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Factors influencing the effectiveness of blended learning activities: A case study of Vietnam National University, Hanoi

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Abstract Blended learning (BL) is an increasingly important pedagogical approach that combines traditional classroom instruction with digital resources to enhance student engagement and learning experiences. This study aims to evaluate the factors that influence the effectiveness of teaching activities in a BL model. Four groups of factors with a total of 20 sub-factors are considered, including lecturer-related factor (6 sub-factors), student-related factor (6 sub-factors), organizational factor (4 sub-factors), and technology factor (4 sub-factors). To collect data, this study conducted interviews with experts and managers who have extensive experience in managing training activities at Vietnam National University, Hanoi. The generalized fuzzy analytic hierarchy process (AHP) method is applied to evaluate the effectiveness of BL activities at VNU-Hanoi. The results revealed that lecturer-related factors have the most significant impact on the effectiveness of BL activities at VNU-Hanoi, followed by technology, organizational, and student-related factors. These findings highlight the importance of supporting and preparing lecturers to deliver effective BL experiences.

Keywords: blended learning, fuzzy AHP, generalized fuzzy numbers, VNU-Hanoi

1. Introduction

Blended learning (BL) is defined as the combination of face-to-face and online learning (Williams 2002). BL is considered a mix of traditional teaching methods (face-to-face in the classroom) and technology to support learning (information technology and internet communication), leading to reduced classroom time (Garrison et al 2002). BL can also be described as a combination of online instruction and classroom-based guidance to organize and support learning activities (Boelens et al 2015). With BL, the lecturer will guide part of the learning, and the rest will be done online without the lecturer, making students more active and familiar with new concepts than passive learning in traditional classrooms.

Over the past decade, BL has emerged as a global trend in the context of education (Allen and Seaman, 2006). BL is increasingly being widely used in higher education in many countries because it has advantages of both traditional and online teaching methods (Graham 2004; Harding et al 2005; Poon 2014). These advantages include greater flexibility (Macedo-Rouet et al 2009) and cost savings (Harding et al 2005) compared to traditional classes (Woltering et al 2009), especially when teaching a large number of students. Some previous studies have shown that the BL approach increases student engagement and learning experience because it has a positive impact on students' perception of teaching methods and learning platforms (Edward et al 2018; Ghazal et al 2018; Alebaikan and Troudi 2010; Gomez and Igado 2008; Graham 2007; Garrison and Kanuka 2004). BL emphasizes learning as well as teaching, thus creating conditions for students to participate more in the learning process, become more enthusiastic, and therefore improve their persistence and commitment (Ismail et al 2018, López-Pérez et al 2011).

University education has many characteristics that are suitable for implementing BL, such as the students' level of information technology, highly qualified lecturers, and easy access to technology. Currently, there are many studies on the factors affecting the effectiveness of teaching according to the BL model at universities. Al-Busaidi and Al-Shihi (2011) and Babic (2012) studied the factors related to satisfaction and acceptance of the use of BL by lecturers. In which, they focused on studying the impact of factors related to the individual characteristics of lecturers (concerns about computer use, technology experience, personal innovation), LMS system characteristics (system quality, information quality, service quality), and organizational characteristics (management support, incentive policies, training). According to Babic (2012), in addition to the factors related to lecturers, there are also factors related to the characteristics of students and the organization that affect the

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effectiveness of teaching according to the BL model at universities. Studies increasingly focus on the factors of lecturers as an intrinsic motivator (Ibrahim and Nat 2019; Wang and Ma 2020). However, the effective use of BL in the university education environment is a combination of many different factors related to human (lecturers and students), organization, and technology (Ma'arop et al 2016).

Recent studies have used the UTAUT2 model developed by Venkatesh et al (2003) to evaluate the factors influencing the successful implementation of BL in higher education (Azizi et al 2020; Apandi and Raman 2020). This model focuses on factors related to the intention and behavior of technology use. The model has been shown to be suitable for applying BL (Alshahrani and Walker 2017). However, implementing BL cannot be achieved simply by integrating online and face-to-face teaching (Azizan 2010). Therefore, it is necessary to determine the impact and role of students, lecturers, and administrators to ensure successful implementation of BL in higher education (Graham 2013; Güzer and Caner 2014). An overview of the literature indicates a lack of comprehensive studies that have systematically examined the factors that influence the effectiveness of Blended Learning activities, encompassing the lecturer, student, organizational, and technology platform aspects. Moreover, there appears to be a dearth of research exploring the prioritization level of these influencing factors on the effectiveness of BL activities, specifically within the context of universities in developing countries like Vietnam.

Nowadays, the fuzzy Analytic Hierarchy Process proposed by Chang (1996) is one of the most commonly used multi-criteria decision-making methods. Many studies have utilized Chang's method in the field of education, such as Lin (2010), Chen et al (2015), Kustiyahningsih et al (2020), Arora et al (2021), Menekşe and Akdağ (2022), and Zhu et al (2022). Although this method has value, in some special cases, it exhibits certain limitations that have been addressed in studies by Wang et al (2008) and Hue et al (2022).

