journal of Education and Practice, 9(1), 128-140.

Alkhatib, O. J. (2018). An interactive and blended learning model for engineering education. Journal of Computers in Education, 5(1), 19-48.

Al-Samarraie, H., & Saeed, N. (2018). A systematic review of cloud computing tools for collaborative learning: Opportunities and challenges to the blended-learning environment. Computers & Education, 124, 77-91.

Ali, A., & Rauf, M. B. (2023). Designing A Blended Learning Model for Public Sector Universities of Pakistan. Voyage Journal of Educational Studies, 3(4), 94-118.

Amabile, T. M. (1996). Creativity in Context. Boulder, CO: Westview.

Ardianti, S., Sulisworo, D., & Pramudya, Y. (2019). Efektivitas blended learning berbasis pendekatan stem education berbantuan schoology untuk meningkatkan critical thinking skill pada materi fluida dinamik. Prosiding Seminar Nasional Pendidikan Kaluni, 2. https://doi.org/10.30998/prokaluni.v2i0.67

Aydogdu, M., & Yalvac, B. (2022). The effect of inquiry-based learning on students' achievement and motivation in science education. Education and Human Sciences, 14(2), 329-342.

Ba, S., Stein, D., Liu, Q., Long, T., Xie, K., & Wu, L. (2021). Examining the effects of a pedagogical agent with dual-channel emotional cues on learner emotions, cognitive load, and knowledge transfer performance. Journal of Educational Computing Research, 59(6), 1114-1134.

Bacovic, M., Andrijasevic, Z., & Pejovic, B. (2022). STEM education and growth in Europe. Journal of the Knowledge Economy, 13(3), 2348-2371.

Banks, F., & Barlex, D. M. (2014). Beyond the subject silos in STEM–the case for ‘looking sideways' in the secondary school curriculum.

Baran, E., Canbazoglu Bilici, S., Mesutoglu, C., & Ocak, C. (2019). The impact of an out-of-school STEM education program on students’ attitudes toward STEM and STEM careers. School Science and Mathematics, 119(4), 223-235.

Blankenburg, J. S.,Höffler, T.N.,&Parchmann, I. (2016). Fostering today what is needed tomorrow: Investigatingstudents’interestsinscience.ScienceEducation,100,364–391.

Bettencourt, G. M., Manly, C. A., Kimball, E., & Wells, R. S. (2020). STEM degree completion and first-generation college students: A cumulative disadvantage approach to the outcomes gap. The Review of Higher Education, 43(3), 753-779.

Boisjoly, R. (2021). Recognition of Value: A Critical Step in the Value Creation Process.

Callahan, C., Howell, J. B., & Maddox, L. E. (2019). Selecting and designing visual curriculum materials for inquiry-based instruction. Social Studies Research and Practice, 14(3), 321-334.

Castro, R. (2019). Blended learning in higher education: Trends and capabilities. Education and Information Technologies, 24(4), 2523-2546.

Chachashvili-Bolotin, S., Milner-Bolotin, M., & Lissitsa, S. (2016). Examination of factors predicting secondary students’ interest in tertiary STEM education. International Journal of Science Education, 38(3): 366–390. http://doi.org/10.1080/09500693.2016.1143137

Cronje, J. C. (2021). Covid-19 Policy Implications for Blended Learning in Higher Education in the Fourth Industrial Revolution. Progressio, 41(1), 16-pages.

Domann, M. (2020). Los Angeles County Public Works’ STEM Outreach Program and Female Students’ Decision to Pursue a Degree in STEM (Doctoral dissertation, California State University, Northridge).

Denson, C. D., & Hill, R. B. (2010). Impact of an engineering mentorship program on African-

American male high school students’ perceptions and self-efficacy. Journal of Industrial Teacher Education, 47(1): 99-127.

Dziuban, C., Graham, C., Moskal, P., Norberg, A., & Sicilia, N. (2018). Blended learning: the new normal and emerging technologies. International Journal of Educational Technology in Higher Education, 15(1). https://doi.org/10.1186/s41239-017-0087-5

El-Sabagh, H. A. (2021). Adaptive e-learning environment based on learning styles and its impact on development students' engagement. International Journal of Educational Technology in Higher Education, 18(1), 1-24.

Eugenijus, L. (2023). Integrating Blended Learning and STEM Education: Innovative Approaches to Promote Interdisciplinary Learning. Research and Advances in Education, 2(9), 20-36.

Fan, S. C., & Yu, K. C. (2017). How an integrative STEM curriculum can benefit students in engineering design practices. International Journal of Technology and Design Education, 27, 107-129.

Fazal, M., & Bryant, M. (2019). Blended learning in middle school math: The question of effectiveness. Journal of Online Learning Research, 5(1), 49-64.

