

Assessing the Quality of a Web-based Learning System for Nurses

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Abstract Continuing professional education is essential for nurses to update their clinical skills and knowledge to meet the complex demands of current patient care. Compared to traditional in-class continuing education, a web-based learning system is efficient for nurses with a three shift-working schedule and is timely to deliver knowledge about newly emerging epidemics such as Severe Acute Respiratory Syndrome. Many studies reveal the advantages of various web-based learning systems but seldom evaluate them from the perspective of quality. This study develops an instrument to assess the quality of a web-based learning system for nurses' continuing education based on the quality dimensions of a mature information systems success model. The research results show that all indicators of the instrument provide a fit to the quality measurement of a web-based learning system and have high reliability and validity. Based on the research findings, implications and limitations are discussed.

Keywords Quality measurement · Electronic learning (E-learning) · Continuing nurse education · Web-based learning system

Introduction

With the global shortage of registered nurses [1] and rapid changes in today's work environment, continuing professional education is essential for nurses to update their clinical skills and knowledge to meet the complex demands of current patient care [2, 3]. Traditional courses in continuing education are taught using lectures, practical classes, and seminars, which require participants to physically go to the same place for learning at a fixed time and which require transportation that is costly and inconvenient for nurses who are on a three-shift work schedule. Meanwhile, newly emerging epidemics may require new skills and services which need to be delivered in an efficient way of instead a traditional classroom setting.

An extreme case that happened recently was the outbreak of the Severe Acute Respiratory Syndrome (SARS) epidemic. Due to the lack of sufficient skills and knowledge in treating the disease, 7 medical staff and 66 patients lost their lives to the epidemic [4]. Those medical staff members (including doctors and nurses) at Taipei Municipal Heping Hospital were just wearing "no to light" protection (paper mask) because no knowledge about SARS had been distributed [5, 6]. Another reason for the fast intra-hospital transmission was due to the fact that Taiwanese patients like to do doctor shopping to find the best and least-expensive medical care, which is explained in the study of Cheng [7] for promoting electronic medical records which traced where they visited. As information technology (IT) changes the way that people work,

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communicate, and learn, its impact on global health care and education is phenomenal [8–12]. To prevent the spreading of the disease, most SARS related training courses were then done electronically. The development of the World Wide Web has become one of the many delivery mechanisms of education. It has been suggested that web-based learning is the future of all types of distance education [13].

Although prior studies report the advantages and benefits that nurses or students gained from web-based learning systems [e.g., 14–17], very few studies evaluate the system from the perspective of quality. Attack and Rankin [15] even raised questions about the quality of web-based learning systems. Meanwhile, studies conclude that the barriers nurses face when using web-based learning systems are mostly due to their computer anxiety and skill [15, 18]. Kennedy [19] concludes that the most useful guidance for online teachers may specifically come from the IS industry. Therefore, the purpose of this study is to develop an instrument to assess the quality of a web-based learning system for nurses, and to provide a useful model for both learners and system designers to remove the barriers that limit web-based learning.

Web-based learning

The term web-based learning means the Internet is equipped with a supportive delivery medium [20]. Khan [21] sees web-based distance learning as synonymous with e-learning, Internet-based training, advanced distributed-learning, courseware and web-based instruction, computer based or assisted learning, online learning, and open/flexible learning. These new forms of media allow educators to deliver flexible continuing education demanded by healthcare service providers and health professionals [18, 22–24].

Recently, the concept of web-based learning has been applied to nursing (continuing) education. As to the results of adopting web-based learning, registered nurses were satisfied about the web-based courses they had accessed [14–15]. The primary advantages of e-learning are the convenience and the ease with which an individual can access his/her needed information [22, 25]. Although the Internet can provide a golden educational opportunity for increasing information literacy and lifelong learning skills, it will never satisfactorily enable cost savings without impacting on the quality of nurse education currently provided [22].