As a leading university in Vietnam with 19 member universities/college and research institutes, Vietnam National University, Hanoi (VNU-Hanoi) has a mission to train high-quality human resources, foster talent, conduct advanced technology research, transfer knowledge, and play a key role in innovating the higher education system in Vietnam. In recent years, VNU-Hanoi has invested in digital transformation, quality assurance, and management, including initiatives such as the implementation of a digital university project, teaching innovation, the establishment of an online training platform, and the establishment of a digital university management center. VNU-Hanoi has issued various policies to promote digital transformation, with a focus on digitizing materials and staff and student data, enhancing online administrative procedures, and implementing online training. VNU-Hanoi has also developed the "VNU-Hanoi digital university architecture until 2025 and vision towards 2030 according to the e-government architecture framework of Vietnam, version 2.0," a plan to apply IT and develop a digital university until 2025, guidelines for ensuring information security and database security on VNU-Hanoi's IT platforms, and a proposal for an ICT framework for the smart university town of VNU-Hanoi. These are important foundations for implementing the policy of developing online training and BL at VNU-Hanoi. Therefore, the aim of this study is to evaluate the factors that influence the effective organization of teaching according to the BL model at VNU-Hanoi. In this study, a new generalized fuzzy AHP presented by Hue et al (2022) was applied to evaluate the effectiveness of BL activities at VNU-Hanoi.

2. Literature review on the factors influencing the effectiveness of blended learning activities

2.1. Lecturer

In both online and traditional teaching, lecturers or facilitators play a crucial role in determining the success of the model. Lecturers need to know how to use modern technologies to serve teaching, choose appropriate resources for different students, design and select suitable evaluation methods according to the students' abilities and technology skills. In reality, lecturers not only organize learning activities but also have the responsibility to guide, direct, and develop learning content to help students' self-access. It is essential to teach students information processing skills, including necessary computer skills. Teaching in a complex BL context requires more comprehensive and flexible lesson design to improve the learning process of students (Baran et al 2013; Comas-Quinn 2011). Many studies have emphasized the role of lecturers in promoting students' learning experiences and the success of BL models, including factors such as readiness, teaching experience, lesson content, appropriate teaching methods, technology competence, and student assessment methods.

a) Teaching experience

Teaching experience with traditional methods helps lecturers decide which parts of the course can be replaced or adjusted to fit the combined teaching approach. Teaching experience with BL helps lecturers have more confidence in applying technology in teaching, and the knowledge that technology can better meet the needs of students (Alammary et al 2014). Lecturers are encouraged to gradually adopt the replacement approach. They should start by shifting a small portion of the course content to online format, gradually reducing the amount of face-to-face teaching time to suit and then expanding the scale as needed until a harmonious combination of face-to-face and online teaching is achieved (Brunner 2006; Duhaney 2004).

b) Readiness

The transition from traditional learning methods to BL requires both lecturers and students to accept and be ready to innovate in teaching and learning methods. At that time, the lecturer's belief in the usefulness of the BL method played a crucial role and brought about changes in their teaching curriculum. If they believe in the benefits that the model brings, they will be

ready to apply and develop it (Colorado and Eberle 2009, Ottenbreit-Leftwich et al 2010). According to the research of Poon (2014) and Dakduk et al (2018), lecturer readiness is the main factor determining the effectiveness of implementing BL.

c) Pedagogical method

According to the TPCK (technological pedagogical content knowledge) framework developed by Koehler and Mishra (2008), in order to improve student learning in a combined learning model, lecturers need to harmoniously combine content knowledge, technological knowledge, and pedagogical knowledge (practice, process, strategies, teaching and learning methods). Pedagogical knowledge specifically refers to the effective teaching methods lecturers use to promote student learning (Koehler and Mishra 2006; Koehler et al 2014; Hubber and Loong 2013). The pedagogical method places the student at the center and is an important factor in creating a successful combined learning course. This method requires lecturers to act as facilitators to enhance students' learning, to know how to promote a positive learning process and self-adjustment, to create opportunities for interaction, and to have an evaluation method for students' learning and timely feedback (Thanh and Renshaw 2013). The quick feedback from lecturers on students' requirements helps to increase students' positive learning experience, especially for those without prior technology experience (Cheng 2012; Costley and Lange 2016). This interaction occurs not only in the classroom but also through online forms, which helps students to achieve learning goals more effectively (Garnham and Kaleta 2002). In combined learning, students rely less on lecturers and learning materials and instead rely on guides (Cheung and Vogel 2013; Holley and Oliver 2010). Guides are required to understand students' motivation when participating in online learning, in order to guide them to use online learning tools and develop new teaching methods to attract students (Vanslambrouck et al 2018).

d) Technology capability

For BL models, technology is always a crucial factor. Both lecturers and students work on the online learning system (LMS). Therefore, the technology competence of users motivates lecturers to apply the BL model (Gautreau 2011) and plays an important role in the success of the BL model (Thompson et al 2006; Venkatesh and Davis 2000, Wan et al 2007, Mahdizadeh et al 2008). User experience with technology is their exposure to technology, along with skills and abilities achieved through the use of technology (Thompson et al 2006). This is obvious because lecturers need these skills not only to design lessons and perform other online tasks but also to support students when they encounter difficulties.

e) Lecture content

For both traditional and BL, high-quality lecture content is always one of the decisive factors in student satisfaction, promotes student learning, and is essential for any educational context (Lin and Wang 2012; Mondi et al 2007; Wong et al 2020). A principle in designing teaching in BL is that the distribution mechanism of content, teaching activities, and assessment activities must be based on lecture content, student learning needs, and the ability to meet the applied technological solutions (Garrison and Vaughan 2008; McGee and Reis 2012; Means et al 2013). Lecturers can design lecture content for BL models in the form of visual images, multimedia presentations, and case analysis to enhance the student learning experience.

f) Evaluation methodology in teaching

Evaluation is a continuous and ongoing process in teaching that helps lecturers monitor students' learning progress, identify their difficulties in learning, and provide timely feedback to help them adjust their learning process to achieve their learning goals. Learning based on interaction along with effective evaluation methods can significantly improve students' achievement and learning motivation, while reducing the pressure of knowledge accumulation (Chu et al 2019; Cauley and McMillan 2010).