Fernández, I., Burgueño, R., & Gil-Espinosa, F. (2021). High school physical education teachers’ perceptions of blended learning one year after the onset of the covid-19 pandemic. International Journal of Environmental Research and Public Health, 18(21), 11146. https://doi.org/10.3390/ijerph182111146

Ginting, D., Barella, Y., Linarsih, A., & Woods, R. (2021, November). Emergency remote teaching practices in the perspective of cognitive load of multimedia learning theory. In 1st International Conference of Education, Social and Humanities (INCESH 2021) (pp. 96-106). Atlantis Press.

Glazer, F. S. (Ed.). (2023). Blended learning: Across the disciplines, across the academy. Taylor & Francis.

Gonzalez, H. B. (2014). The National Science Foundation: Background and Selected Policy Issues. Washington, DC: Congressional Research Service.

Gottfried, A. E., Preston, K. S. J., Gottfried, A. W., Oliver, P. H., Delany, D. E., & Ibrahim, S. M. (2016). Pathways from parental stimulation of children’s curiosity to high school science course accomplishments and science career interest and skill. International Journal of Science Education, 38(12): 1972–1995. http://doi.org/10.1080/09500693.2016. 1220690

Gottfried, A. E. (2020). Intrinsic motivation and the adolescent student. In Handbook of youth and adolescence (pp. 56-75). Springer, Cham.

Gough, A. (2014). STEM policy and science education: scientistic curriculum and sociopolitical silences. Springer Journal, 10(14): 234-256. http://doi.org/10. 1007/s11422-014-9590-3

Haryadi, R., Situmorang, R., & Khaerudin, K. (2021). Enhancing Students' High-Order Thinking Skills through STEM-Blended Learning on Kepler's Law During Covid-19 Outbreak. Jurnal Penelitian Dan Pembelajaran IPA, 7(2), 168-192.

Herman, L., Adnan, A., & Yurniwati, Y. (2021). Effect of blended learning on students' learning outcomes: a meta-analysis. Jurnal Pendidikan Progresif, 11(2), 309-325. https://doi.org/10.23960/jpp.v11.i2.202113

Hernandez, P. R., Paolillo, J. G., & Su, R. (2022). Fostering STEM identity through mentor programs: A review of the literature. Review of Educational Research, 92(2), 206-255.

Hirudayaraj, M., & Matić, J. (2021). Leveraging human resource development practice to enhance organizational creativity: A multilevel conceptual model. Human Resource Development Review, 20(2), 172-206.

Hsu, R., and Tsai, T. (2022). Assessing the impact of a project-based learning robotics course with integrating of stem education using content analysis method. European Journal of Stem Education, 7(1), 09. https://doi.org/10.20897/ejsteme/12633

Huang, Q., and Lee, V. (2022). Exploring first-year university students' blended learning experiences during the covid-19 through the community of inquiry model. International Journal of Information and Learning Technology, 39(4), 373-385. https://doi.org/10.1108/ijilt-02-2022-0024

Jalinus, N. (2021). Developing blended learning model in vocational education based on 21st century integrated learning and industrial revolution 4.0. Turkish Journal of Computer and Mathematics Education (TURCOMAT), 12(8), 1239-1254.

Jensen, F., & Sjaastad, J. (2013). a Norwegian Out-of-School Mathematics Project'S Influence on Secondary Students' Stem Motivation. International Journal of Science and Mathematics Education, 11(6): 1437–1461. http://doi.org/10.1007/s10763-013-9401-4

Juškevičienė, A., Dagienė, V., & Dolgopolovas, V. (2021). Integrated activities in STEM environment: Methodology and implementation practice. Computer Applications in Engineering Education, 29(1), 209-228.

Karakaş, A. and Hidiroğlu, Ç. (2022). Transdisciplinary role of technology in stem education. Malaysian Online Journal of Educational Technology, 10(4), 276-293. https://doi.org/10.52380/mojet.2022.10.4.411

Kelley, T., and Knowles, J. (2016). A conceptual framework for integrated stem education. International Journal of Stem Education, 3(1). https://doi.org/10.1186/s40594-016-0046-z

Koculu, A., and Girgin, S. (2022). The effect of e-stem education on students' perceptions and engineering design process about environmental issues. World Journal of Education, 12(6), 49. https://doi.org/10.5430/wje.v12n6p49

Krismadinata, K., Verawardina, U., Jalinus, N., Rizal, F., Sukardi, S., Sudira, P., … &

Novaliendry, D. (2020). Blended learning as instructional model in vocational education: literature review. Universal Journal of Educational Research, 8(11B), 5801-5815. https://doi.org/10.13189/ujer.2020.082214

Kruglanski, A. W. (2018). Violent radicalism and the psychology of prepossession. Social Psychological Bulletin, 13(4), 1-18.

