ISSN 2090-3359 (Print)
ISSN 2090-3367 (Online)

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Advances in Decision Sciences

Volume 27
Issue 2
June 2023

亞洲大學
ASIA UNIVERSITY

Published by Asia University, Taiwan

Factors Influencing Online Professional Skills Training Programs for Lecturers: A Case Study of Vietnam National University, Hanoi, and its Implications on Decision Sciences

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Received: May 26, 2023; First Revision: June 7, 2023;

Last Revision: July 22, 2023; Accepted: July 23, 2023;

Published: September 24, 2023

Abstract

Purpose: The application of decision science combines qualitative and quantitative frameworks to offer valuable insights into decision-making processes, spanning beyond business, computer science, public health, environmental science, economics, and finance, to include the field of education. Under the impact of the COVID-19 pandemic and digital transformation, online training has become a trend in many universities worldwide. This study aims to develop a new integrated multi-criteria decision-making model to determine the priority levels of factors impacting the effectiveness of online professional skills training programs for lecturers at the Vietnam National University, Hanoi (VNU-Hanoi).

Design/methodology/approach: A novel integrated approach has been developed, which combines the generalized fuzzy Analytic Hierarchy Process (AHP) with the fuzzy Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). This approach effectively determines the priority levels of influencing factors by using the fuzzy TOPSIS method with generalized trapezoidal fuzzy numbers (TrFNs). The data for this study was collected through in-depth interviews with experts and managers at the VNU-Hanoi.

Findings: The research findings indicate that learners and training program content are the most influential factors in the effectiveness of online training courses in enhancing lecturers' professional competence at the VNU-Hanoi. Drawing on principles from Decision Science, several recommendations have been proposed for the VNU-Hanoi and its member universities and schools: (i) allocate sufficient time and provide resource support to enable lecturers' participation in training courses; (ii) create comprehensive training content for lecturers, encompassing political ideology, ethics, professional knowledge, modern pedagogical skills, and life skills; (iii) strengthen the utilization of scientific, technological, and information technology skills, along with a digital transformation in management, teaching, and learning processes, to meet the broader development needs of society. The study results also demonstrate the feasibility of the proposed model in addressing practical issues.

Originality/value: This study proposes a novel integrated generalized fuzzy AHP-TOPSIS approach to determine the priority levels of factors influencing the effectiveness of online training courses in enhancing lecturers' professional competence at the VNU-Hanoi. The study considers 21 sub-factors across five factors, including the policies of higher education institutions, training program content, learners, instructors, and technology for online training. This is new in the literature.

Keywords: TOPSIS; the generalized fuzzy Analytic Hierarchy Process; Generalized trapezoidal fuzzy numbers; Lecturers’ professional competence

JEL classification: D81, I23

1. Introduction

The development of lecturers' performance is an important application of Decision Science. Developing professional competence among lecturers plays a crucial role in enhancing teaching quality and improving students' learning outcomes (Gerard et al., 2011). Professional development for lecturers can encompass various forms, such as designing training courses for faculty development, organizing forums for subject-matter exchanges and discussions through workshops and training activities (within the institution, at the national or international level), and the recent trend of establishing communities of practices (Jimenez-Silva & Olson, 2012). These activities enhance lecturers' knowledge, subject-specific skills, and teaching practices, thereby improving the quality of educational and training activities to meet the institution's and society's demands. Computer technology and the Internet have significantly increased teaching (Cole et al., 2017; Kontos, 2015). This has provided opportunities for developing online courses in professional development programs for lecturers. Online learning offers a different approach to a diverse range of learners and caters to individual learning needs (Tudor et al., 2015), particularly suited for adult learners. According to Knowles et al. (2015), adult education (andragogy) should follow six principles: (1) addressing the learner's need to know, (2) considering the learner's self-concept, (3) taking into account the learner's prior experience, (4) assessing the readiness to learn, (5) focusing on the orientation to learning, and (6) considering the motivation to learn. Many studies have analyzed the factors influencing the effectiveness of online learning in skill development courses for adult learners (Almaiah et al., 2019b; Bragg et al., 2021; Carolan et al., 2020; Dumais et al., 2013; Dwivedi et al., 2020; Johnson et al., 2018; Mishra et al., 2020; Saleem et al., 2022). However, research on the impact of factors on the effectiveness of online learning for lecturers still needs to be completed. Five factors with 21 sub-factors commonly addressed in studies have been found to influence the effectiveness of online learning in skill development courses for adult learners, including higher education institution policies, training program content, learners (lecturers), instructors, and technology for online training.

Nowadays, the analytic hierarchy process (AHP) proposed by Saaty (1987) is widely used to determine the weights of criteria and the influence of factors. Chang (1996) extended Saaty's (1987) AHP approach by incorporating fuzzy numbers. Some recent applications of the fuzzy AHP approach can be found in (Abusaeed et al., 2022; Abdullah et al., 2023; Chandna et al., 2021; Shi & Lai, 2023; Singh & Prasher, 2019; Y. Wang et al., 2020). However, Chang's (1996) fuzzy AHP method is limited to using normalized triangular fuzzy numbers. Furthermore, in some cases, Chang's (1996) approach resulted in the irrational weighting of decision criteria (Hue et al., 2022). Therefore, to overcome the limitations of Chang's (1996) fuzzy approach, this study integrates the generalized fuzzy with the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) to denazify and determine the priority levels of factors. The fuzzy TOPSIS technique is a practical and useful method for ranking and selecting a range of potential alternatives by measuring Euclidean distances. TOPSIS was initially developed by Hwang and Yoon in 1981. It is founded on the principle that the preferred alternative should have the shortest distance from the positive ideal solution and the greatest distance from the negative ideal solution.