2.2. The student factors

The student is the subject who directly participates in the educational process and receives knowledge from the lecturer. Unlike the traditional teaching method, the student is considered the center in the BL model (Suprabha and Subramonian 2015). The use of the BL model will improve the learning experience and expand the student's learning through greater freedom in learning methods, enhancing interaction between the lecturer and the student, exploiting learning tools, and comprehensive development of cognition, emotions, and physicality (Tayebinik and Puteh 2013).

a) Time management

When changing from the traditional learning method to the new learning method, the direct classroom learning time will decrease, however, this does not necessarily affect the student's learning effectiveness (Müller and Mildenberger 2021). In addition, when participating in the BL model, the student's time management and self-discipline are extremely important. Students need to change their learning methods and approach new applications, so they need to have the skill to allocate time reasonably to complete online and blended courses. Lecturers need to help students stay on track through email reminders, progress plan notifications, and expected completion deadlines (Shand and Farrelly 2018).

b) Learning attitude

Learning attitude is related to the student's views and emotions about participating in the blended teaching process. A positive attitude towards this teaching approach can reflect the student's participation and have a good impact on their learning outcomes (Akbarov et al 2018, Ja'ashan 2015). Studies often point out that students have a positive attitude towards

blended teaching (Alsalhi et al 2019, Arrosagaray et al 2019), and this teaching method is also evaluated to improve students' attitudes towards learning in general (Nja et al 2022).

c) Learning motivation

The student's motivation comes from the flexibility of this method, they will work at their own learning pace, be more comfortable learning with different online tools, and communicate with the lecturer freely at any time (Banditvilai 2016, Birbal et al 2018). Studies also show that the application of technology in learning will improve students' learning motivation (Ciampa 2014, Chiu 2021 Alsadoon et al 2022).

d) Digital literacy

Studies show that the ability to receive and process digital information has a positive effect on the learning outcomes of students in BL (Mayer et al 2014, Oyarzun and Pedreira 2016). Digital literacy is considered an important factor in students' success in BL, as it helps students to access and use information efficiently and effectively (Bawaneh et al 2019, Wu and Wu 2018).

2.3. Organizational Factors

In addition to lecturers and students, the organizational factor contributes to the success of the BL model, specifically, the higher education institution. The role of the organization, in addition to providing infrastructure and support activities, also promotes the sustainability of factors related to lecturers and students in implementing the BL model (Wong et al 2014; Yeop et al 2016). Yeop et al (2016) pointed out that the organization is the main factor that helps the team of lecturers and students successfully implement BL, but this is the least studied factor. The supportive factors of the organization must include policies, support activities, facilities, and most importantly, technology.

a) Encouraging policies

Encouraging policies can affect the satisfaction of users of the BL model, especially lecturers. These encouraging policies come from the educational institution with the main purpose of encouraging and motivating lecturers to implement the teaching model. Encouragement can be in the form of monetary and non-monetary rewards. The most common form that educational institutions use to encourage lecturers is to organize teaching awards (Sumner and Hostetler 1999).

b) Support activities

Betts (2014) pointed out that one of the barriers to the participation of students and lecturers in BL is the lack of support from the organization. When transitioning from traditional teaching models to blended models, both students and lecturers lack knowledge and skills, so training for students and professional development support for lecturers are essential (Vaughan 2007). This is also demonstrated in Ndon's (2006) study, where training, counseling, and support from the organization will greatly help lecturers who have no experience in teaching blends. Support related to course design, online teaching materials development, training in new teaching skills to encourage student participation (Dziuban et al 2006; Aycock et al 2002; Gamham and Kaleta 2002).

c) Strategy and Implementation Plan

Garrison and Kanuka (2004) have clarified the essential role of schools in creating policies, strategies, plans, and resources to ensure the successful implementation of BL models. Establishing a clear and effective strategy and implementation plan for BL models makes it easier for organizations to mobilize resources and implement tasks, thereby achieving the mission and goals of the organization more easily (Niemiec and Otte 2009).

d) Infrastructure

The infrastructure plays an important role in the success of delivering online content and can hinder technology adoption in both lecturers and students (Nanayakkara and Whiddett 2005, Abusalim et al 2020). To carry out and effectively respond to BL, educational institutions need an intelligent classroom system consisting of devices that support learning, including sound systems, projectors, lighting systems, online meeting systems, etc. (Dangwal 2017).