Researchers indicate that learners do not always make adequate choices for their learning program [26], yet there is a substantial debate on the quality of web-based education [27]. In addition, not all students can benefit

from web-based learning due the miscellaneous learning tools which make the learning environment more complex [26, 28]. Such environments assume learners have the ability to make good judgments on their own learning needs. Using web-based learning has to be complemented with an awareness of the qualitative aspects of the knowledge retrieved because the quality of an e-learning system will affect the final learning result [22, 26]. However, measuring quality has been quite elusive in the past research because there are many intangible dimensions to online programs that make the measurement of quality quite challenging [29].

Prior research in quality assessment

From the customer's view, quality is important in meeting a customer's expectations of the product or service being delivered. Such product quality is usually defined as a user criterion that has to do with excellence, truthfulness in labeling or a subjective customer assessment of the total value offering [30]. Consequently, with quality, a product or service can be successful.

In the Information Systems (IS) discipline, the quality dimensions also play a critical role for determining IS success. The original IS success model introduced in 1992 by DeLone and McLean, is based on the review of more than 180 published papers. This model organizes a rich body of research and provides a comprehensive view of IS success and is widely accepted as the principal criterion for evaluating IS [31]. Many studies indicated that service quality is an important element in IS research. For example, Pitt et al. [32] pointed out that the service quality must be included in measuring IS success and Li [33] argued that both system and human aspects need to be considered in measuring IS success. DeLone and McLean [34] reviewed more than 100 articles from major journals in the field of Management IS and agreed to add service quality into their revised IS success model. Today, the more complete and better-known approach to assess quality dimensions is the revised IS success model of DeLone and McLean [34]. The three quality dimensions of the revised IS success model are system quality (SYSQ), information quality (IQ), and service quality (SERVQ). SYSQ is associated with the issue of whether the technical components (including hardware, software, and user manuals) of delivered IS provide the quality of information and service as required by stakeholders [34]. The IQ represents the users' perception of the output quality generated by an IS. The SERVQ instrument was originally developed by interviewing executives in various service industries and is introduced to measure IS service quality provided by IT departments in organizations [35, 36]. Researchers have applied and tested the service

quality measurement instrument from marketing into the original IS success model [32]. Thus the revised IS success model with the three quality dimensions becomes mature in measuring the IS success.

Materials and methods

Considering that web-based learning for nurses is one kind of IS application, the three parsimonious quality antecedents of the mature IS success model are adapted to develop the research model of this study (Fig. 1).

The associated instrument for measuring the quality of a web-based learning system within the nursing context was developed. This study uses the web site of the Formosans’ e-Medical School (FeMS) which is a project supported by the Department of Health (DOH) since 2003 to achieve the goal of e-healthcare in the e-government map of Taiwan. FeMS is designed to serve two different groups of users: the general public and the medical profession. In other words, FeMS is open to all the residents in Taiwan to access healthcare related information on its web site. The major functions of FeMS include offering the most updated information on medical care, conducting online learning classes, evaluating the learning outcomes, interacting online between students and teachers or among students, and providing individualized services such as a news bulletin, visitor services, and a special column for medical care. All nurses registered as a member of FeMS have the opportunity to participate. Although the FeMS is supported by DOH, nurses from any hospital of the country can register and have access to the system.

Survey instrument

The design of the survey instrument and variables selected in each quality construct was based on related IS studies