Vietnam National University - Hanoi (VNU-Hanoi) is one of Vietnam's leading multidisciplinary research, training, and innovation centers. As of 2022, VNU-Hanoi has 37 member units, including 09 member universities, 03 affiliated schools, 07 affiliated research institutes; 4,751 staff members, including 2,634 scientific staff with 67 professors, 431 associate professors, and 1,639 doctors and Ph.D. holders; 54,864 students, including 7,000 master's and doctoral students and nearly 1,000 international students; 506 undergraduate and postgraduate training programs. Also, in 2022, VNU-Hanoi had 34 research groups, 210 laboratories, and 1,610 scientific and technological products (including 1,509 prestigious international publications, 86 inventions and valuable solutions, and 15 transfer and startup products). With a large training scale, the development of the faculty to meet the requirements of ensuring the quality of highly skilled human resources is a priority for VNU-Hanoi, especially in the context of solid digital transformation in education. In recent years, VNU-Hanoi has issued many policies to support lecturers, researchers, and young scientific staff, including programs to enhance the capabilities of lecturers. The program aims to provide faculty members and researchers at the VNU-Hanoi with new knowledge and skills in teaching methods and the application of information technology in teaching. The program is organized entirely online through the VNU learning management system platform. In addition, to support online learning activities, the Center for Teaching Excellence, VNU Institute for Education Quality Assurance organizes seminars in a direct and/or combined direct and online format, including Course design and implementation based on outcome-based education and blended learning models; using a learning management system to organize blended teaching activities; developing electronic lectures and learning materials; organizing interactive teaching activities using online tools; designing assessment activities based on learner competency development; efficiently utilizing online learning resources, etc. From August 2021 to December 2022, VNU-Hanoi organized 06 training sessions (each lasting 12 weeks) with over 1,000 faculty members and teachers participating in the program. As of early 2023, this training program has been expanded and implemented for higher education and vocational institutions nationwide through fully online training.

This study aims to address the limitations of Chang's (1996) approach by developing a novel integrated approach that combines the generalized fuzzy AHP and fuzzy TOPSIS. The proposed model incorporates the use of generalized TrFNs within the TOPSIS method to accurately determine the priority levels of influencing factors. To demonstrate the applicability of the proposed approach, it is applied to determine the priority levels of factors impacting the effectiveness of online professional skills training programs for lecturers at the VNU-Hanoi. Data for this study were gathered via in-depth interviews conducted with experts and managers affiliated with the VNU-Hanoi. Several recommendations are suggested for the VNU-Hanoi and its member universities and schools to enhance the effectiveness of online training courses and improve the professional capacity of teachers.

2. Literature review on factors impacting the effectiveness of online professional skills training programs for lecturers

2.1. Policies of Higher Education Institutions

The supportive policies of higher education institutions are among the key factors influencing faculty participation in training programs and their ability to complete the professional skills development curriculum (Saleem et al., 2022). These supportive policies may include provisions for time availability, financial support, tangible recognition of learning outcomes, and opportunities for the practical application of professional skills. For learners who are faculty members and working professionals in general, the challenges of completing training programs often stem from the constraints imposed by their workplace (Ninlawan, 2015). One of the factors contributing to learner non-completion is the overload of work responsibilities, the inability to allocate time for learning due to work schedules, and the lack of workplace support in arranging work schedules (Erickson & Noonan, 2010; Dumais et al., 2013; Park & Choi, 2009; Rao & Giuli, 2010). Conversely, financial support from educational institutions has been found to enhance the likelihood of program completion (Park & Choi, 2009; Willging & Johnson, 2009). Factors such as the work environment, leadership attention and recognition of course outcomes, and the potential for career advancement for program participants significantly impact their ability to complete professional skills training programs (Julian & Ruiz, 2020; Park & Choi, 2009). Furthermore, the practical application of teaching skills acquired through professional skills training programs improves the quality of training program outcomes (Brown & Woods, 2012; Griffin et al., 2018).

2.2. Training program content

Similar to all training and educational programs, the content of professional skills training programs is a crucial factor that influences the success of the courses. This is particularly significant for e-learning programs where the interaction between learners and instructors is limited by distance and space. A training program with content that aligns with the learners' needs will yield positive outcomes for the training program (Almaiah et al., 2019b; Julian & Ruiz, 2020; Mtebe & Raisamo, 2014; Ozudogru & Hismanoglu, 2016; Willging & Johnson, 2009). Furthermore, professional skills training courses should indicate their objectives, learning outcomes, and program structure. When learners clearly understand the training goals and content, they are more likely to actively participate and take ownership of the learning process, focusing on the content that aligns with their interests (Carrillo & Flores, 2020; Van Nuland et al., 2020). Other studies have also indicated that the duration of the training program influences the effectiveness of online professional skills training for faculty (Bragg et al., 2021; Griffin et al., 2018; Hofer & Grandgenett, 2012; Marquez et al., 2016).

Additionally, for online courses where the primary interaction for learners is with learning materials and lectures on the online learning system, the provision of engaging, understandable, and accessible learning materials also increases the completion rate of learners. Learning materials that are overly complex or contain excessively specialized terminology may not be suitable for enhancing learners' motivation for learning (Joo, 2014; Pierrakeas et al., 2004). Willging and Johnson (2009) identified one specific reason for learners not completing courses as the lack of online interaction and personalized learning environments. Croxton (2014) emphasized that the online interactivity of learning materials is an important component of learner satisfaction and persistence in completing courses.

2.3. Learners

Online education allows adult learners to develop professional skills and engage in lifelong learning. However, achieving high effectiveness in online learning requires learners to possess information technology skills, time management abilities, motivation, and commitment to learning (lack of interest in programs or materials, less commitment to education). Additionally, concentrating on online learning is crucial (Saleem et al., 2022). Johnson et al. (2018) highlighted that adult learners' effective use of computers and the internet plays a significant role in the online learning process. Learners with weak information technology skills or older learners may face difficulties in online learning, such as accessing reliable information on the internet and participating in interactive learning activities (Chang & Kang, 2016), which can lead to non-completion of courses (Appana, 2008).

Furthermore, time management and organizational skills also affect the effectiveness of online courses for adult learners. This is due to the characteristics of adult learners, who often face challenges in juggling multiple roles and responsibilities related to work, family, and society. Work overload and a lack of time management skills make it difficult for adult learners to concentrate and meet the requirements of the course (Selwyn, 2011; Yasmin, 2013). There is a clear gender difference in this aspect, with female learners being more affected due to family-related responsibilities (Selwyn, 2011).

Adult learners are active, self-directed, and goal-oriented learners with experience and professional expertise (Knowles, 1996; Lindeman, 2015). However, they may need more motivation and commitment to completing a professional development or career advancement program. The reasons identified could be a lack of interest in the program content and learning materials (the course content not meeting the learners' expectations or being too tricky, learners lacking foundational knowledge for the course, leading to barriers in comprehension), the online learning environment not being truly engaging, or the voluntary nature of the courses (Geri et al., 2017; Hollis & Was, 2016; Kara, 2019; Mishra et al., 2020). Therefore, for adult learners, support in online learning methods is necessary to promote learning success in an online environment. Adult learners, especially older learners (aged 50 to 65), require both technological support (Erickson & Noonan, 2010) and pedagogical support in accessing learning materials (Dumais et al., 2013; Furnborough, 2012) to be able to succeed in online learning environments.