2.4. Technology Platform

Establishing a good technology platform is a key task for an organization in creating an effective BL model (Niemiec and Otte 2010). The technology platform relates to the organization's decision to invest, choose user-friendly systems (lecturers and students) (Liu and Tourtellott 2011; Taylor and Newton 2012), and provide technical resources to enhance teaching and learning activities (Garrison and Kanuka 2004; Bokolo et al 2020).

a) Hardware system

The hardware infrastructure includes computer systems, the quality of the server system, and internet access speed (Ahmed 2010). The quality of the server system is also very important, with enough bandwidth to allow large-scale BL activities to take place (Carbonell et al 2012). Since BL integrates online components with computer and web-based technologies, low-quality or inadequate technology platforms will directly affect the learning effectiveness of students. It must be recognized that investing in a technology platform will cost a significant amount for an organization. However, the average cost per student

for a BL course will be much lower than organizing a traditional course (Battaglino et al 2012). In addition, the cost of educational technology will continue to decrease over time (Salmon 2005; Schneider 2010).

b) Software system

The software system can be considered a prerequisite for implementing a BL model. Nowadays, educational institutions often invest in building software or learning management systems (LMS) to implement BL models. The LMS is often the technology platform for BL environments (Black et al 2007). The LMS is a server-based or cloud-based system that allows for the management, operation of document systems, guidance, tracking, reporting, and provision of e-learning technologies for courses or training programs. This system includes the entire ecosystem that covers the learning process, interactive interfaces, and participants, including lecturers, students, assistants, and administrators. In this sense, the LMS has created a space for exchanging and sharing information throughout the BL process (Lopes 2011).

c) Technical support activities

Technical support activities involve technical elements related to the technology platform (hardware and software systems) that help facilitate effective teaching and learning (Gamham and Kaleta 2002). Educational institutions should plan and sign contracts with information technology (IT) providers to ensure they provide reliable IT infrastructure that meets the learning and teaching needs of students and faculty, as well as have a plan to expand or improve the technology infrastructure as demand and usage increases (Moskal et al 2013).

3. Methodology

Hue et al (2022) proposed an improved fuzzy AHP approach that uses generalized fuzzy numbers to overcome the shortcomings of Chang's (1996) fuzzy AHP approach. The procedures of Hue et al's (2022) approach are as follows:

- Developing the fuzzy comparison matrix:

$$\tilde{T} = (\tilde{x}_{ij})_{nxn} = \begin{bmatrix} (1,1,1;w_{11}) & (a_{12},b_{12},c_{12};w_{12}) & \cdots & (a_{1n},b_{1n},c_{1n};w_{1n}) \\ (a_{21},b_{21},c_{21};w_{21}) & (1,1,1;w_{22}) & \cdots & (a_{2n},b_{2n},c_{2n};w_{2n}) \\ \vdots & \vdots & \vdots & \vdots \\ (a_{n1},b_{n1},c_{n1};w_{n1}) & (a_{n2},b_{n2},c_{n2};w_{n2}) & \cdots & (1,1,1;w_{nn}) \end{bmatrix}$$

where $\tilde{x}_{ij} = (a_{ij},b_{ij},c_{ij};w_{ij})$, $\tilde{x}_{ij}^{-1} = (1/c_{ij},1/b_{ij},1/a_{ij};w_{ij})$ for $i, j = 1,\ldots,n$ and $i \neq j$.

- Defining the values of the fuzzy synthetic extents:

The values of fuzzy synthetic extents, S_i are defined in Equation (1).

$$S_i = \left(g_i,h_i,k_i;\min(w_{ij})\right) = \sum_{j=1}^{n} M_{g_i}^{j} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{n} M_{g_i}^{j}\right]^{-1}$$

$$= \left(\frac{\sum_{j=1}^{n} a_{ij}}{\sum_{j=1}^{n} a_{ij} + \sum_{k=1,k\neq i}^{n}\sum_{j=1}^{n} c_{kj}}, \frac{\sum_{j=1}^{n} b_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n} b_{ij}}, \frac{\sum_{j=1}^{n} c_{ij}}{\sum_{j=1}^{n} c_{ij} + \sum_{k=1,k\neq i}^{n}\sum_{j=1}^{n} a_{kj}}; \min(w_{ij}) \right) \quad (1)$$

where $\sum_{j=1}^{n} M_{g_i}^{j} = \left(\sum_{j=1}^{n} a_{ij}, \sum_{j=1}^{n} b_{ij}, \sum_{j=1}^{n} c_{ij}; \min(w_{ij})\right)$, $i, j = 1,2,...,n$

- Calculate the distance between the centroid point $S_i = (\bar{x}_{S_i}, \bar{y}_{S_i}), i = 1,2,...,n$ and the minimum point $G = (x_{\min}, y_{\min})$:

$$D(S_i,G) = \sqrt{(\bar{x}_{S_i} - x_{\min})^2 + (\bar{y}_{S_i} - \frac{\varpi}{3} y_{\min})^2} \quad (2)$$

where $x_{\min} = \min(g_i), y_{\min} = \min(w_{ij}), \bar{x}_{S_i} = (g_i + h_i + k_i)/3, \bar{y}_{S_i} = \min(w_{ij})/3$

- Defining the weight vector $W = (w_1,\ldots,w_n)^T$ of the fuzzy comparison matrix:

$$w_i = \frac{D(S_i, G)}{\sum_{i=1}^{n} D(S_i, G)} = \frac{\sqrt{(\bar{x}_{S_i} - x_{\min})^2 + (\bar{y}_{S_i} - \frac{\varpi}{3} y_{\min})^2}}{\sum_{i=1}^{n} \sqrt{(\bar{x}_{S_i} - x_{\min})^2 + (\bar{y}_{S_i} - \frac{\varpi}{3} y_{\min})^2}}, \quad i = 1, \ldots, n \tag{3}$$

