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The Use of a DANP with VIKOR Approach for Establishing the Model of E-Learning Service Quality

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ABSTRACT

In practical environments, e-learners encounter service providers of varying quality. A wide range of criteria are used to assess service quality, but most of these criteria have interdependent or interactive characteristics, which can make it difficult to effectively analyze and improve service quality. The purpose of this study is to address this issue using a hybrid MCDM (multiple criteria decision-making) approach that includes the DEMATEL (decision-making trial and evaluation laboratory), DANP (the DEMATEL-based analytic network process) and VIKOR methods to achieve an optimal solution. By exploring the influential interrelationships between criteria related to e-learning, this approach can be used to solve interdependence and feedback problems, allowing for greater satisfaction of the actual needs of e-learners.

Keywords: e-learning and service quality, DANP (DEMATEL-based analytic network process), MCDM (multiple criteria decision-making), VIKOR, INRM

INTRODUCTION

In recent years, workplace learning has utilized technology to meet the demands of employees and Higher Education for continued professional development (Hsieh, 2016; Keramati, 2011). The majority of research in this field has previously focused on analysis at the student level (de Jong, 1998; Sun, Tsai, Finger, Chen, Yeh, 2008), whereas this investigation is focused on E-Learning. Although it is very beneficial to have ready access to all of this stored information, the process of digital learning does require the learner to choose his own materials. In certain cases, the abundance of available information can cause significant problems for learners. The quantity of available teaching material online is increasing at an exponential rate that greatly exceeds the maximum rate at which learners can absorb this material. Jonassen et al. call for E-Learning to embrace a constructivist approach to learning systems, as certain programs are not suited for e-learners who must accommodate themselves to a particular type of teaching material. E-Learning attempts to address this issue through the use of interactive games or simulations (Rosenberg, 2001; Zhang, Zhou, Briggs, 2006). Given the motivations stated above, this research therefore seeks to

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State of the literature

- This study using a hybrid MCDM approach that includes the DEMATEL, DANP and VIKOR methods to achieve an optimal solution.
- These results suggest that performance quality should be viewed as the most important factor for overall improvement of E-Learning services. The main characteristics of the motivations for using digital learning include searching for information, maximizing learning speed and accessing information daily. Users with these characteristics emphasize informational access.

Contribution of this paper to the literature

- A wide range of criteria are used to assess service quality, but most of these criteria have interdependent or interactive characteristics, which can make it difficult to effectively analyze and improve service quality.
- In this study, the evaluations of E-Learning service provided by the domain experts produced useful results. In descending order, the improvement priorities obtained from this analysis was as follows: convenience, social and informational.

answer the following questions: What are the characteristics of the digital learning population? What variables influence learning motivation? What is the relationship between motivation and action? What variables influence action?

The purpose of the present study is to address these questions by employing the multiple criteria decision-making (MCDM) method to examine the dependent relationships among various dimensions of the criteria related to passenger satisfaction and intentions regarding the use of E-Learning services in Taiwan; ultimately, this procedure will produce suggestions for optimal improvement models. The first step in this process is to construct a more integrated model of service evaluation systems. A DEMATEL (decision-making trial and evaluation laboratory) technique is used to construct an influential network relationship map (INRM), which is then utilized to illustrate the influential network of the determinants that are related to E-Learning service. Subsequently, the DEMATEL-based ANP (DANP) method is employed to determine the influential weights of the criteria for further analysis using VIKOR, which calculates the gap distances to the desired level of service delivery.

LITERATURE REVIEW

This section begins by reviewing the concepts underlying E-Learning and the digital learning environment. As E-Learning has become an important trend for the training systems of modern enterprises. The findings from the literature addressing convenience type, information type, social type and certain external elements are presented to explain the technology usage behavior of students in an E-Learning environment.

E-Learning

E-Learning refers to the ability to use digital or electronic tools (through both wired and wireless Internet connections) to retrieve digital information or teaching materials for further online or offline learning activities, to apply technology wisely and to help digital students learn effectively. At present, the rapid growth of digital information is a continuing trend, and the rate of increase in the available information surpasses our abilities to absorb and apply that information. The growth rate of digital information is also too rapid for traditional learning to keep pace (Bouhnik, Marcus, 2006). Ideally, E-Learning seeks to provide a configurable infrastructure that integrates learning materials, tools and services into a single solution that creates, delivers training or educational content quickly, effectively and economically (de Jong, 1998). We hope to use the instantaneous and interactive qualities of technology and the Internet to design improved teaching materials.