2.4. Instructors /Tutors

In online learning, adult learners require effective and timely support from the institution, instructors, counseling departments, and course management. Instructors have an evident influence on the satisfaction and success of learners. The frequency of interaction with learners, such as limited communication and interaction (Joo, 2014) or even a lack of feedback provided to learners (Dumais et al., 2013), poses challenges in online learning. Not all instructors feel comfortable in the online teaching environment. The transition from traditional (face-to-face) teaching to online or blended learning can be stressful as instructors feel pressured to quickly adapt to technology applications and new teaching methods while receiving little or no training in online teaching (Dwivedi et al., 2020). The readiness to switch to online education varies between older and younger instructors. Here, the generational difference is evident, with more senior instructors being less proficient in using technology than younger instructors who may be more adept with newer technologies (Govindarajan & Srivastava, 2020).

Challenges related to instructors' technological competencies include inadequate information technology skills (Almaiah et al., 2019a; García-Morales et al., 2021) and instructors' level of access and acceptance of e-learning systems (Almaiah et al., 2019b). Additionally, the online teaching method can be a factor that impacts the success of the course (Carrillo and Flores, 2020). In the context of the COVID-19 pandemic, the sudden transition from face-to-face to online teaching poses challenges for instructors in terms of their readiness in terms of competencies and pedagogical methods for effective online teaching (Marinoni et al., 2020).

2.5. Technology

Adult learners in online education face numerous challenges related to technology. These challenges often arise from insufficient technical infrastructure and learning platforms, as well as concerns regarding security and privacy. The technological infrastructure and tools supporting online education encompass hardware, software, physical facilities, and network connectivity within universities. However, these aspects often suffer from inadequate support due to limited technical staff and resources available for essential activities such as installation, operation, maintenance, network management, and security. Additionally, issues like slow internet speeds and high internet traffic during e-learning sessions further contribute to negative learning experiences for learners, ultimately leading to a decline in the quality and effectiveness of online courses (Almaiah & Almulhem, 2018; Almaiah et al., 2019a; Mishra et al., 2020). The lack of readiness or accessibility to online learning support software provided by educational institutions is also a significant barrier for learners. Many online learning applications and software require users to pay, while learners may not have the financial means, and educational institutions may not provide support (Carolan et al., 2020). Concerns about the security of the e-learning system are also a common reason for lecturers and students to be more open to participating in learning and interaction on the online learning platform.

Table 1. Factors influencing the effectiveness of online learning in professional skills development courses for lecturers

Factors	Sub-factors	References
Policies of higher education institutions (P)	Provide conditions for study time for lecturers (P1)	Park & Choi (2009), Erickson & Noonan (2010), Rao & Giuli (2010), Dumais et al. (2013), Ninlawan (2015)
	Financial support for lecturers (P2)	Willging & Johnson (2009), Park & Choi (2009)
	Tangible recognition of learning outcomes for lecturers (P3)	Park & Choi (2009), Julian & Ruiz (2020)
	Conditions for Vocational Skills Practice (P4)	Brown & Woods (2012), Griffin et al. (2018)
Training program content (C)	Alignment with learners' needs (C1)	Willging & Johnson (2009), Mtebe & Raisamo (2014), Ozudogru & Hismanoglu (2016), Almaiah et al. (2019a), Almaiah et al. (2019b), Julian & Ruiz (2020)
	Clear learning outcomes and program structure (C2)	Van Nuland et al. (2020), Carrillo & Flores (2020)
	Interactivity of online learning materials (C3)	Hofer & Grandgenett (2012), Marquez et al. (2016), Griffin et al. (2018), Bragg et al. (2021)
	Engaging, understandable, and accessible learning materials	Pierrakeas et al. (2004), Joo (2014)

	(C4)	
	Course duration (C5)	Croxton (2014)
Learners (L)	IT proficiency (L1)	Appana (2008), Chang & Kang (2016), Johnson et al. (2018)
	Time management skills (L2)	Selwyn (2011), Yasmin (2013)
	Motivation and commitment to learning (L3)	Knowles (1996), Lindeman (2015), Kara et al. (2019)
	Ability to concentrate on learning (L4)	Mishra et al. (2020)
	Support in online learning methods (L5)	Erickson & Noonan (2010), Dumais et al. (2013)
Instructors (I)	Interaction of instructors (I1)	Joo (2014), Dumais et al. (2013)
	ICT proficiency of instructors (I2)	Almaiah & Alyoussef (2019), Almaiah & Alyoussef (2019), García-Morales et al. (2021)
	Online teaching methods of instructors (I3)	Marinoni et al. (2020), García-Morales et al. (2021)
	Readiness level of instructors when participating in online teaching (I4)	Dwivedi et al. (2020), Govindarajan & Srivastava (2020)
Technology for online training (T)	Technical infrastructure - physical facilities (T1)	Almaiah & Almulhem (2018), Almaiah & Alyoussef (2019), Mishra et al. (2020)
	Software Foundation for Educational Technology (T2)	Mishra et al. (2020), Carolan et al. (2020), Govindarajan & Srivastava (2020), García-Morales et al. (2021)
	Security of the e-learning system (T3)	Almaiah & Almulhem (2018), Almaiah & Alyoussef (2019)

2. Generalized trapezoidal fuzzy numbers

Definition 1. The membership function of TrFN $\tilde{A} = (\tilde{\varepsilon}_1, \tilde{\varepsilon}_2, \tilde{\varepsilon}_3, \tilde{\varepsilon}_4; \tilde{\omega})$ is given by the following equation:

$$\mu_{\tilde{A}}(\tilde{x}) = \begin{cases} \mu_{\tilde{A}}^{L}(\tilde{x}), & \tilde{\varepsilon}_1 \le \tilde{x} \le \tilde{\varepsilon}_2, \\ \tilde{\omega}, & \tilde{\varepsilon}_2 \le \tilde{x} \le \tilde{\varepsilon}_3, \\ \mu_{\tilde{A}}^{R}(\tilde{x}), & \tilde{\varepsilon}_3 \le \tilde{x} \le \tilde{\varepsilon}_4, \\ 0, & \text{otherwise}, \end{cases} \tag{1}$$

where $\mu_{\tilde{A}}^{L}(\tilde{x})$ and $\mu_{\tilde{A}}^{R}(\tilde{x})$ are the left and right membership functions of $\tilde{A}$, respectively.