4. Factors affecting the organization of combined teaching at Vietnam National University, Hanoi

4.1. The current situation of factors affecting the organization of combined teaching at VNU-Hanoi

a) Lecturers and students

VNU-Hanoi is a leading research and educational center in Vietnam. The majority of its scientific staff are top-notch researchers in the country and have a great reputation domestically and internationally in various fields of natural sciences, social sciences and humanities, foreign languages, technology, economics, and education. Many of its researchers have been awarded prestigious national and international prizes. As of 2022, VNU-Hanoi has a total of 4,564 staff members, including 2,502 scientific staff, 58 professors, 390 associate professors, 1,478 Ph.D. holders and Doctor of Science holders. In recent years, VNU-Hanoi has consistently ranked as one of the top universities in Vietnam, among the top 150 universities in Asia, and among the top 1,000 universities in the world, according to THE ranking. As of early 2022, VNU-Hanoi offers nearly 500 training programs to more than 55,000 students (including nearly 1,000 international students and nearly 7,000 postgraduate and doctoral students). VNU-Hanoi currently has 210 laboratories, including 1 national key laboratory, 09 VNU-Hanoi key laboratories, 38 target-oriented laboratories, 140 specialized centers/laboratories, and 22 practical centers/laboratories; and has produced 1,178 scientific and technological products, including 1,110 ISI and/or SCOPUS articles, 57 patents, useful solutions, 11 transfer and startup products (VNU-Hanoi, 2022a).

In the context of digital transformation, the teaching methods of lecturers are strongly influenced by both teaching tools and methods. Huyen and Hanh (2021) indicated that the presentation method (95.4%) and group discussion method (92%) are the two most commonly used methods by lecturers at the VNU-Hanoi. The least common method is role-playing (34%) and other methods (3.9%). This shows that lecturers have suitable methods to organize teaching activities, especially combined teaching activities. Regarding teaching materials, the survey results show that the most common forms of teaching materials used by lecturers to send to students are paper and electronic versions. Specifically, the proportion of lecturers who use electronic versions is 96.6%, while the proportion of those who use paper versions is 74.7%. This indicates that lecturers at the VNU-Hanoi have widely applied information technology in their teaching activities. The higher proportion of using electronic versions shows that the trend of electronic materials has become dominant over paper materials. Another group of lecturers uses various materials to send to students (12.7%). These materials can include links to documents, websites, reference lists, films, or information for students to find additional materials.

Regarding student assessment methods, the level of satisfaction of students with the assessment methods of lecturers at the VNU-Hanoi is still quite low (Nhat, 2021). Therefore, in order to further improve the quality of assessment activities, lecturers should not only use appropriate assessment methods that match the learning outcomes of the course but also accurately reflect the student's ability. Especially in combined teaching, lecturers should not only focus on the final exam results but also pay attention to assessing the student's learning process.

b) Organizational factors

In 2019, VNU-Hanoi established the Teaching Support Center under the Institute of Educational Quality Assurance with the mission of researching, approaching, and disseminating new educational technologies and methods for the entire VNU-Hanoi system, ensuring consistency and coherence throughout the system. During the 2019-2023 period, the center has carried out tasks such as consulting the leaders of VNU-Hanoi on policies to encourage lecturers to innovate and apply positive teaching methods, providing guidance and support to lecturers in teaching activities, organizing activities and events (seminars, training courses, conferences, etc.) on new trends and approaches in educational science, providing training and training courses for lecturers on technology and teaching methods to serve the innovation of teaching activities.

In 2021, VNU-Hanoi put into operation the VNU LMS Learning Management System, a system designed to serve the combined teaching model throughout VNU-Hanoi. The use of the VNU LMS system helps lecturers organize and manage online and offline learning activities. In addition, VNU-Hanoi has issued regulations, guidelines, and policies to encourage lecturers to innovate teaching methods and effectively implement the combined teaching model. Some units have signed contracts with lecturers to support the cost of organizing learning activities on the VNU LMS system, such as the University of Social Sciences and Humanities and the University of Education.

VNU-Hanoi has many policies to encourage lecturers to innovate teaching methods. Specifically, VNU-Hanoi has issued regulations and guidelines on implementing innovative teaching activities at VNU-Hanoi during the 2019 - 2025 period, and has issued regulations on online training and building electronic lectures at VNU-Hanoi. In the construction of online lectures, lecturers are provided with technical support and funding from the unit and VNU-Hanoi. In addition, VNU-Hanoi has issued

regulations on the VNU-Hanoi Lecturer Award and awards for teaching innovation at VNU-Hanoi, with the participation of lecturers and researchers throughout VNU-Hanoi. In which, the award for teaching innovation with many specific criteria is a strong motivation for lecturers to innovate teaching methods.

c) The technology foundation factors

VNU-Hanoi has built and operated a Technology Application and Digital Learning Development Room to serve the innovation of teaching and learning in approaching Industry 4.0 technology. This technology application room is not only a studio for building teaching content but also a space for testing, training, and applying new educational technology solutions. It helps to connect existing learning content production studios at VNU-Hanoi and is also a part of the E-learning system and smart university ecosystem at VNU-Hanoi. Some units in VNU-Hanoi, such as the VNU University of Languages and International Studies, VNU University of Education, and Institute for Education Quality Assurance, have invested in modern and professional Studio rooms to digitize teaching materials and lectures that meet the requirements of combined teaching.