Informational, Convenience, and Social Motivations

Although there is a great deal of research that evaluates different aspects of E-Learning, there are few published data regarding the variables that influence learning motivation factors in an E-Learning context. McQuail organized the motivation and satisfaction considerations underlying the use of media in 1994 (McQuail, 1994). In

that study, the motivations of the audience were organized into four broad categories, including information, self-assurance, social interactions, and pure entertainment. Examining these classifications individually, they can be further subcategorized into users who wish to accomplish one or more of the following goals: receive information and advice; develop a sense of security; learn new things; pursue personal values; search for help; discover innovations for their lives; experience sympathy for others; have social contact; have surrogate social contact; escape from their troubles and worries; enter an imaginative world; pass time; and develop particular habits.

Convenience Motivations

E-Learning studies stress that the CSFs for E-Learning include the following aspects: technology and infrastructure; design; instructor and learner characteristics; support; and content issues. Additional success factors include course and environmental dimensions (Saaty, 1996). The benefits of E-Learning have been discussed in many articles (Bouhnik, & Marcus, 2006; Liu, Tzeng, & Lee, 2012). In particular, Rosenberg has noted that these benefits include the lack of lag before commencing learning, the lack of distance restrictions, the ability to update information immediately, and the ability to share content and information easily among various learners and instructors.

Informational Motivations

Alavi observes that technology-mediated learning environments may improve students' achievements; in his study, a virtual class scored an average of 20% higher than a traditional one (Alavi, 1994). E-Learning is still in its infancy in developing countries, as these nations experience challenges that differ from the issues faced in developed countries. Many developing countries have expressed an interest in the implementation of E-Learning (Grönlund & Islam, 2010). In the present economy, companies face increasing pressures to cut costs and provide customers with the high levels of quality that they expect. In this context, interactivity in E-Learning is the method of choice for the training of complex tasks in the workplace, as we will demonstrate. Thus, E-Learning represents an almost ideal approach for flexible and cost-effective competence development, as it can be used without restrictions related to physical location and time (Horton & Horton, 2003). Livari, in conjunction with Delone & McLean (McQuail, 1994) characterized system quality as the degree to which an information system possesses the desired characteristics and measured this quality using the following criteria: convenience of access, system flexibility, system integration, response time, interaction, navigation, and ease of use.

Social Motivations

Casarotti et al. provide extensive discussions of the interaction between relationships and expand the study of the making of friends through E-Learning (Casarotti, Pieti, & Sartori, 2002). One of the effective ways to understand, describe and assess aspects of E-Learning design and implementation is Saade dimensional model (Saade, & Bahli, 2005). The findings of this model suggest that it may be important to integrate interactive instructional techniques into E-Learning systems (Bernroider, 2008).

METHODOLGY

Tzeng and Huang indicate that the multiple criteria decision-making (MCDM) method can consider multiple criteria simultaneously and assist decision-makers in estimating optimal solutions, given the characteristics of the limited cases that are available (Tzeng, Tsaur, Laiw, & Opricovic, 2002a). First, the DEMATEL method was used to confirm the effect of each criterion and to explore the relevance of the various connection service parameters. Subsequently, the DANP (DEMATEL-based ANP) approach, which is a novel combination of the DEMATEL and ANP methods based on the concepts of Saaty, was adopted to calculate the influential weights of each criterion (Saaty, 1996). Finally, the VIKOR method was used to empirically evaluate the overall performance of connection services.