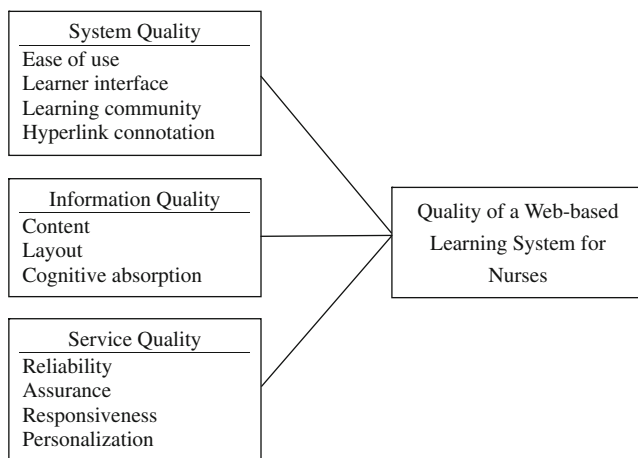


Fig. 1 Research framework

and the characteristics of the web-based learning system [31, 35, 37–39]. The questionnaire contains two parts. The first part comprises eight questions to collect basic information about the respondent and his/her hospital. The second part includes 28 items that measure the constructs of SYSQ, IQ, and SERVQ, and two satisfaction items used as criterion in analyzing validity to probe the perceived quality on the FeMS.

The SYSQ is measured by four indicators: ease of use; learner interface, learning community, and hyperlink connotation. Ease of use items represent the degree to which a person believes that a particular system is user friendly. Learner interface items deal with the degree to which a person believes that a particular system is stable and its response time is fast. Learning community items measure a person’s believes that a particular system can support interactions between teacher/student and student/student. Hyperlink connotation items deal with the extent to which a user can easily decode and correctly interpret the hyperlinks on the site. The IQ is measured by three indicators: content, layout, and cognitive absorption. Content items represent the degree to which a person believes that a particular system has provided information content that meet his/her needs. Layout items deal with the assessment that output of a particular system is clear and presented in a useful format. Cognitive absorption items deal with the degree to which a person believes that he/she is in a state of deep involvement with a particular system. The SERVQ is measured by four indicators: reliability, assurance, responsiveness, and personalization. Reliability items represent the assessment that a particular website would honor its promises. Assurance items deal with the degree to which a person believes that a particular website is trustworthy and free of privacy and security threats. Responsiveness items concern the willingness or readiness of website administrators to provide service. It involves timeliness of service. Personalization items measure the autonomy of a person provided by a particular system. All of the items of the indicators were on a seven-point scale ranging from strongly disagree (1) to strongly agree (7). The references of each indicator are summarized in Table 1.

An expert panel, consisting of three scholars of nursing informatics and web-education, was consulted to review the instrument for content validity. They checked the completeness and suitability of the each item of the questionnaire using a review form. The questionnaire was then modified accordingly.

Data collection

This study focuses on how nurses obtained experiences with the asynchronous continuing professional courses and perceived the quality of those courses on FeMS. Therefore,

Table 1 Indicators and their references of the instrument

Construct	Indicator	Items	Reference
SYSQ	Ease of use	Q1, Q2	Rai et al. (2002)
	Learner interface	Q3, Q4	Wang (2003)
	Learning community	Q5, Q6, Q7, Q8	Wang (2003)
	Hyperlink connotation	Q9, Q10	Muyllle et al. (2004)
IQ	Content	Q11, Q12, Q13	Wang (2003)
	Layout	Q14, Q15, Q16	Muyllle et al. (2004)
	Cognitive absorption	Q17, Q18	Agarwal & Karahanna (2000)
SERVQ	Reliability	Q19, Q20	Parasuraman et al. (1985)
	Assurance	Q21, Q22, Q23	Parasuraman et al. (1985)
	Responsiveness	Q24, Q25	Parasuraman et al. (1985)
	Personalization	Q26, Q27, Q28	Wang (2003)
*	Satisfaction	Q29, Q30	Wang (2003)

Criterion questions are indicated by (*)

an approval was granted from the administrator of FeMS to attach our questionnaire on their web page of the nursing continuing education system.

An E-mail was sent to all nurse members of FeMS inviting them to participate in the web survey. Incentives such as gift certificates and mobile disks were provided to promote the rate of response. Once a voluntary respondent linked to the questionnaire, an agreement form proposed by FeMS to inform the participants that they had the right to refuse to participate in or withdraw from the study at any time. Only participants who agreed on a consent form were then able to open the questionnaire file. The survey lasted for 1 month.