Lamanauskas, V., Makarskaitė-Petkevičienė, R., Gorghiu, G., Manea, V., & Pribeanu, C. (2021). Extrinsic and intrinsic motivation in online education during the pandemic as perceived by lithuanian and romanian university students. https://doi.org/10.37789/rochi.2021.1.1.23

Tahunan, L. (2016). Akademi Sains Negara. Malaysia

Lawson, A., Davis, C., & Son, J. (2019). Not all flipped classes are the same: Using learning science to design flipped classrooms. Journal of the Scholarship of Teaching and Learning, 19(5).

Lian, Y., Tsang, K., & Zhang, Y. (2021). The construction and sustainability of teachers' positive emotions toward stem educational work. Sustainability, 13(11), 5769. https://doi.org/10.3390/su13115769

Locke, E. A., & Schattke, K. (2019). Intrinsic and extrinsic motivation: Time for expansion and clarification. Motivation Science, 5(4), 277.

Lynch, T., & Ghergulescu, I. (2017). Review of virtual labs as the emerging technologies for teaching STEM subjects. INTED2017 proceedings, 6082-6091.

Martins, A., Costa, C., & Santos, M. (2021). Project-based learning in STEM education: A systematic literature review. International Journal of Technology in Education and Science, 5(4

Martyniuk, O., Martyniuk, O., ПАНКЕВИЧ, С., & Muzyka, I. (2021). Educational direction of stem in the system of realization of blended teaching of physics. Educational Technology Quarterly, 2021(3), 347-359. https://doi.org/10.55056/etq.39

Miller, K., Sonnert, G., & Sadler, P. (2018). The influence of students' participation in STEM competitions on their interest in STEM careers. International Journal of Science Education, Part B, 8(2), 95-114.

Ministery of Education (MOE). (2013). Pelan Pembangunan Pendidikan Malaysia (PPPM 2013-2025).

Ministery of Education (MOE). (2015). Pembelajaran abad ke-21: Amalan dan Pelaksanaan di sekolah. Buletin Anjakan: Buletin Transformasi Pendidikan Malaysia 2013–2016. http://www.padu.edu.my/files/Anjakan_Bil_4_(2015)_Final.pdf.

Mutakinati, L., Anwari, I., & Kumano, Y. (2018). Analysis of students' critical thinking skill of middle school through stem education project-based learning. Jurnal Pendidikan Ipa Indonesia, 7(1), 54-65. https://doi.org/10.15294/jpii.v7i1.10495

Naidoo, J., and Singh-Pillay, A. (2020). Teachers' perceptions of using the blended learning approach for stem-related subjects within the fourth industrial revolution. Journal of Baltic Science Education, 19(4), 583-593. https://doi.org/10.33225/jbse/20.19.583

Nientied, P., & Toska, M. (2019). Motivation of knowledge workers–the case of albania. Organizacija, 52(1), 33-44.

Nili, F., & Tasavori, M. (2022). Linking an autonomy-supportive climate and employee creativity: The influence of intrinsic motivation and company support for creativity. European Business Review, 34(5), 666-688.

Noni, N., Jabu, B., Basri, M., Ziska, I., Agung, M., Mas'ud, B., & Dangnga, M. (2019). Need analysis to design blended learning model: an instructional design to create a dynamic, engaging and student-centered learning environment.. https://doi.org/10.2991/icamr-18.2019.19

Novaliendry, D. (2020). Blended learning as instructional model in vocational education: literature review. Universal Journal of Educational Research, 8(11B), 5801-5815. https://doi.org/10.13189/ujer.2020.082214

Ojaleye, O., & Awofala, A. O. (2018). Blended Learning and Problem-Based Learning Instructional Strategies as Determinants of Senior Secondary School Students' Achievement in Algebra. International Journal of Research in Education and Science, 4(2), 486-501.

Owston, R., York, D., Malhotra, T., & Sitthiworachart, J. (2020). Blended learning in stem and non-stem courses: how do student performance and perceptions compare?. Online Learning, 24(3). https://doi.org/10.24059/olj.v24i3.2151

Putra, P., Ahmad, N., Wahyuni, S., & Narulita, E. (2021). Analysis of the factors influencing of pre-service science teacher in conceptualization of stem education: self-efficacy and content knowledge. Jurnal Penelitian Pendidikan Ipa, 7(SpecialIssue), 225-230. https://doi.org/10.29303/jppipa.v7ispecialissue.877

Rahman, Z., Rijanto, T., Basuki, I., & Sumbawati, M. (2020). The implementation of blended learning model on motivation and students' learning achievement. International Journal for Educational and Vocational Studies, 2(9).

https://doi.org/10.29103/ijevs.v2i9.2694

Rathore, A. S., Sharma, A., & Massoudi, M. (2021). Personalized Engineering Education Model Based on Artificial Intelligence for Learning Programming. In 2021 6th International Conference on Computing, Communication and Security (ICCCS) (pp. 1-10). IEEE.