Table 1. The dimensions and criteria associated with E-Learning

Dimensions/Origin	Criteria	Evaluated Item
Information Type (D_1)	Time unlimit (C_{11})	Digital learning provides scheduling flexibility and avoids temporal restrictions
	Increase Knowledge (C_{12})	Digital learning can improve the results of knowledge absorption.
	Repeated learning (C_{13})	Digital learning permits the repeated learning of educational content.
	Quick access (C_{14})	Digital learning allows quick access to information.
	Learning anywhere (C_{15})	Digital learning does not have site limitations.
Convenience Type (D_2)	Lessen pressure (C_{21})	Digital learning lessens my learning pressure.
	Content interesting (C_{22})	Digital learning makes the learning process more interesting.
	Time go faster (C_{23})	Digital learning makes the time go faster.
	Interactive environment (C_{24})	Digital learning provides an interactive environment.
Social Type (D_3)	Broaden my friend (C_{31})	Digital learning can broaden my friend-making group.
	Online learning (C_{32})	Digital learning permits the learning of information without requiring face-to-face interactions.
	Common topic (C_{33})	Digital learning is a common topic among my friends.

Evaluation Criteria and Data Collection

A list of factors was found in the literature, as discussed above. These factors are included as the evaluation criteria of this study and incorporated into the design of the hybrid MCDM survey, which included three dimensions and twelve criteria (see **Table 1**).

Because this survey is focused on E-Learning, the perspectives regarding the assessment criteria were received from domain experts through personal interviews and completed surveys. The expert group is comprised of 30 expert users who employed E-Learning. Among these experts, 16 individuals are experienced E-Learning leaders, 8 individuals are officials from the E-Learning departments of government, and the remaining 6 individuals are E-Learning scholars. The survey collected the ratings of these experts for each criterion using a 5-point scale ranging from 0 (no effect) to 4 (extremely influential). A total of 30 surveys were obtained during the period from June 2015 to July 2015. Each interview conducted with an expert was approximately 40 to 50 minutes in duration, and the surveys were collected at the end of the interviews.

Building a Network Relationship Using the DEMATEL Technique

The DEMATEL technique is commonly used to solve problems in MCDM. The DEMATEL approach is employed in this study to display the direct/indirect influential relationships in the analyzed subsystems, as this display assists in developing a complete decision model. The DEMATEL technique uses matrix calculations to obtain all of the direct and indirect influential relationships and the strength of each effect. A visual structural matrix and influence diagram is used to depict the influential relationship and the level of influence among the criteria of a complex system (Chen, Tzeng, & Hsu, 2011; Huang, Shyu, & Tzeng, 2007; Wang, 2003; Horton, & Horton, 2003).

Using the DANP Method to Determine the Influence of Weights

After the DEMATEL approach confirms the influential relationships between the criteria, the DANP method is used to obtain their most accurate weights. The ANP, introduced by Saaty, seeks to decrease the limitations associated with the analytic hierarchy process (AHP), thereby creating a solution for determining nonlinear and complex network relationships (Saaty, 1996). Therefore, this research supplements the DEMATEL

technique with the utility of the ANP to solve the dependence and feedback problems associated with the interrelationships between the criteria (Liaw, Huang, & Chen, 2007; Chao, & Chen, 2009). Saaty proposed a method for the analysis of the ANP by adopting the limiting-process method to evaluate the powers of the supermatrix (Tsai, Chou, Hsu, 2009). Although the ANP can theoretically be used for the treatment of interdependencies, it is wise to first adopt the DEMATEL technique to generate influential relationships; moreover, the treatment of interdependencies in an unweighted supermatrix requires the use of the DEMATEL. Thus, a hybrid MCDM model that combines the DEMATEL technique with the ANP (DANP) method can be used to solve dependence and feedback problems. This combined method has been successfully used in various fields for purposes that include the evaluation of E-Learning (Tzeng, Teng, Chen, & Opricovic, 2002). To gain valuable decision-making information, the DEMATEL approach is first used to draw a relationship diagram for connection service. The DANP method is then utilized to determine the influential weights of the evaluation criteria and prioritize them accordingly.

Evaluating the Total Performance Using the VIKOR Method

The VIKOR method was developed by Opricovic & Tzeng as a multicriteria decision-making method to solve discrete decision problems containing no commensurable and conflicting criteria (Opricovic, & Tzeng, 2007; Ou Yang, Shieh, & Leu, 2009; Opricovic, &Tzeng, 2002; Opricovic, & Tzeng, 2003; Opricovic, & Tzeng, 2004).