Results

The whole number of medical members of FeMS provided by DOH was about 1065. 154 nurses completed our questionnaire voluntarily which represented about 14.5% of the medical members of FeMS. Considering web-survey responses are typically much lower than paper mail or telephone surveys, 14.5% can be regarded as satisfactory.

All respondents were female, mostly aged between 21 and 30 (40.26%) years, and graduated from junior college (58.44%). There were 78.3% of the respondents who had at least 3years experience in Internet usage and among them 36% had over 6years experience. In other words, the sampled data shows that most respondents were young, well educated, and experienced with the Internet. Most respondents belonged to regional hospitals and were entry-level nurses. The detailed demographic data of the participants are shown in Table 2.

The whole member of FeMS has an age distribution from 20 or less (1.95%), 21–30 (21.2%), 31–40 (33%), 41–

50 (17.7%), and 51–60 (17.7%). Compared to the age distribution of the whole member, the sample has more 21–30 members (twice than that of the whole member). The possible reason was the younger members surfed on the Internet much often and were attracted more by the incentive we provided for filling the questionnaire.

The reliability of an instrument describes the consistency of the instrument in measuring the same phenomenon over time. When examining the validity of an instrument, generally three aspects of validity are used: content validity, criterion-related validity, and construct validity.

The major purpose of content validity is assessing the degree of correspondence between the items selected to constitute a summated scale and its conceptual definition [40]. Since the scales were first derived from theory-based studies, and then reviewed by an expert panel, there is professional agreement about the content of the questionnaire. The correlation between the total scores on the instrument and the measurements of valid criterion is used to assess criterion-related validity. As high quality means high satisfaction, this study follows the expert's suggestion and uses total satisfaction, items Q29 and Q30 [39], as the valid criterion. The total scores summed from the 28-item and scores summed from the valid criterion are first calculated, and then the Pearson correlation method is used to test the criterion-related validity of the scores. The Pearson correlation results showed that the 28-item instrument has a criterion-related validity of 0.525 and is significant at the 0.01 levels with an acceptable criterion-related validity.

Construct validity is used to assess how well this study translated theoretical concepts into actual programs. The frequently used statistic methods to test construct validity are multitrait-multimethod matrix (MTMM) and factor analysis. Both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) are commonly used

Table 2 Demographic data of the respondents

Measure	Item	Frequency	Percent
Gender	Female	154	100
Education	Senior high school	5	3.25
	Junior college	90	58.44
	College	48	31.17
Age	Research institute	11	7.14
	<20	3	1.95
	21–30	62	40.26
	31–40	50	32.5
	41–50	33	21.4
Medical institute	51–60	6	3.89
	Clinics and others	16	10.49
	Local hospitals	44	28.57
	Region hospitals	81	52.60
Position	Medical centers	13	8.44
	Low-level workers	108	70.13
	Low-rank manager	30	19.48
	Middle-rank manager	14	9.09
Frequency of Internet use per week	High-rank manager	2	1.30
	<1 time	11	7.13
	1–3 times	37	24.03
	4–7 times	47	30.52
	8–14 times	22	14.29
Experience in using Internet	>15 times	37	24.03
	<1 year	10	6.50
	1–2 years	35	22.73
	3–5 years	70	45.45
	6–8 years	30	19.48
Experience in using FeMS per week	>9 years	9	5.84
	<1 h	86	55.84
	1–2 h	46	29.87
	2–4 h	15	9.74
	>5 h	7	4.55

for factor analysis. If prior theories or hypotheses are available, CFA is preferred to EFA [41]. Since the instrument developed in this study is based on the quality concept derived from the DeLone and McLean updated IS success model [34] and the items of the questionnaire were adopted from prior research that had consequentially been tested by EFA or MTMM, CFA was used to verify the construct validity of this instrument. This study proposed that nurses' perception regarding quality of a web-based learning system can be also classified into perceptions regarding system quality, IQ, and service quality of the system. Therefore, second CFA is used to validate the proposed research framework of this study.