Definition 2. ***Arithmetic operations on generalized TrFNs***

$\tilde{F}=(\tilde{\varsigma}_1,\tilde{\varsigma}_2,\tilde{\varsigma}_3,\tilde{\varsigma}_4;\tilde{\omega}_{\tilde{F}})$ and $\tilde{T}=(\tilde{\tau}_1,\tilde{\tau}_2,\tilde{\tau}_3,\tilde{\tau}_4;\tilde{\omega}_T)$ are two generalized TrFNs, where $\tilde{\varsigma}_1,\tilde{\varsigma}_2,\tilde{\varsigma}_3,\tilde{\varsigma}_4,\tilde{\tau}_1,\tilde{\tau}_2,\tilde{\tau}_3$ and $\tilde{\tau}_4$ are real values, $\tilde{\omega}_F,\tilde{\omega}_T\in[0,1]$. The following arithmetic operators are defined for the generalized TrFNs $\tilde{F}$ and $\tilde{T}$ by the following equations:

(i). Addition $(+)$:

$$\tilde{F}(+)\tilde{T}=\left\{\tilde{\varsigma}_1+\tilde{\tau}_1,\tilde{\varsigma}_2+\tilde{\tau}_2,\tilde{\varsigma}_3+\tilde{\tau}_3,\tilde{\varsigma}_4+\tilde{\tau}_4;\min(\tilde{\omega}_{\tilde{F}},\tilde{\omega}_T)\right\}, \tag{2}$$

(ii). Subtraction $(-)$:

$$\tilde{F}(-)\tilde{T}=\left\{\tilde{\varsigma}_1-\tilde{\tau}_4,\tilde{\varsigma}_2-\tilde{\tau}_3,\tilde{\varsigma}_3-\tilde{\tau}_2,\tilde{\varsigma}_4-\tilde{\tau}_1;\min(\tilde{\omega}_{\tilde{F}},\tilde{\omega}_T)\right\}, \tag{3}$$

(iii). Multiplication (x):

$$\tilde{F}(\text{x})\tilde{T}=\left\{\tilde{\varsigma}_1\text{x}\,\tilde{\tau}_1,\tilde{\varsigma}_2\text{x}\,\tilde{\tau}_2,\tilde{\varsigma}_3\text{x}\,\tilde{\tau}_3,\tilde{\varsigma}_4\text{x}\,\tilde{\tau}_4;\min(\tilde{\omega}_{\tilde{F}},\tilde{\omega}_T)\right\}, \tag{4}$$

(iv). Division $(/)$:

$$\tilde{F}(/)\tilde{T}=\left\{\tilde{\varsigma}_1/\tilde{\tau}_4,\tilde{\varsigma}_2/\tilde{\tau}_3,\tilde{\varsigma}_3/\tilde{\tau}_2,\tilde{\varsigma}_4/\tilde{\tau}_1;\min(\tilde{\omega}_{\tilde{F}},\tilde{\omega}_T)\right\}, \tag{5}$$

where $\tilde{\varsigma}_1,\tilde{\varsigma}_2,\tilde{\varsigma}_3,\tilde{\varsigma}_4,\tilde{\tau}_1,\tilde{\tau}_2,\tilde{\tau}_3$ and $\tilde{\tau}_4$ are non-zero positive real numbers.

3. Proposed an integrated generalized fuzzy AHP-TOPSIS approach

This section proposes an integrated generalized fuzzy AHP-TOPSIS approach to overcome the shortcomings of Chang's (1996) fuzzy approach. The procedure of the proposed approach is as follows:

(i) Developing the comparison matrix for generalized TrFNs

$$\tilde{X}=(\tilde{t}_{uv})_{\delta\text{x}\delta}=\begin{bmatrix}(1,1,1,1;\tilde{\omega}_{11}) & (\tilde{n}_{12},\tilde{o}_{12},\tilde{p}_{12},\tilde{q}_{12};\tilde{\omega}_{12}) & \cdots & (\tilde{n}_{1\delta},\tilde{o}_{1\delta},\tilde{p}_{1\delta},\tilde{q}_{1\delta};\tilde{\omega}_{1\delta}) \\ (\tilde{n}_{21},\tilde{o}_{21},\tilde{p}_{21},\tilde{q}_{21};\tilde{\omega}_{21}) & (1,1,1,1;\tilde{\omega}_{22}) & \cdots & (\tilde{n}_{2\delta},\tilde{o}_{2\delta},\tilde{p}_{2\delta},\tilde{q}_{2\delta};\tilde{\omega}_{2\delta}) \\ \vdots & \vdots & \vdots & \vdots \\ (\tilde{n}_{\delta 1},\tilde{o}_{\delta 1},\tilde{p}_{\delta 1},\tilde{q}_{\delta 1};\tilde{\omega}_{\delta 1}) & (\tilde{n}_{\delta 2},\tilde{o}_{\delta 2},\tilde{p}_{\delta 2},\tilde{q}_{\delta 2};\tilde{\omega}_{\delta 2}) & \cdots & (1,1,1,1;\tilde{\omega}_{\delta\delta})\end{bmatrix}, \tag{6}$$

where $\tilde{t}_{uv}=(\tilde{n}_{uv},\tilde{o}_{uv},\tilde{p}_{uv},\tilde{q}_{uv};\tilde{\omega}_{uv})$, $\tilde{t}_{uv}^{-1}=(1/\tilde{q}_{uv},1/\tilde{p}_{uv},1/\tilde{o}_{uv},1/\tilde{n}_{uv};\tilde{\omega}_{uv})$ for $u,v=1,\dots,\delta$ and $u\neq v$.

(ii) Calculating the generalized fuzzy synthetic extents

In this study, the Wang et al. (2008) normalization formula is employed to calculate the values of fuzzy synthetic extents, as the following equation:

$$\tilde{E}_u = \left(\tilde{j}_u, \tilde{k}_u, \tilde{l}_u, \tilde{m}_u; \min(\tilde{\omega}_{uv})\right) = \sum_{v=1}^{\delta} \tilde{H}_{uv} \otimes \left[\sum_{u=1}^{\delta}\sum_{v=1}^{\delta} \tilde{H}_{uv}\right]^{-1}$$