VIKOR introduces the multicriteria ranking index based on the closeness of a solution to the ideal and may be applied within MCDM to identify a compromise solution (Ou Yang, Shieh, Leu, & Tzeng, 2008). This solution is the compromise between the positive-ideal (desired) solution and the negative-ideal (worst) solution. Using this concept, the method can rank and select alternatives for all criteria, using the same criteria for each alternative, and thereby derive a compromise solution that contains minimal gaps (Opricovic, & Tzeng, 2003). In this study, VIKOR is used to rank the unimproved gaps in the overall E-Learning service performances evaluated by experts. For this process, we use the performance scores from 0 to 4 (very bad ←0, 1, 2, 3, 4→very good) obtained from questionnaires; thus, the aspiration level can be set at a score of 4, and the worst value possible is a score of zero. Therefore, in this research, we set as the aspiration level and as the worst value, an approach that differs from traditional methods. The approach used in this study can avoid the situation of "Choosing the best from among inferior choices/options/alternatives" (i.e., it can avoid the notion of picking the best apple from a barrel of rotten apples). This method is widely used in various fields, such as information security (Ou Yang, Shieh, Leu, & Tzeng, 2008), tourism policy management (Liu, Tzeng, & Lee, 2012), hospitality management (Chen, Tzeng, & Hsu, 2011), big data (Yang, Huang, Kao, & Tasi, 2017), environmental education (Hsueh, & Su, 2016) and bus transportation management (Tzeng, Lin, & Opricovic, 2005).

Empirical Case Analysis of E-Learning

This section conducts an overall assessment of E-Learning to propose improvement strategies using an empirical case involving E-Learning in Taiwan. The data collected from expert users are analyzed by a hybrid MCDM method, and the results from this analysis are presented in useful decision-making models.

Description of the problems

The rapid growth of information technology has allowed digital learning to exceed prior spatial and temporal restrictions, resulting in the transfer of knowledge at a faster pace. For this reason, digital learning has become a new addition to the field of multimedia. An examination of research into the field of digital learning around the world reveals that the primary focus of this research is the media content of the educational material, whereas the learners of this digital information are being neglected. This neglect will influence digital learner motivation. The quantity of teaching material available is increasing at an exponential rate that far exceeds the rate at which learners can absorb this material. Research into the future development of E-Learning will permit purveyors of additional digital learning content to optimize their strategies regarding this material.

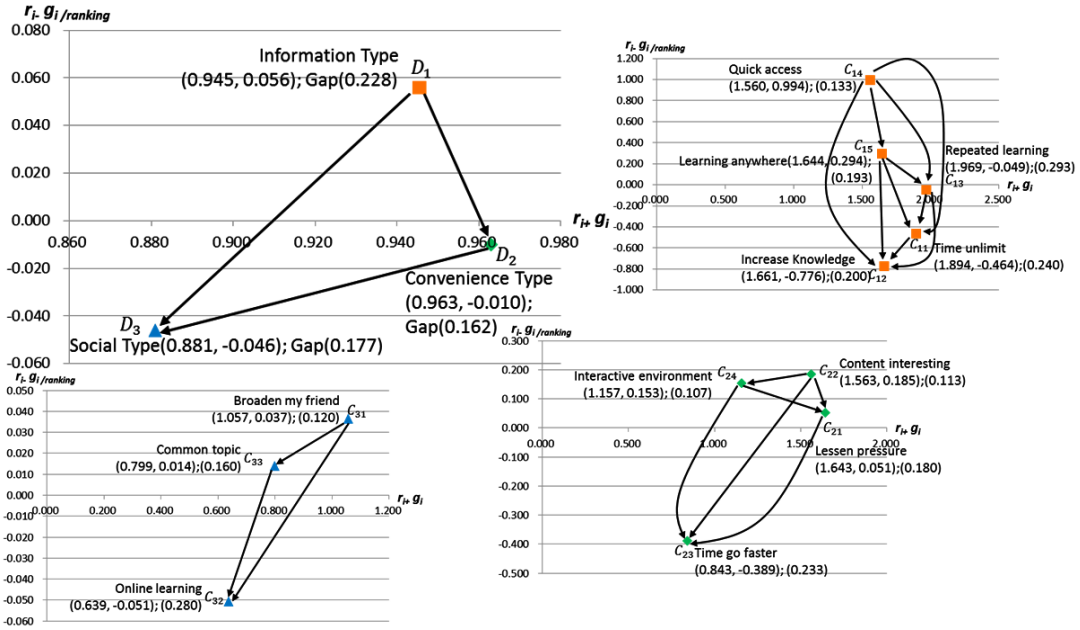

Figure 1. The Influential Network Relation Map (INRM) of determinants within the E-Learning service

