Evaluating Mobile Learning Adoption in Higher Education based on New Hybrid MCDM Models

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Abstract: This study investigated the mobile learning adoption of evaluation in higher education. Mobile learning is a new form of learning utilizing the unique of mobile devices. However, students' readiness for mobile learning has yet to fully explore in Taiwan. 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) for constructing influential network relationship, DANP (DEMATEL-based ANP) for finding the influential weights, and VIKOR methods combining the influential weights of DANP for evaluating the performance gaps in each criterion and then how based on influential network relationship map (INRM) to reduce gaps for achieving aspiration level. An empirical case as example is illustrated to show that these hybrid MCDM. By evaluating the influential interrelationships between criteria related to mobile learning, this approach can be used to solve interdependence and feedback problems, allowing for greater satisfaction of the actual needs of mobile learning behaviour.

1 INTRODUCTION

This study contributes in higher education in three ways. First, the adoption of mo-bile learning is explored from a multi-faceted perspective including attitude-related behaviors to mobile learning, perceived behavioral control, and trust-related behaviors. This implies that university practitioners should consider these three fac-tors before employing m-learning. Second, the current study shows the relative im-portance of perceived behavior control (i.e., perceptions of internal and external con-straints on behavior) (Taylor and Todd, 1995) in the decision to adopt mobile learning. That is, students who are confident with mobile devices are likely to adopt mobile learning. Hence, universities need to provide students with training opportunities about the basic functions and applications of mobile learning technologies. Lastly, the current findings reveal that usefulness and ease of use affect students' attitude for adopting mobile learning. Thus, to facilitate the acceptance of mobile learning, the learning environment should be perceived as useful and easy to use. A better understanding of the process of mobile learning adoption will help researchers and decision makers work together to implement proper strategies for mobile learning.

Most of the conventional multi-criteria decision analysis (MCDA) models cannot handle the analysis of complex relationships among different hierarchical levels of criteria. Yet the decision to adopt mobile learning requires decision model that does just that. The purpose of the present study is to address these issues; we develop a hybrid MCDM model that combines DEMATEL, DANP, and VIKOR. The hybrid method overcome the limitations of existing decision models and can be used to help us analyze the criteria that influence mobile learning issue. In particular, we use Tai-wan's college students as an example to study the interdependence among the factors that influence the

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user behavior of mobile learning in the higher education as well as evaluate alternative user behavior processes to achieve the aspired levels of performance from mobile learning.

2 METHODLOGY

This Section comprises four parts: the first part presents the DEMATEL technique for building an influential network relationship; the second part calculates the influential weights using DANP (DEMATEL-based ANP); the third, the last part uses VIKOR to evaluate total accreditation performance; finally, describes the data collection.

2.1 DEMATEL for Establishing an Influential Network Relationship

DEMATEL is mainly used to solve complex problems to clarify their essential nature. DEMATEL uses matrix and related mathematical theories (Boolean operation) to calculate the cause and effect relationships involved in each element. This technique is widely used to solve various complex studies, and particularly to understand complex problem structures and provide viable problem-solving methods (Tzeng *et al*., 2007). DEMATEL is based on the concept of influential relation map, which can distinguish the direct/indirect influential relationship of the criteria, allowing decision-makers to identify the key criterion for developing strategies for improving accreditation performance in higher education of this study.

2.2 Find the Influential Weights using the DANP

This study not only uses the DEMATEL technique to confirm the interactive relationship among the various dimensions/criteria, but also seeks the most accurate influential weights. This study found that ANP can serve this purpose. This study used the basic concept of ANP (Saaty, 1996), which eliminates the limitations of Analytic Hierarchy Process (AHP) and is applied to solve nonlinear and complex network relations (Saaty, 1996). ANP is intended to solve interdependence and feedback problems of criteria. This study thus applies the characteristics of influential weights ANP and combines them with DEMATEL (call DANP, DEMATEL-based ANP) to solve these kind of problems based on the basic concept of ANP. This approach yields more practical results.