$$= \left(\begin{array}{c} \dfrac{\sum_{j=1}^{\delta} \tilde{j}_{uv}}{\sum_{v=1}^{\delta} \tilde{j}_{uv} + \sum_{z=1,z\neq u}^{\delta} \sum_{v=1}^{\delta} \tilde{m}_{kv}}, \dfrac{\sum_{j=1}^{\delta} \tilde{k}_{uv}}{\sum_{j=1}^{\delta} \tilde{k}_{uv} + \sum_{z=1,z\neq u}^{\delta} \sum_{v=1}^{\delta} \tilde{l}_{uv}}, \\ \dfrac{\sum_{j=1}^{\delta} \tilde{l}_{uv}}{\sum_{j=1}^{\delta} \tilde{l}_{uv} + \sum_{z=1,z\neq u}^{\delta} \sum_{v=1}^{\delta} \tilde{k}_{uv}}, \dfrac{\sum_{j=1}^{\delta} \tilde{m}_{uv}}{\sum_{j=1}^{\delta} \tilde{m}_{uv} + \sum_{z=1,z\neq u}^{\delta} \sum_{v=1}^{\delta} \tilde{j}_{uv}}; \min(\tilde{\omega}_{uv}) \end{array} \right), \quad (7)$$

where $\sum_{v=1}^{\delta} \tilde{H}_{uv} = \left(\sum_{v=1}^{\delta} \tilde{j}_{uv}, \sum_{v=1}^{\delta} \tilde{k}_{uv}, \sum_{v=1}^{\delta} \tilde{l}_{uv}, \sum_{v=1}^{\delta} \tilde{m}_{uv}; \min(\tilde{\omega}_{uv})\right), \ u, v = 1, 2, ..., \delta.$

(iii) Determine $\tilde{I}^+, \tilde{I}^-, \tilde{d}_u^+$ ***and*** $\tilde{d}_u^-$

This section defines a "positive-ideal solution" (FPIS, $\tilde{I}^+$) and a "negative ideal solution" (FNIS, $\tilde{I}^-$) in the following equations:

$$\tilde{I}^+ = (1,1,1,1;1), \quad (8)$$

$$\tilde{I}^- = (0,0,0,0;1), \quad (9)$$

The distances of $\tilde{I}_u$ from $\tilde{I}^+$ and $\tilde{I}^-$ are defined as in equations (10)-(11):

$$\tilde{d}_u^+ = \min(\tilde{\omega}_u)\sqrt{\sum_{u=1}^{\delta} (\tilde{E}_u - \tilde{I}^+)^2}, \quad (10)$$

$$\tilde{d}_u^- = \min(\tilde{\omega}_u)\sqrt{\sum_{u=1}^{\delta} (\tilde{E}_u - \tilde{I}^-)^2}, \quad (11)$$

where $\tilde{E}_u$ is the value of fuzzy synthetic extents, $u = 1, ..., \delta.$

(iv). Determine the prioritization level of influencing factors

This study applies a closeness coefficient (W_u) to determine the prioritization level of the influencing factors in the following equation:

$$W_u = \frac{\dfrac{\tilde{d}_u^-}{\tilde{d}_u^+ + \tilde{d}_u^-}}{\sum_{u=1}^{\delta}\left(\dfrac{\tilde{d}_u^-}{\tilde{d}_u^+ + \tilde{d}_u^-}\right)}, \quad (12)$$

where $\tilde{d}_u^+$ and $\tilde{d}_u^-$ are the distances of $\tilde{I}_u$ from $\tilde{I}^+$ and $\tilde{I}^-$, respectively, $u = 1, ..., \delta.$

Figure 1 shows the proposed integrated generalized fuzzy AHP-TOPSIS approach used to determine the priority levels of influencing factors that impact the effectiveness of online professional skills training programs for lecturers.

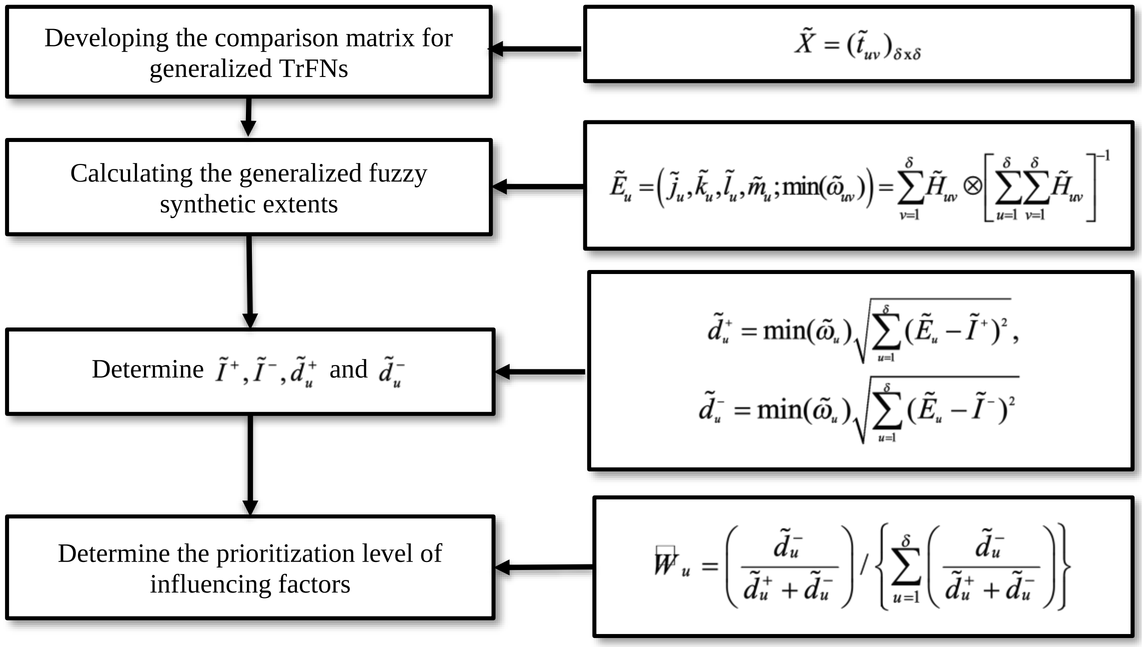

Figure 1. The flowchart of the proposed integrated generalized fuzzy AHP-TOPSIS approach

4. Application of the integrated generalized fuzzy AHP-TOPSIS approach

In this section, the improved integrated generalized fuzzy AHP-TOPSIS approach is applied to define the priority factors impacting the effectiveness of online professional skills training programs for lecturers at the VNU-Hanoi, Vietnam. Tables 3-8 present the average evaluation values of the committee (consisting of 04 decision makers) regarding the impact of 05 factors with 21 sub-factors using the trapezoidal fuzzy conversation scale in Table 2.