Table 2. The total influential effect matrix T_c of criteria

T_c	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{21}	C_{22}	C_{23}	C_{24}	C_{31}	C_{32}	C_{33}
C_{11}	0.12	0.20	0.22	0.03	0.15	0.25	0.10	0.12	0.08	0.14	0.08	0.07
C_{12}	0.18	0.09	0.11	0.02	0.05	0.15	0.07	0.07	0.08	0.13	0.05	0.06
C_{13}	0.27	0.32	0.16	0.05	0.17	0.31	0.25	0.23	0.16	0.23	0.15	0.12
C_{14}	0.33	0.34	0.32	0.06	0.23	0.37	0.26	0.22	0.17	0.31	0.25	0.13
C_{15}	0.27	0.27	0.21	0.13	0.08	0.28	0.15	0.13	0.11	0.24	0.18	0.09
C_{21}	0.22	0.31	0.23	0.04	0.07	0.18	0.25	0.21	0.19	0.25	0.19	0.15
C_{22}	0.20	0.31	0.21	0.04	0.07	0.30	0.15	0.24	0.19	0.29	0.18	0.23
C_{23}	0.08	0.07	0.07	0.02	0.03	0.09	0.07	0.04	0.03	0.06	0.04	0.06
C_{24}	0.16	0.27	0.20	0.07	0.08	0.23	0.21	0.12	0.09	0.28	0.20	0.20
C_{31}	0.25	0.29	0.20	0.06	0.09	0.21	0.18	0.20	0.11	0.15	0.18	0.22
C_{32}	0.11	0.12	0.13	0.07	0.10	0.20	0.10	0.08	0.09	0.13	0.07	0.10
C_{33}	0.12	0.22	0.16	0.03	0.05	0.19	0.19	0.13	0.07	0.23	0.09	0.08

Constructing the network relation map using the DEMATEL technique

In accordance with the questionnaires completed by the experts (30 samples of experts), the initial matrix A is obtained by pairwise comparisons. From this initial matrix, a normalized matrix D is derived and is available for calculating the total effect matrix T of the criteria. The result is highly significant and very reliable, with a high consistency ratio of 97% (larger than 95%; error ratio in gap = 0.026 < 5%, as observed in the footnote beneath **Table 2**), and it can be used to derive the sum of the influences given and received by each criterion (**Table 2**); these influences are further illustrated in the influential network relation map (INRM) depicted in **Figure 1**.

Table 3. The sum of the influences given and received for each criteria

Dimensions/criteria	r_i	g_i	$r_i + g_i$	$r_i - g_i$ /ranking
Information Type (D_1)	**0.501**	**0.445**	**0.945**	**0.056(1)**
Time unlimit (C_{11})	0.715	1.18	1.894	-0.464
Increase Knowledge (C_{12})	0.442	1.22	1.661	-0.776
Repeated learning (C_{13})	0.960	1.01	1.969	-0.049
Quick access (C_{14})	1.277	0.28	1.560	0.994
Learning anywhere (C_{15})	0.969	0.68	1.644	0.294
Convenience Type (D_2)	**0.476**	**0.486**	**0.963**	**-0.010(2)**
Lessen pressure (C_{21})	0.847	0.80	1.643	0.051
Content interesting (C_{22})	0.874	0.69	1.563	0.185
Time go faster (C_{23})	0.227	0.62	0.843	-0.389
Interactive environment (C_{24})	0.655	0.50	1.157	0.153
Social Type (D_3)	**0.418**	**0.463**	**0.881**	**-0.046(3)**
Broaden my friend (C_{31})	0.547	0.51	1.057	0.037
Online learning (C_{32})	0.294	0.34	0.639	-0.051
Common topic (C_{33})	0.406	0.39	0.799	0.014

Note: $\frac{1}{n^2}\sum_{i=1}^{n}\sum_{j-1}^{n}\frac{\left|t_{ij}^{p}-t_{ij}^{p-1}\right|}{t_{ij}^{p}}\times 100\% = 3\% < 5\%$, where t_{ij}^{p} and t_{ij}^{p-1} denote the average influence of i criterion upon j by samples p and p-1, respectively, and n denotes the numbers of criteria; thus, the results above are significant at the 97% level, which is greater than the 95% level used to test for significance.