2.3 Evaluating Competitiveness Gaps using VIKOR

Opricovic and Tzeng (2004) proposed the compromise ranking method (VIKOR) as a suitable technique for implementation within MCDM (Tzeng et al., 2005; Opricovic and Tzeng, 2004; Opricovic and Tzeng, 2007; Liu and Tzeng, 2012). VIKOR uses the class distance function (Yu, 1973) based on the concept of the Positive-ideal (or we adopt the Aspiration level) solution and Negative-ideal (or we adopt the Worst level) solution and puts the results in order. For normalized class distance function it is better to be near the positive-ideal point (the aspiration level) and far from the negative-ideal point (the worst value) for normalized class distance function.

2.4 Data Collection

Table 1 descripts the framework of dimensions and criteria. And the data was collected from 32 education experts who understand mobile learning trend and usage (in consensus, significant confidence is 96.375%, more than 95%; i.e., gap error =3.265%, smaller less 5%). Most of the education experts have teaches more than ten years in higher education. Expert perspectives on all criteria within the criteria were collected via personal interviews and a questionnaire. Expert elicitation was conducted in Nov., 2012, and it took 60 to70 minutes for each subject to complete a survey.

Table 1: Framework of dimensions and criteria.

Dimensions	Criteria
Attitude-related behaviours $\boldsymbol{D}_1$	Relative advantage C_1
	Compatibility C_2
	Complexity C_3
Perceived behavioural control $\boldsymbol{D}_2$	Self-efficacy C_4
	Resource facilitating conditions C_5
	Technology facilitating conditions C_6
Trust-related behaviours $\boldsymbol{D}_3$	Disposition to trust C_7
	Structural assurance C_8
	Trust belief C_9

3 EMPIRICAL STUDY ANALYSIS FOR MOBILE LEARNING ISSUE

In this section, an empirical study is displayed to illustrate the application of the proposed model for evaluating and selecting the best method that can help decision makers to understand how to improve their evaluations of mobile learning user-behaviour.

3.1 Analysis of Result

In this paper, we confirmed DEMATEL decision-making structure, and analysed from three dimensions with 9 criteria of the user-behaviour perspective on mobile learning. According to the expert questionnaires, we obtain the total influence matrix $\boldsymbol{T}$ of dimensions and criteria shown in Table 2 to Table 3. We find the cognition and opinion from experts in three dimensions, and the relationship between the extents of the impact can also be found which is compared to other dimensions as show in Table 2.

Table 2: The total effect matrix of $\boldsymbol{T}_D$ and sum of effects on dimensions.

D	D_1	D_2	D_3	d_i	s_i	d_i+s_i	d_i-s_i
D_1	0.827	0.813	0.817	2.457	2.532	4.989	-0.075
D_2	0.888	0.784	0.822	2.494	2.338	4.832	0.156
D_3	0.817	0.741	0.767	2.325	2.406	4.730	-0.081

According to the total influence prominence $(d_i + s_i)$, "attitude-related behaviours (D_1)" has the highest influence of the strength of relationship that means the most important influencing dimensions; in addition, "trust-related behaviours (D_3)" is all the factors that affect the least degree of other dimensions. According to the influence relationship $(d_i - s_i)$, we can also find "perceived behavioural control (D_2)" is the highest degree of influence relationship that affects other dimensions directly. Otherwise, "trust-related behaviours (D_3)" is the most vulnerable to influence that compare with other dimensions. According to Table 3, we can obtain all the criteria of the impact of relations with each criterion. And then, from Table 4 shows the relationship between the extents of the direct or indirect influences and compares them with other criteria. "Technology facilitating conditions (C_6)" is the most important considerations criteria; in addition, "structural assurance (C_8)" is the influence of all criteria in the least degree of other criteria. Furthermore, we can also find in Table 4 that shows "self-efficacy (C_4)" is the highest degree of influence relationship in all the criteria. And, "technology facilitating conditions (C_6)", is the most vulnerable to impact of criteria that compare with other criteria.

We use DEMATEL to confirm the influence relationship with the criteria, and expect to obtain the most accurate influence weights. The purpose of DANP is to solve the interdependence and feedback problems of each criterion (Saaty, 1996). Therefore, we structure the quality assessment model by DEMATEL which combination with DANP model to obtain the influential weight of each criterion as show in Table 4.