Table 2. Trapezoidal fuzzy conversation scale

Order	Linguistic values	TrFNs
1	Equal importance (EI)	(1, 1, 1, 1; 1.0)
2	Between EI and WI	(1, 2, 3, 4; 0.7)
3	Weak importance of one over another (WI)	(2, 3, 4, 5; 0.7)
4	Between WI and SI	(3, 4, 5, 6; 0.8)
5	Strong importance (SI)	(4, 5, 6, 7; 0.8)
6	Between SI and VSI	(5, 6, 7, 8; 0.9)
7	Very strong importance (VSI)	(6, 7, 8, 9; 0.9)
8	Between VSI and AI	(7, 8, 9, 10; 1.0)
9	Absolute importance (AI)	(8, 9, 10, 10; 1.0)

Table 3. Averaged fuzzy comparison matrix of five factors assessed by the committee

Factors	P	C	L	E	T
P	(1.00, 1.00, 1.00, 1.00; 1.00)	(1.11, 1.40, 1.71, 1.71; 0.70)	(1.06, 1.32, 1.59, 1.59; 0.80)	(1.06, 1.57, 2.08, 2.08; 0.70)	(1.29, 1.80, 2.31, 2.31; 0.70)
C	(0.47, 0.59, 0.72, 0.72; 0.70)	(1.00, 1.00, 1.00, 1.00; 1.00)	(0.79, 0.79, 0.80, 0.80; 0.80)	(0.81, 0.83, 0.88, 0.88; 0.70)	(1.54, 2.05, 2.56, 2.56; 0.70)
L	(0.54, 0.63, 0.76, 0.76; 0.80)	(1.23, 1.25, 1.26, 1.26; 0.80)	(1.00, 1.00, 1.00, 1.00; 1.00)	(3.29, 4.05, 4.81, 4.81; 0.70)	(2.00, 2.50, 3.00, 3.00; 0.80)
I	(0.39, 0.48, 0.64, 0.64; 0.70)	(1.00, 1.14, 1.20, 1.20; 0.70)	(0.18, 0.21, 0.25, 0.25; 0.70)	(1.00, 1.00, 1.00, 1.00; 1.00)	(2.28, 3.03, 3.79, 3.79; 0.70)
T	(0.35, 0.43, 0.56, 0.56; 0.70)	(0.32, 0.39, 0.49, 0.49; 0.70)	(0.29, 0.33, 0.40, 0.40; 0.80)	(0.22, 0.26, 0.33, 0.33; 0.70)	(1.00, 1.00, 1.00, 1.00; 1.00)

Table 4. Averaged fuzzy comparison matrix of four sub-factors assessing “Policies of higher education institutions”

P	P1	P2	P3	P4
P1	(1.00, 1.00, 1.00, 1.00; 1.00)	(2.04, 2.54, 3.05, 3.56; 0.70)	(0.58, 0.84, 1.11, 1.40; 0.70)	(0.84, 1.36, 1.90, 2.53; 0.70)
P2	(0.28, 0.33, 0.39, 0.49; 0.70)	(1.00, 1.00, 1.00, 1.00; 1.00)	(1.05, 1.31, 1.58, 1.88; 0.70)	(0.78, 1.03, 1.28, 1.54; 0.70)
P3	(0.72, 0.90, 1.19, 1.73; 0.70)	(0.53, 0.63, 0.76, 0.95; 0.70)	(1.00, 1.00, 1.00, 1.00; 1.00)	(0.58, 0.84, 1.11, 1.41; 0.70)
P4	(0.40, 0.53, 0.74, 1.19; 0.70)	(0.65, 0.78, 0.97, 1.29; 0.70)	(0.71, 0.90, 1.19, 1.74; 0.70)	(1.00, 1.00, 1.00, 1.00; 1.00)

Table 5. Averaged fuzzy comparison matrix of five sub-factors assessing “Training program content”

C	C1	C2	C3	C4	C5
C1	(1.00, 1.00, 1.00, 1.00; 1.00)	(3.25, 4.00, 4.75, 5.25; 0.70)	(3.75, 4.75, 5.75, 6.75; 0.70)	(2.28, 3.03, 3.78, 4.53; 0.70)	(2.75, 3.75, 4.75, 5.75; 0.70)
C2	(0.19, 0.21, 0.25, 0.31; 0.70)	(1.00, 1.00, 1.00, 1.00; 1.00)	(2.29, 2.80, 3.31, 3.83; 0.70)	(0.58, 0.84, 1.11, 1.41; 0.70)	(2.50, 3.25, 4.00, 4.75; 0.70)
C3	(0.15, 0.17, 0.21, 0.27; 0.70)	(0.26, 0.30, 0.36, 0.44; 0.70)	(1.00, 1.00, 1.00, 1.00; 1.00)	(0.78, 0.78, 0.79, 0.79; 0.90)	(3.75, 4.75, 5.75, 6.75; 0.70)
C4	(0.22, 0.26, 0.33, 0.44; 0.70)	(0.71, 0.90, 1.19, 1.74; 0.70)	(1.26, 1.27, 1.28, 1.29; 0.90)	(1.00, 1.00, 1.00, 1.00; 1.00)	(3.25, 4.25, 5.25, 6.25; 0.70)
C5	(0.17, 0.21, 0.27, 0.36; 0.70)	(0.21, 0.25, 0.31, 0.40; 0.70)	(0.15, 0.17, 0.21, 0.27; 0.70)	(0.16, 0.19, 0.24, 0.31; 0.70)	(1.00, 1.00, 1.00, 1.00; 1.00)

Table 6. Averaged fuzzy comparison matrix of five sub-factors assessing "Learners"

L	L1	L2	L3	L4	L5
L1	(1.00, 1.00, 1.00, 1.00; 1.00)	(2.25, 3.00, 3.75, 4.50; 0.70)	(0.36, 0.38, 0.40, 0.46; 0.70)	(1.11, 1.38, 1.66, 1.97; 0.70)	(0.78, 0.78, 0.78, 0.79; 1.00)
L2	(0.22, 0.27, 0.33, 0.44; 0.70)	(1.00, 1.00, 1.00, 1.00; 1.00)	(0.58, 0.60, 0.63, 0.68; 0.70)	(0.80, 1.06, 1.33, 1.63; 0.70)	(0.19, 0.23, 0.30, 0.44; 0.70)
L3	(2.18, 2.47, 2.67, 2.81; 0.70)	(1.48, 1.60, 1.67, 1.72; 0.70)	(1.00, 1.00, 1.00, 1.00; 1.00)	(2.04, 2.55, 3.06, 3.58; 0.70)	(1.04, 1.29, 1.55, 1.81; 0.70)
L4	(0.51, 0.60, 0.72, 0.90; 0.70)	(0.62, 0.75, 0.94, 1.25; 0.70)	(0.28, 0.33, 0.39, 0.49; 0.70)	(1.00, 1.00, 1.00, 1.00; 1.00)	(1.07, 1.58, 2.10, 2.63; 0.70)
L5	(1.27, 1.28, 1.29, 1.29; 1.00)	(2.29, 3.33, 4.36, 5.38; 0.70)	(0.55, 0.65, 0.77, 0.97; 0.70)	(0.38, 0.48, 0.63, 0.93; 0.70)	(1.00, 1.00, 1.00, 1.00; 1.00)