Table 3 indicates that certain criteria have positive values for $r_i + g_i$ and thus greatly influence the other criteria; these influential criteria are known as dispatchers. Other criteria have negative values for $r_i - g_i$ and thus are greatly influenced by the remaining criteria. These influenced criteria are known as receivers. A significantly positive value for $r_i - g_i$ represents the situation in which a criterion affects other criteria significantly more than it is affected by other criteria, implying that the criterion in question should be a priority for improvement. For instance, Information Type ($\boldsymbol{D}_1$) has the highest positive value of $r_i - g_i$ for dimensions, at 0.056, and thus has a strong influence on the other dimensions. Social motivations ($\boldsymbol{D}_3$) have the lowest value of ri - gi for dimensions, at -0.046, and are therefore the most vulnerable to influence. Therefore, the improvement priorities can be ordered with $\boldsymbol{D}_1$ as the highest priority and $\boldsymbol{D}_3$ as the lowest priority. This effect is illustrated further in **Figure 1**.

Calculating the influential weights using the DANP approach

After the DEMATEL approach has confirmed the influential relationships among the criteria, the most accurate weights for these criteria are calculated using the DANP approach. Through pairwise comparisons of the unweighted and weighted supermatrices, the limiting power of the weighted supermatrix is obtained, and a steady-state condition that indicates the weight of each criterion (**Table 4**) for further analysis by the VIKOR approach is obtained.

Evaluating the total performance using the VIKOR method

Using the scores derived by the DANP approach, VIKOR computes overall E-Learning performance, as shown in **Table 4**. The integrated index that is obtained from this process allows decision-makers to identify problem-solving points either from a dimensional perspective or by considering the criteria as a whole. The priority sequence for reaching the desired level can be determined by the weights of the performance values (from high to low) and gap values (from low to high).

Table 4. The performance evaluation of the case study by VIKOR

Dimensions/criteria	Local Weights (from DANP)	Global Weights (from DANP)	Performance values	GAP(Ranking) by VIKOR
Information Type (D_1)	0.318		7.721	0.228(1)
Time unlimit (C_{11})	0.267	0.085	7.600	0.240(3)
Increase Knowledge (C_{12})	0.305	0.097	8.000	0.200(5)
Repeated learning (C_{13})	0.241	0.077	7.067	0.293(1)
Quick access (C_{14})	0.067	0.021	8.667	0.133(9)
Learning anywhere (C_{15})	0.120	0.038	8.067	0.193(6)
Convenience Type (D_2)	0.349		8.381	0.162(3)
Lessen pressure (C_{21})	0.343	0.119	8.200	0.180(7)
Content interesting (C_{22})	0.255	0.089	8.867	0.113(11)
Time go faster (C_{23})	0.224	0.078	7.667	0.233(4)
Interactive environment (C_{24})	0.179	0.062	8.933	0.107(12)
Social Type (D_3)	0.333		8.228	0.177(2)
Broaden my friend (C_{31})	0.427	0.142	8.800	0.120(10)
Online learning (C_{32})	0.285	0.095	7.200	0.280(2)
Common topic (C_{33})	0.288	0.096	8.400	0.160(8)
Total performance value			**8.119**	
Total Gap				**0.188**

For instance, the Convenience Type (D_2) exhibits the highest performance value of 8.381 and the lowest gap value of 0.162 and is thus the most satisfied (and satisfying) dimension. By contrast, the dimension of Information Type (D_1) is the least satisfying dimension and should be assigned lowest priority in terms of improvement because it exhibits the lowest performance value (7.721) and the largest gap value (0.228). Hence, if the strategic target of the decision-makers is to reach the desired level, D_2 should be the first priority for improvement, followed by D_3 and then D_1. Overall, the performance values have an average of 8.119, relative to a desired level of 10. The gaps for improvement have an average of 0.188, relative to a desired level of 0, indicating the needs that E-Learning must address.