Table 3: The total effect matrix of $\boldsymbol{T}_c$ for criteria.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
C_1	0.773	0.848	0.901	0.738	0.768	0.978	0.836	0.790	0.919
C_2	0.868	0.827	0.920	0.805	0.816	1.011	0.865	0.804	0.921
C_3	0.802	0.812	0.695	0.656	0.687	0.858	0.734	0.680	0.801
C_4	0.886	0.940	0.911	0.662	0.784	0.979	0.833	0.774	0.902
C_5	0.787	0.857	0.833	0.690	0.617	0.872	0.743	0.704	0.815
C_6	0.920	0.954	0.902	0.778	0.795	0.879	0.859	0.815	0.956
C_7	0.882	0.882	0.863	0.702	0.737	0.941	0.729	0.800	0.925
C_8	0.690	0.698	0.673	0.550	0.580	0.731	0.680	0.541	0.740
C_9	0.885	0.894	0.882	0.728	0.748	0.954	0.871	0.809	0.805

Table 4: The gap evaluation of mobile learning by VIKOR.

D/C	Local Weight	Global weight (DANP)	Mobile learning gap (r_{ki})
D_1	**0.348**		**0.197**
C_1	0.329	0.115	0.113
C_2	0.339	0.118	0.213
C_3	0.332	0.116	0.266
D_2	**0.322**		**0.296**
C_4	0.300	0.097	0.228
C_5	0.310	0.100	0.366
C_6	0.389	0.125	0.294
D_3	**0.331**		**0.295**
C_7	0.331	0.109	0.266
C_8	0.310	0.102	0.338
C_9	0.359	0.119	0.284
Total gaps			**0.261**

In addition, we can find the critical criteria in higher education of mobile learning user behaviour are identified as technology facilitating conditions (C_6), trust belief (C_9) and compatibility (C_2). Furthermore, the influence weights combine with the DEMATEL technique to assess the priority of

problem-solving based on the gaps identified by VIKOR method and the influence network relationship map.

An empirical study involving mobile learning user behaviour in the multiple stages (intention stage and adoption stage) are used to evaluate and improve the total accreditation gaps using the VIKOR method, as listed in Table 4. Decision makers can identify problem-solving issues according to this integrated index, either from the perspective of the criteria as a whole or from that of an individual dimension.

Using the overall/dimension criteria, the gap values can be determined by the priority sequence improvement for reaching the desired level. In the intention stage, resource facilitating conditions (C_5), with a higher gap value of 0.366, are the first criterion to be improved.

Improvement priority can also be applied to the individual dimension. In the attitude-related behaviours (D_1) of the intention stage, for instance, the priority gap values are ordered as follows: complexity (C_3), compatibility (C_2), relative advantage (C_1). In the perceived behavioural control (D_2) of the intention stage, the priority gap values are ordered as follows: resource facilitating conditions (C_5), technology facilitating conditions (C_6), self-efficacy (C_4). In the trust-related behaviours (D_3) of the intention stage, the improvement priorities can be sequenced as follows: structural assurance (C_8), trust belief (C_9), disposition to trust (C_7). Using the gap values provided by the panel experts above, improvement priority schemes are unique and comprehensive, both from the separate dimensions and from the overall points of view, as shown in Table 4.

For decision makers, understanding improvement priorities of mobile learning user behavior for client must be easier to understand than the gaps in higher education.

3.2 Discussions and Implications

The empirical results are discussed as follows. First, according to the DEMATEL model, we could recognize the interrelationship of each dimension and criterion the influential relationship network map for each dimension and criterion (as Fig. 1 shows). In Fig. 1, the perceived behavioral control (D_2) is affecting other dimensions- attitude-related behaviors (D_1), and, trust-related behaviors (D_3); visibly perceived behavioral control (D_2) plays an important role and it has the highest and intensity influence in its relationship to other dimensions. Thus, higher education leader should first improve it, then, followed by attitude-related behaviors (D_1), trust-related behaviors (D_3) for evaluating and improving the mobile learning user behaviors in the higher education.