Table 7. Averaged fuzzy comparison matrix of four sub-factors assessing "Instructors"

I	I1	I2	I3	I4
I1	(1.00, 1.00, 1.00, 1.00; 1.00)	(1.50, 2.00, 2.50, 3.00; 0.70)	(0.56, 0.57, 0.58, 0.59; 0.90)	(1.56, 2.07, 2.58, 3.10; 0.70)
I2	(0.33, 0.40, 0.50, 0.67; 0.70)	(1.00, 1.00, 1.00, 1.00; 1.00)	(0.58, 0.59, 0.61, 0.66; 0.70)	(0.84, 1.11, 1.40, 1.71; 0.70)
I3	(1.69, 1.73, 1.76, 1.79; 0.90)	(1.51, 1.63, 1.69, 1.74; 0.70)	(1.00, 1.00, 1.00, 1.00; 1.00)	(1.79, 2.30, 2.81, 3.33; 0.70)
I4	(0.32, 0.39, 0.48, 0.64; 0.70)	(0.59, 0.72, 0.90, 1.19; 0.70)	(0.30, 0.36, 0.43, 0.56; 0.70)	(1.00, 1.00, 1.00, 1.00; 1.00)

Table 8. Average fuzzy comparison matrix of three sub-factors assessing "Technology for online training"

T	T1	T2	T3
T1	(1.00, 1.00, 1.00, 1.00; 1.00)	(0.78, 0.79, 0.79, 0.80; 0.90)	(1.75, 2.50, 3.25, 4.00; 0.70)
T2	(1.25, 1.26, 1.27, 1.28; 0.90)	(1.00, 1.00, 1.00, 1.00; 1.00)	(1.75, 2.50, 3.25, 4.00; 0.70)
T3	(0.25, 0.31, 0.40, 0.57; 0.70)	(0.25, 0.31, 0.40, 0.57; 0.70)	(1.00, 1.00, 1.00, 1.00; 1.00)

By utilizing Equation (7), Chang's approach, and Tables 03-08, we have computed the fuzzy synthetic extent values of factors and sub-factors, which are presented in Table 09.

Table 9. Fuzzy synthetic extent values of factors and sub-factors

Factors	**Fuzzy synthetic extents (proposed approach)**	**Fuzzy synthetic extents (Chang's approach)**	**Sub-factors**	**Fuzzy synthetic extents (proposed approach)**	**Fuzzy synthetic extents (Chang's approach)**
P	(0.15, 0.21, 0.27, 0.35; 0.7)	(0.14, 0.20, 0.29, 0.41; 0.70)	P1	(0.23, 0.32, 0.41, 0.49; 0.70)	(0.19, 0.30, 0.44, 0.65; 0.70)
			P2	(0.14, 0.20, 0.26, 0.33; 0.70)	(0.13, 0.19, 0.27, 0.37; 0.70)
			P3	(0.13, 0.18, 0.24, 0.33; 0.70)	(0.12, 0.17, 0.25, 0.39; 0.70)
			P4	(0.13, 0.17, 0.23, 0.33; 0.70)	(0.12, 0.17, 0.24, 0.40; 0.70)

C	(0.12, 0.15, 0.19, 0.25; 0.7)	(0.11, 0.15, 0.20, 0.27; 0.70)	C1	(0.28, 0.36, 0.45, 0.53; 0.70)	(0.23, 0.34, 0.49, 0.69; 0.70)
			C2	(0.13, 0.17, 0.23, 0.29; 0.70)	(0.12, 0.17, 0.24, 0.34; 0.70)
			C3	(0.11, 0.15, 0.19, 0.25; 0.70)	(0.10, 0.14, 0.20, 0.27; 0.70)
			C4	(0.12, 0.16, 0.21, 0.28; 0.70)	(0.11, 0.16, 0.22, 0.32; 0.70)
			C5	(0.03, 0.04, 0.05, 0.07; 0.70)	(0.03, 0.04, 0.05, 0.07; 0.70)
L	(0.22, 0.28, 0.34, 0.42; 0.7)	(0.20, 0.27, 0.36, 0.49; 0.70)	L1	(0.15, 0.20, 0.25, 0.31; 0.70)	(0.14, 0.19, 0.26, 0.35; 0.70)
			L2	(0.07, 0.09, 0.12, 0.16; 0.70)	(0.07, 0.09, 0.12, 0.17; 0.70)
			L3	(0.21, 0.27, 0.32, 0.39; 0.70)	(0.20, 0.26, 0.34, 0.44; 0.70)
			L4	(0.09, 0.13, 0.17, 0.23; 0.70)	(0.09, 0.12, 0.17, 0.25; 0.70)
			L5	(0.15, 0.20, 0.26, 0.33; 0.70)	(0.14, 0.20, 0.27, 0.38; 0.70)
I	(0.13, 0.17, 0.22, 0.28; 0.7)	(0.12, 0.17, 0.23, 0.32; 0.70)	I1	(0.23, 0.29, 0.35, 0.41; 0.70)	(0.20, 0.28, 0.37, 0.49; 0.70)
			I2	(0.13, 0.16, 0.19, 0.24; 0.70)	(0.12, 0.15, 0.20, 0.26; 0.70)
			I3	(0.28, 0.34, 0.39, 0.45; 0.70)	(0.26, 0.33, 0.41, 0.50; 0.70)
			I4	(0.10, 0.12, 0.15, 0.20; 0.70)	(0.10, 0.12, 0.16, 0.22; 0.70)
T	(0.05, 0.07, 0.09, 0.13; 0.7)	(0.05, 0.07, 0.09, 0.13; 0.70)	T1	(0.30, 0.37, 0.44, 0.51; 0.70)	(0.25, 0.35, 0.47, 0.64; 0.70)
			T2	(0.33, 0.41, 0.48, 0.56; 0.70)	(0.28, 0.39, 0.52, 0.70; 0.70)
			T3	(0.11, 0.13, 0.17, 0.22; 0.70)	(0.11, 0.13, 0.17, 0.24; 0.70)