Discussions and implications

In terms of managerial implications, the findings of the DEMATEL method can provide certain insights that may allow decision makers to improve service performance by targeting the criteria that most significantly influence the performance of the service with regard to the other criteria examined (Tseng, 2010). For the empirical case studied here, the dimensions and criteria of influence are calculated and illustrated using an INRM (**Figure 1**). In accordance with the degrees of influence depicted in **Figure 1**, the improvement priorities, from highest to lowest, is the convenience, informational and social dimensions. This order of priorities is an important insight for decision-makers, as it indicates that the experts surveyed recognize that the convenience dimension must be assigned the highest priority. Efforts in this direction will produce network effects on E-Learning convenience and spontaneously influence the social aspects of E-Learning. This finding verifies the general convenience-informational-social paradigm and is consistent with the results of most previous studies (Chen, Tzeng, & Hsu, 2011; Saaty, 1996; Opricovic, 1998). Moreover, this new finding improves upon previous causal findings regarding the convenience and/or informational dimensions and the previous results, suggesting that convenience influences social aspects of learning through informational effects. The strength of the INRM presented here is that it allows us to illustrate influential network relationships (from the perspective of either the dimensions or the criteria) in greater depth than the analysis provided by a simple linear relationship (as shown in **Figure 1**).

Certain criteria, such as quick access, interesting content and broadened friend-making opportunities, are confirmed to have a greater influence on the other criteria within their particular dimension. Notably, improvements in quick access to information are the first priority for improving convenience, as addressing the

search needs of users motivated by convenience may increase satisfaction for these users. These convenience-motivated users are generally willing to be exposed to digital learning or digital media. Through digital learning, learners can utilize the flexible hours and space to educate themselves and can quickly gain access to large amounts of diverse information. The decision-makers for E-Learning must carefully consider the excellence of these digital education processes. In addition, increasing the knowledge absorbed through E-Learning is identified in this study as the most influential determinant for informational users. Given this result, E-Learning developers should design E-Learning processes providing quick, targeted and highly rich information delivery policies that address relevant initiatives for users, such as the problem-solving abilities, manners and discipline of employees.

In addition, the overall performance values provided in **Table 4** indicate an average performance value of 8.119, relative to a desired level of 10. The average gap that indicates the need for improvement is 0.188, relative to a desired level of 0. The Convenience Type ($\boldsymbol{D}_2$) exhibits the smallest gap value (0.162) and thus should be the first priority for improvement for decision makers attempting to achieve the desired level. This dimension encompasses users that are characteristically motivated by the desire to broaden their friend-making group, participate in an interactive environment and share common topics among their friends of similar age groups. This group emphasizes social interactions and making friends. On the whole, the current investigation has consistently found the Information Type dimension to be the most influential of the dimensions examined and has determined that responsiveness related to quick problem-solving abilities of the employees, with the largest gap value of 0.228, is the least satisfying criterion.

These results suggest that performance quality should be viewed as the most important factor for overall improvement of E-Learning services. Given these empirical findings, the main characteristics of the motivations for using digital learning include searching for information, maximizing learning speed and accessing information daily. Users with these characteristics emphasize informational access.

CONCLUSIONS

This research modeled the strategies that should be pursued to improve the connection service to the urban airport in Taipei. The dependent relationships among the various criteria were addressed using a novel hybrid MCDM method that combines the DEMATEL (used to construct the NRM), DANP (used to determine the relative weights of the criteria) and VIKOR (used to determine the improvement priority) methods. In this study, the evaluations of connection service provided by the domain experts produced useful results. In descending order, the improvement priorities obtained from this analysis was as follows: convenience, social and informational. The average gap between the actual and desired levels of E-Learning performance was 0.188, which indicates the current deficiencies in E-Learning that must be addressed.

Our study demonstrates how the efficiency of an E-Learning service can be improved and how to reach the desired performance in the context of long-term development of E-Learning under the current, favorable combinations. The empirical test of our approach, which was conducted using a case study of the E-Learning services in Taiwan, illustrated the usefulness of this approach in accounting for complex components of E-Learning services and provided meaningful implications for decision-makers. Overall, the results and implications promulgated in this article may be valuable for both practitioners and researchers, as well as for those locations that are attempting to expand the development of E-Learning.

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