Sahin, D., & Yilmaz, R. M. (2020). The effect of Augmented Reality Technology on middle school students' achievements and attitudes towards science education. Computers & Education, 144, 103710.

Sepp, S., Howard, S. J., Tindall-Ford, S., Agostinho, S., & Paas, F. (2019). Cognitive load theory and human movement: Towards an integrated model of working memory. Educational Psychology Review, 31, 293-317.

Serrano, D. R., Dea-Ayuela, M. A., Gonzalez-Burgos, E., Serrano-Gil, A., & Lalatsa, A. (2019). Technology-enhanced learning in higher education: How to enhance student engagement through blended learning. European Journal of Education, 54(2), 273-286.

Setiadi, D. (2022). The management of blended learning during covid 19 pandemic of private senior high school in narmada., 388-394. https://doi.org/10.2991/978-2-494069-21-3_42

Siddiqui, D. A. (2019). Impact of motivation on employees performance in Pakistan. Business Management and Strategy, 10(1), 1-22.

Singh, J., Steele, K., & Singh, L. (2021). Combining the best of online and face-to-face learning: Hybrid and blended learning approach for COVID-19, post vaccine, & post-pandemic world. Journal of Educational Technology Systems, 50(2), 140-171.

Sunardi, J., Geok, S., Komarudin, K., Yuliarto, H., & Meikahani, R. (2021). Effect of blended learning, motivation, study hour on student learning achievement. Jurnal Keolahragaan, 9(2), 168-177. https://doi.org/10.21831/jk.v9i2.40508

Szulawski, M., Kaźmierczak, I., & Prusik, M. (2021). Is self-determination good for your effectiveness? A study of factors which influence performance within self-determination theory. PLoS One, 16(9), e0256558.

Takeda, K., Sumiyoshi, T., Matsumoto, M., Murayama, K., Ikezawa, S., Matsumoto, K., & Nakagome, K. (2018). Neural correlates for intrinsic motivational deficits of schizophrenia; implications for therapeutics of cognitive impairment. Frontiers in Psychiatry, 9, 178.

Tan, C., Zakuan, N., & Aziz, M. (2022). Recent trends of blended learning and flipped classroom in malaysia. Arab World English Journal, (2), 290-301. https://doi.org/10.24093/awej/covid2.19

Timotheou, S., & Ioannou, A. (2021). Collective creativity in STEAM Making activities. The Journal of Educational Research, 114(2), 130-138.

Topping, K. J., Douglas, W., Robertson, D., & Ferguson, N. (2022). Effectiveness of online and blended learning from schools: A systematic review. Review of Education, 10(2), e3353.

Trevallion, D., & Trevallion, T. (2020). STEM: Design, implement and evaluate. International Journal of Innovation, Creativity and Change, 14(8), 1-19.

Uzunboylu, H. (2019). Editorial. New Trends and Issues Proceedings on Humanities and Social Sciences, 6(5). https://doi.org/10.18844/prosoc.v6i5.4381

Vallée, A., Blacher, J., Cariou, A., & Sorbets, E. (2020). Blended learning compared to traditional learning in medical education: systematic review and meta-analysis. Journal of Medical Internet Research, 22(8), e16504. https://doi.org/10.2196/16504

Wahono, B., Narulita, E., Chang, C., Darmawan, E., & Irwanto, I. (2021). The role of students' worldview on decision-making: an indonesian case study by a socio-scientific issue-based instruction through integrated stem education. Eurasia Journal of Mathematics Science and Technology Education, 17(11), em2027. https://doi.org/10.29333/ejmste/11246

Wang, C., Dev, R., Soh, K., Nasirudddin, N., Yuan, Y., & Ji, X. (2023). Blended learning in physical education: a systematic review. Frontiers in Public Health, 11. https://doi.org/10.3389/fpubh.2023.1073423

Wiebe, E., Unfried, A., & Faber, M. (2018). The relationship of STEM attitudes and career interest. EURASIA Journal of Mathematics, Science and Technology Education, 14(10).

Xiong, Y., & Suen, H. K. (2018). Assessment approaches in massive open online courses: Possibilities, challenges and future directions. International Review of Education, 64(2), 241-263.

Yavuz, F., & Ozdemir, S. (2019). Flipped Classroom Approach in EFL Context: Some Associated Factors. World Journal on Educational Technology: Current Issues, 11(4), 238-244.