Using Equations (8)-(12), the weight vectors of the factors and sub-factors on the effectiveness of online training courses in enhancing lecturers' capabilities are shown in Table 10. However, Chang's approach is unable to determine the priority levels of influencing factors and sub-factors in the case of generalized TrFNs. The research results indicate that learners and training program content factors have the strongest impact on the effectiveness of online training courses in improving the professional capacity of lecturers at the VNU-Hanoi. Specifically, for learners, IT proficiency (L1), motivation and commitment to learning (L3), and support in online learning methods (L5) are the most important factors influencing the effectiveness of online training courses. On the other hand, for the training program content factor, clear learning outcomes and program structure (C2), interactivity of online learning materials (C3), and engaging, understandable, and accessible learning materials (C4) play a significant role in determining the effectiveness of online training courses. Therefore, drawing from Decision Science, to ensure the effectiveness of online professional skills training programs for lecturers at the VNU-Hanoi, learners (who are lecturers) need to be supported not only with time and financial assistance from the member universities and schools but also possess clear motivation, determination, and the ability to utilize technology for online learning. Additionally, the training content for lecturers should be comprehensive, encompassing political ideology, ethics, professional knowledge, modern pedagogical skills, and life skills. Specifically, there should be a strong emphasis on training and developing positive teaching methods and formats that foster learners' independence, creativity, autonomy, and self-directed learning. It is also crucial to enhance the application of scientific, technological, and information technology skills, as well as digital transformation in management, teaching, and learning processes, to meet society's overall development demands. Some previous studies have indicated that online learning requires learners to possess information technology skills, time management abilities, motivation, and commitment to learning (Saleem et al., 2022). Additionally, time management and organizational skills influence online courses' effectiveness for adult learners. The challenges related to lecturers' technological competencies include inadequate information technology skills (García-Morales et al., 2021) and lecturers' level of access and acceptance of e-learning systems (Almaiah et al., 2019b). Figure 2 displays the global weights assigned to the sub-factors.

Table 10. Weight vector of factors and sub-factors impacting the effectiveness of online professional skills training programs for lecturers

Factors	Weight scores	Subfactors	Weight scores	Global weights
P	0.240	P1	0.346	0.083
		P2	0.224	0.054
		P3	0.217	0.052
		P4	0.214	0.051
C	0.174	C1	0.389	0.068
		C2	0.201	0.035
		C3	0.172	0.030
		C4	0.192	0.033
		C5	0.046	0.008
L	0.304	L1	0.220	0.067
		L2	0.110	0.033
		L3	0.287	0.087
		L4	0.152	0.046
		L5	0.231	0.070
I	0.197	I1	0.318	0.063
		I2	0.178	0.035
		I3	0.359	0.071
		I4	0.146	0.029
T	0.085	T1	0.401	0.034
		T2	0.440	0.037
		T3	0.159	0.014

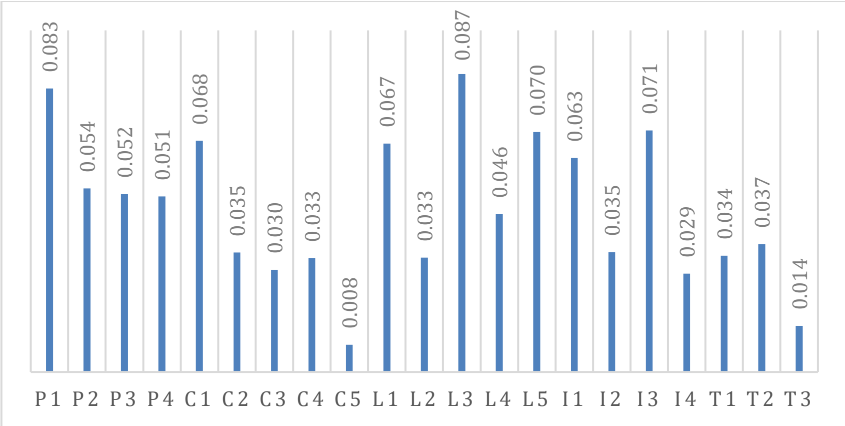

Figure 2. The global weights of sub-factors impacting the effectiveness of online professional skills training programs for lecturers

5. Conclusion

Under the impact of the COVID-19 pandemic and digital transformation, developing professional capacity for teachers through online training plays a vital role in enhancing the quality of higher education. To contribute to the literature in this direction, this study developed a new integrated fuzzy AHP-TOPSIS approach for prioritizing factors in online professional skills training programs for lecturers at the VNU-Hanoi. The shortcomings of Chang's (1996) fuzzy AHP approach were indicated, including the following: (i) it is limited to using normalized triangular fuzzy numbers, and (ii) in some cases, Chang's (1996) approach resulted in the irrational weighting of decision criteria. Therefore, to overcome the limitations of Chang's (1996) fuzzy approach, this study applied the TOPSIS method by using generalized trapezoidal fuzzy numbers (TrFNs) to determine the prioritization level of influencing factors. The study considered 21 sub-factors across five factors, including the policies of higher education institutions, training program content, learners, instructors, and technology for online training. Data for the study were collected through in-depth interviews with experts and managers at the Vietnam National University, Hanoi (VNU-Hanoi). The research results indicate that learners and training program content factors have the most substantial impact on the effectiveness of online training courses in improving the professional capacity of teachers at the VNU-Hanoi. Based on Decision Science principles, several recommendations were put forward for the VNU-Hanoi and its member universities and schools: (i) allocate sufficient time and provide resource support to enable lecturers' participation in training courses; (ii) create comprehensive training content for lecturers, encompassing political ideology, ethics, professional knowledge, modern pedagogical skills, and life skills; (iii) strengthen the utilization of scientific, technological, and information technology skills, along with digital transformation in management, teaching, and learning processes, to meet the broader development needs of society. The research also demonstrates the feasibility of the proposed model in addressing practical issues. However, the proposed integrated fuzzy AHP-TOPSIS approach was limited to static time and real numbers. Future research could focus on expanding and refining the proposed approach in a dynamic timeframe and interval fuzzy numbers. Academics and practitioners could apply our approach to study some important issues in Decision Sciences, including Economic, Investment, Financial, Business, and Tourism, see, for example, Ali et al. (2022), Erulgen et al. (2022), Gohar et al. (2022), Hao & Wong (2021), Johari et al. (2022), Kien et al. (2018), Mendieta-Aragon & Garín-Muñoz (2020), Naveed et al. (2023), Noman et al. (2023), Quynh (2023), Vo et al. (2019), and many others for more information.

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