In 2021, VNU-Hanoi launched the VNU LMS online learning system to develop a combined teaching model throughout the university. This system was built on a modern technology platform, with the ability to expand, connect, and exchange data with training management software systems and other software. The VNU LMS system is installed and operated at the data center of VNU-Hanoi. VNU LMS is designed to allow the number of simultaneous access (CCU) to meet the current online learning demand of 5000 CCUs and can be expanded based on the addition of corresponding infrastructure capacity. After being put into operation at the units, the system received very positive feedback on quality and performance compared to previous systems. In the academic year 2022-2023, VNU University of Education and VNU University of Social Sciences and Humanities used VNU LMS to implement teaching courses based on the combined approach. VNU LMS is a new platform put into use, so there is always positive and timely support to quickly resolve hardware issues as well as software usage issues for users. VNU-Hanoi has built various forms of support to ensure online teaching and learning activities, such as building instruction toolkits, feedback/ suggestion recording tools, direct chat/exchange channels via chat applications (Zalo, Viber, Telegram, etc.) to quickly detect and handle problems. The VNU LMS system is built to serve online teaching and learning and combined teaching models. However, some learning activity organization tools have not yet met the requirements of units in different fields.

4.2. Evaluation results of factors influencing the effectiveness of BL teaching model at Vietnam National University, Hanoi

Based on a review of literature, this study evaluated four groups of factors that influence the effectiveness of BL teaching model at universities under VNU-Hanoi, including: factors related to lecturers, factors related to students, factors related to organizations, and factors related to technology platform. Table 1 provides an overview of the factors and sub-factors used in this study.

Table 1 Factors affecting the effectiveness of teaching in the BL model.

No	Factors	Sub-factors	References
1	**Lecturer (L)**	Teaching experience (L1) Willingness to switch to blended teaching (L2) Appropriate pedagogical methods for organizing blended teaching (L3) Technological ability to organize blended teaching (L4) Skills in creating visually appealing and engaging lesson plans (L5) Effective student assessment methods (L6)	Holley and Oliver (2010), Gautreau (2011), Hubber and Loong (2013), Alammary et al (2014), Dakduk et al (2018), Vanslambrouck et al (2018), Wong et al (2020), Chu et al (2019)
2	**Student (S)**	Time management skills (S1) Positive learning attitude (S2) Study motivation (S3) Numeracy skills (S4) Active learning methods (S5) Personal learning devices (S6)	Ramdass and Harripaul (2018), Arrosagaray et al (2019), Müller and Mildenberger (2021), Dai et al (2021), Yilmaz-Na and Sönmez (2022), Staddon (2022)
3	**Organization (O)**	Encouragement policies for lecturers (O1) Support activities for teaching for lecturers and students (O2) Effective strategy and implementation plan (O3) Infrastructure system to meet demands (O4)	Sumner and Hostetler (1999), Vaughan (2007), Niemiec and Otte (2009), Dangwal (2017), Abusalim et al (2022)
4	**Technology platform (T)**	Hardware system ensuring access (T1) Software system meeting teaching and learning requirements (T2) Timely technical support activities (T3) Equipment for developing learning materials (T4)	Niemiec and Otte (2010), Ahmed (2010), Lopes (2011), Moskal et al (2013), Bokolo et al (2020)

Table 2 presents the linguistic variables and their fuzzy numbers used in this study.

Table 2 Linguistic values and fuzzy numbers.

Linguistic values	Fuzzy numbers
Equal importance (E_I)	(1,1,1;1.0)
Between E_I and W_I	(1,2,3;0.6)
Weak importance of one over another (W_I)	(2,3,4;0.7)
Between W_I and S_I	(3,4,5;0.8)
Strong importance (S_I)	(4,5,6;0.8)
Between S_I and V_S_I	(5,6,7; 0.9)
Very strong importance (V_S_I)	(6,7,8; 0.9)
Between V_S_I and A_I	(7,8,9; 1.0)
Absolute importance (A_I)	(8,9,9; 1.0)

In this study, Hue et al's (2022) approach was applied to evaluate the factors influencing the effectiveness of teaching using the BL model at VNU-Hanoi. The data for the study was collected through interviews with a panel of five experts who have many years of experience in managing training activities at VNU-Hanoi. Tables 3-7 present the average fuzzy comparison matrix assessment of factors and sub-factors by the committee.

Table 3 Average fuzzy comparison matrix assessment of four factors by the committee.

Factors	L	S	O	T
L	(1.00, 1.00, 1.00; 1.00)	(4.67, 5.67, 6.67; 0.80)	(2.67, 3.33, 4.00; 0.70)	(3.00, 4.00, 5.00; 0.70)
S	(0.16, 0.19, 0.23; 0.70)	(1.00, 1.00, 1.00; 1.00)	(0.49, 0.88, 1.39; 0.60)	(0.56, 0.67, 1.00; 0.60)
O	(0.46, 0.50, 0.57; 0.70)	(2.44, 3.17, 4.00; 0.70)	(1.00, 1.00, 1.00; 1.00)	(1.33, 1.67, 2.00; 0.70)
T	(0.21, 0.28, 0.40; 0.70)	(1.00, 1.67, 2.33; 0.70)	(0.75, 0.78, 0.83; 0.70)	(1.00, 1.00, 1.00; 1.00)

Table 4 The average pairwise comparison value of the six sub-factors of the lecturer factor.