Second, after analyzing the dimensions, we would illustrate the considered-criteria in each dimension. According to the results, we illustrate the influence relationship-digraph-map of criteria in Fig. 1. Hence, for the influence relationship of these criteria, in the attitude-related behaviors dimension (D_1): compatibility (C_2) was the most influence criterion and should be improved first, followed by relative advantage (C_1) and complexity (see Fig. 1 for more details on the causal relationship in D_1, D_2 ,and D_3). Each of the evaluation dimensions and criteria creates the necessary behaviors for inducing mobile learning user behaviors in the higher education. Therefore, high education leader should evaluate all of the dimensions and criteria for the mobile learning user behavior in accordance with Fig. 1. This evaluation method can be used in most of the higher education. However, school leader should keep in mind that, when applying this model, some differences exist. The level of importance for the 9 criteria may vary according to the particulars of each high education, and the school leader should compare the evaluation methods for each mobile learning user behavior model before making deciding upon the optimal using adoption method.

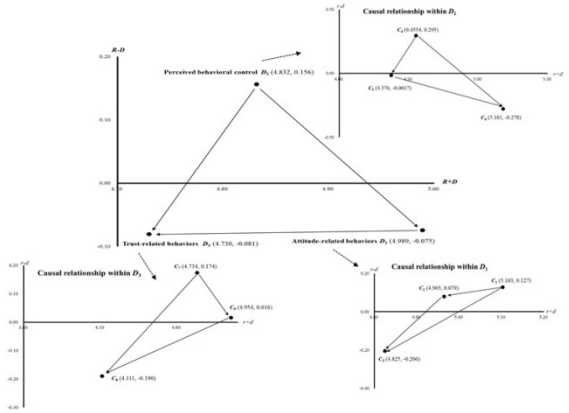

Fig. 1: The influential network relationship map of each dimension and criterion

Finally, the overall gap values (i.e., the distance to 0) shown in Table 4 that indicate room for

improvement are 0.261 in the intention stage, and 0.235 in the adoption stage. In the multiple-stage perspective, the perceived behavioral control (D_2), featuring the largest gap value of 0.296 in intention stage, and the trust-related behaviors (D_3) featuring the largest gap value of 0.295 in adoption stage, which should be the first priority for improvement if decision makers wish to achieve the desired level. For long-term improvement, the decision makers should manage internal motivation carefully, as mentioned above. Given these empirical findings, our results, as holistically formulated in Table 5, fulfil the purpose of this research. Evaluating the mobile learning user behaviour model provided by this study can extend to most higher education using mobile learning user behaviour. However, school administrators should be cautious when applying this model. The importance of the 9 criteria may vary according to the situation, and administrators should compare the mobile learning user behavior and define the gap in that stage before making decision on optimal technology use.

Table 5: Sequence of improvement priority for mobile learning user behaviour.

Formula	**Sequence of improvement priority**
F1:Influential network of dimensions	$(D_2),(D_1),(D_3)$ (D_1): $(C_1),(C_2),(C_3)$ (D_2): $(C_4),(C_5),(C_6)$
F2:Influential network of criteria within individual dimensions	$(D_3),(D_2),(D_1)$
F3:Sequence of dimension to rise to aspired/desired level (by gap value, from high to low)	(D_1): $(C_3),(C_2),(C_1)$ (D_2): $(C_5),(C_6),(C_4)$ (D_3): $(C_7),(C_9),(C_8)$
F1:Influential network of dimensions	$(D_2),(D_1),(D_3)$ (D_1): $(C_1),(C_2),(C_3)$ (D_2): $(C_4),(C_5),(C_6)$

4 CONCLUSIONS

Mobile learning service has an important role in the training of higher education. Its decisions are complicated by the fact that various criteria are uncertainty and may vary across the different product categories and use situations. Based on the export and literature review, we developed the three dimensions and 9 criteria that align with the mobile learning service of environment. So we applied the methodology of hybrid MCDM model combining DANP with VIKOR in empirical case. The main reason is among the numerous approaches that are available for conflict management, hybrid MCDM is one of the most prevalent. VIKOR is a method within MCDM; it is based on an aggregating function representing closeness to the ideal (aspiration level), which can be viewed as a derivative of compromise programming for avoiding "choose the best among inferior alternatives (i.e., pick the best apple among a barrel of rotten apples)". In a decision-making process, we used the global and local weights into alternatives performance, such as that in Table 5, to allow school leader to select the best mobile learning adoption factor. We haven't only selected the best factor, but also found how to improve the gaps to achieve the aspiration level in mobile learning service performances.

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