Lecturer	L1	L2	L3	L4	L5	L6
L1	(1.00, 1.00, 1.00; 1.00)	(0.33, 0.36, 0.41; 0.70)	(0.34, 0.37, 0.43; 0.70)	(0.57, 0.83, 1.20; 0.60)	(0.55, 0.80, 1.10; 0.60)	(1.67, 2.10, 2.60; 0.60)
L2	(2.43, 2.78, 3.03; 0.70)	(1.00, 1.00, 1.00; 1.00)	(2.00, 2.40, 2.80; 0.70)	(1.85, 2.47, 3.10; 0.60)	(2.20, 2.80, 3.40; 0.60)	(2.64, 3.45, 4.27; 0.60)
L3	(2.33, 2.68, 2.94; 0.70)	(0.36, 0.42, 0.50; 0.70)	(1.00, 1.00, 1.00; 1.00)	(2.07, 2.70, 3.40; 0.60)	(1.80, 2.40, 3.00; 0.60)	(2.80, 3.80, 4.80; 0.60)
L4	(0.83, 1.20, 1.76; 0.70)	(0.32, 0.41, 0.54; 0.70)	(0.29, 0.37, 0.48; 0.70)	(1.00, 1.00, 1.00; 1.00)	(1.27, 1.90, 2.60; 0.60)	(2.80, 3.60, 4.40; 0.60)
L5	(0.91, 1.25, 1.82; 0.60)	(0.29, 0.42, 0.45; 0.60)	(0.33, 0.42, 0.56; 0.60)	(0.38, 0.53, 0.79; 0.60)	(1.00, 1.00, 1.00; 1.00)	(2.40, 3.20, 4.00; 0.60)
L6	(0.38, 0.48, 0.60; 0.60)	(0.23, 0.29, 0.38; 0.60)	(0.21, 0.26, 0.36; 0.60)	(0.23, 0.28, 0.36; 0.60)	(0.25, 0.31, 0.42; 0.60)	(1.00, 1.00, 1.00; 1.00)

Table 5 The average pairwise comparison value of the six sub-factors of the student factor.

Student	S1	S2	S3	S4	S5	S6
S1	(1.00, 1.00, 1.00; 1.00)	(0.35, 0.39, 0.51; 0.60)	(0.18, 0.24, 0.36; 0.60)	(0.56, 0.82, 1.17; 0.60)	(0.39, 0.45, 0.57; 0.70)	(1.84, 2.25, 2.67; 0.80)
S2	(1.95, 2.54, 2.88; 0.70)	(1.00, 1.00, 1.00; 1.00)	(1.00, 1.00, 1.00; 1.00)	(1.60, 2.60, 3.60; 0.60)	(1.47, 1.90, 2.40; 0.60)	(2.40, 3.40, 4.40; 0.60)
S3	(2.75, 4.25, 5.49; 0.70)	(1.00, 1.00, 1.00; 0.70)	(1.00, 1.00, 1.00; 1.00)	(2.60, 3.60, 4.60; 0.60)	(2.00, 2.80, 3.60; 0.60)	(3.00, 4.00, 5.00; 0.60)
S4	(0.86, 1.22, 1.80; 0.70)	(0.28, 0.38, 0.63; 0.70)	(0.22, 0.28, 0.38; 0.70)	(1.00, 1.00, 1.00; 1.00)	(0.93, 1.20, 1.60; 0.60)	(2.47, 3.10, 3.80; 0.60)
S5	(1.76, 2.22, 2.56; 0.70)	(0.42, 0.36, 0.68; 0.60)	(0.28, 0.36, 0.50; 0.60)	(0.63, 0.83, 1.07; 0.60)	(1.00, 1.00, 1.00; 1.00)	(2.60, 3.60, 4.60; 0.60)
S6	(0.38, 0.44, 0.54; 0.80)	(0.23, 0.29, 0.42; 0.60)	(0.20, 0.25, 0.33; 0.60)	(0.26, 0.32, 0.41; 0.60)	(0.22, 0.28, 0.38; 0.60)	(1.00, 1.00, 1.00; 1.00)

Table 6 The average pairwise comparison value of the six sub-factors of the Organization factor.

Organization	O1	O2	O3	O4
O1	(1.00, 1.00, 1.00; 1.00)	(1.00, 1.00, 1.00; 1.00)	(1.11, 1.50, 2.00; 0.60)	(1.00, 2.00, 3.00; 0.60)
O2	(1.00, 1.00, 1.00; 0.70)	(1.00, 1.00, 1.00; 1.00)	(0.53, 0.94, 1.50; 0.60)	(1.00, 1.00, 1.00; 1.00)
O3	(0.75, 1.11, 1.50; 0.70)	(1.11, 1.83, 2.67; 0.70)	(1.00, 1.00, 1.00; 1.00)	(1.67, 2.67, 3.67; 0.60)
O4	(0.33, 0.50, 1.00; 0.70)	(1.00, 1.00, 1.00; 0.70)	(0.29, 0.42, 0.78; 0.70)	(1.00, 1.00, 1.00; 1.00)

Table 7 The average pairwise comparison value of the six sub-factors of the Technology factor.

Technology	T1	T2	T3	T4
T1	(1.00, 1.00, 1.00; 1.00)	(1.00, 1.00, 1.00; 1.00)	(0.53, 0.94, 1.50; 0.60)	(0.78, 1.17, 1.67; 0.60)
T2	(1.00, 1.00, 1.00; 0.70)	(1.00, 1.00, 1.00; 1.00)	(0.86, 1.28, 1.83; 0.60)	(0.78, 0.83, 1.00; 0.60)
T3	(1.11, 1.83, 2.67; 0.70)	(1.08, 1.78, 2.50; 0.70)	(1.00, 1.00, 1.00; 1.00)	(1.78, 2.50, 3.33; 0.60)
T4	(0.78, 1.17, 1.67; 0.70)	(1.00, 1.33, 1.67; 0.70)	(0.48, 0.86, 1.28; 0.70)	(1.00, 1.00, 1.00; 1.00)

The calculation of fuzzy synthetic extent values of factors and sub-factors is performed by utilizing Equation (1), and the results are presented in Table 8.

Table 8 Calculating fuzzy synthetic extent values for factors and sub-factors.

Factors	Fuzzy synthetic extent	Sub- factors	Fuzzy synthetic extent
L	(0.42, 0.52, 0.62; 0.60)	**L1**	(0.07, 0.11, 0.16; 0.60)
		L2	(0.21, 0.29, 0.38; 0.60)
		L3	(0.18, 0.25, 0.34; 0.60)
		L4	(0.11, 0.17, 0.24; 0.60)
		L5	(0.09, 0.13, 0.19; 0.60)
		L6	(0.04, 0.05, 0.07; 0.60)
S	(0.07, 0.10, 0.16; 0.60)	**S1**	(0.07, 0.10, 0.15; 0.60)
		S2	(0.16, 0.24, 0.33; 0.60)
		S3	(0.22, 0.32, 0.42; 0.60)
		S4	(0.09, 0.14, 0.21; 0.60)
		S5	(0.11, 0.16, 0.23; 0.60)
		S6	(0.04, 0.05, 0.07; 0.60)
O	(0.17, 0.24, 0.31; 0.70)	**O1**	(0.19, 0.29, 0.40; 0.60)
		O2	(0.15, 0.21, 0.29; 0.60)
		O3	(0.23, 0.35, 0.46; 0.60)
		O4	(0.11, 0.15, 0.24; 0.60)
T	(0.10, 0.14, 0.20; 0.60)	**T1**	(0.14, 0.21, 0.30; 0.60)
		T2	(0.15, 0.21, 0.30; 0.60)
		T3	(0.24, 0.36, 0.48; 0.60)
		T4	(0.14, 0.22, 0.32; 0.60)

Table 9 presents the results of analyzing the factors and sub-factors affecting the effectiveness of teaching using the BL model at VNU-Hanoi using Equations (2) and (3). The research results indicate that the lecturer factor, accounting for 54.4%, is the most influential factor on the effectiveness of teaching using the BL model at VNU-Hanoi. Specifically, the lecturer's willingness to switch to blended teaching and the lecturer's appropriate pedagogical method for organizing blended teaching have the greatest impact on the effectiveness of teaching using the BL model at VNU-Hanoi. In practice, in the period 2019-2023, the Teaching Support Center has implemented 6 training sessions through the VNU LMS system for over 1000 lecturers and lecturers at training units under VNU-Hanoi. According to the 2021 report of the Institute for Education Quality Assurance on online training, up to nearly 40% of VNU-Hanoi lecturers have never used any online learning system. The most commonly used systems that lecturers participate in are Moodle and Cousera. About 50% of lecturers face difficulties in using online teaching and learning platforms due to limited technology skills. Only 3.2% of lecturers have no intention of applying online teaching to their courses (VNU-Hanoi, 2022b). The majority of lecturers want to use their teaching time for online teaching or a combination of both. It can be seen that the lecturers have a high willingness to convert and maintain teaching in a harmonious combination of both online and face-to-face teaching approaches. Therefore, in order to enhance the effectiveness of teaching using the Blended Learning (BL) model, VNU-Hanoi and its member universities/colleges need to further strengthen the implementation of training courses aimed at improving technological capabilities and proficiency in utilizing online teaching platforms. Moreover, it is crucial to establish policies that incentivize lecturers to actively engage in teaching and maximize the effectiveness of instructional activities within the BL model. Additionally, member universities/colleges should continue investing in suitable technologies for teaching activities within the BL model, customized to the specific training disciplines offered by the university.

5. Conclusion

Blended learning has emerged as a widely adopted pedagogical approach in higher education worldwide, enhancing the overall quality of education. This study was applied the most recent generalized fuzzy AHP approach to determine the factors that influence the effectiveness of teaching activities in a BL model at VNU, Hanoi. Four groups of factors with a total of 20 sub-factors were considered, including lecturer-related factor (6 sub-factors), student-related factor (6 sub-factors), organizational factor (4 sub-factors), and technology factor (4 sub-factors). The results indicated that the lecturer-related factor (lecturers' readiness to switch to blended teaching and their appropriate pedagogical methods for organizing blended teaching) has the

greatest influence on the effectiveness of BL activities at VNU, followed by technology, organizational, and student-related factors. This study is limited to the utilization of the generalized fuzzy AHP approach within a static time frame. Future research can extend the application of the generalized fuzzy AHP approach to dynamic environments. Furthermore, this study solely focuses on evaluating the factors that influence the effectiveness of teaching activities in a BL model at VNU, Hanoi. Subsequent research can broaden its scope to encompass other universities beyond VNU, Hanoi.

Table 9 Factors and sub-factors weighting affecting BL activities.

Factors	Weight score	Sub- factors	Weight score
L	0.544	**L1**	0.112
		L2	0.274
		L3	0.239
		L4	0.160
		L5	0.132
		L6	0.083
S	0.106	**S1**	0.106
		S2	0.222
		S3	0.296
		S4	0.137
		S5	0.155
		S6	0.082
O	0.221	**O1**	0.294
		O2	0.193
		O3	0.368
		O4	0.145
T	0.129	**T1**	0.193
		T2	0.194
		T3	0.408
		T4	0.205

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Ethical considerations

We confirm that we have obtained all consent required by the applicable law to publish any personal details or images of patients, research subjects, or other individuals used. We agree to provide Multidisciplinary Science Journal with copies of the consent or evidence that such consent has been obtained if requested.

Conflict of Interest

The authors declare that they have no conflict of interest.

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