The result of the second CFA by using LISREL 8.3 is shown in Table 3. All variables converged toward the three constructs with a significant observed level of model fit ($p = 0.000$), which confirmed the measurement model. The standardized lambda coefficients for all the constructs were above 0.7 and revealed high validity. The range of lambda for SYSQ, IQ and SERVQ are from 0.744 to 0.856, 0.803 to 0.920, and 0.825 to 0.943 respectively. Among the three

quality dimensions, the indicators of the SERVQ has the highest construct fit of the instrument and respondents highly care about both IQ and SERVQ constructs.

The detailed relationships between the constructs and the related items were shown in Fig. 2.

Reliability

Reliability means a variable or a set of variables are consistent in what it is intended to measure [40]. The Cronbach's alpha is commonly used to represent the reliability by assessing the internal consistency of items. The Cronbach's α value has to be greater than 0.7 to be considered reliable [40]. In this study, the Cronbach's α for the SYSQ, IQ, and SERVQ were 0.94, 0.95, and 0.96 respectively. Additionally, the Cronbach's α for total quality instrument of 0.9573 confirmed the reliability of the instrument. Though Cronbach's alpha coefficient makes the least restrictive assumptions, alpha does underestimate the reliability of congeneric measures [42]. To circumscribe this problem that an index may be composed

Table 3 The results of the second CFA

Factor of second level	Factor of first level	Quality indicator	Measurement model (λ , SMC)	
Model fit: $\chi^2 = 107.164$, $df = 41$ ($p = 0.000$); GFI = 0.888; AGFI = 0.820; RMR = 0.0296; NFI = 0.937; IFI = 0.960; NNFI = 0.947				
Quality of a Web-based Learning System for Nurses				
	SYSQ		0.869	0.755
		SYSQ1: ease of use	0.856	0.733
		SYSQ2: learner interface	0.819	0.671
		SYSQ3: learning community	0.855	0.730
		SYSQ4: hyperlink connotation	0.744	0.544
	IQ		0.991	0.981
		IQ1: content	0.872	0.761
		IQ2: layout	0.920	0.847
		IQ3: cognitive absorption	0.803	0.645
	SERVQ		0.976	0.953
		SERVQ1: reliability	0.882	0.788
		SERVQ2: assurance	0.943	0.889
		SERVQ3: responsiveness	0.910	0.829
		SERVQ4: personalization	0.825	0.680

Note: λ = standardized validity coefficient; SMC squared multiple correlation

of several measures, this study also obtained the squared multiple correlation (SMC) to test the reliability. The larger the SMC, the more the item is contributing to consistency. In this study the SMC values of all indicators were greater than 0.5, which indicates that the scales extracted high variance of each indicator (see Table 3).

Discussion

The reliability, content validity, criterion-related validity and construct validity tests of the instrument revealed an acceptable and trustworthy result. In summary, this instrument proves useful and all indicators in the instrument

provide a reasonable fit to the quality measurement with high reliability and validity.

Compared with physicians, nurses in Taiwan have fewer learning resources to improve their professional skills and knowledge. The government-provided FeMS website serves as a new channel for them to receive professional continuing education. This may explain why up to 70% of the FeMS members are nurses. The respondents of this survey were mostly entry-level nurses aged between 21 to 30years with a junior college degree. With regard to the characteristics of the respondents in this study, past studies have found that the participative rate in continuing education decreases with increasing age and younger nurses adopt computers better [2, 43, 44]. In addition, the characteristics of the participants show that these novices have a higher motivation to acquire extra skills and more knowledge since they have just started their professional careers with the least experience in the field among their colleagues.

Regarding the respondents' hospitals, nurses from regional hospitals had a higher rate of participation. The possible reasons for this are that medical centers have sufficient IT personnel and resources to invest in professional education and produce their own program and e-learning system. The local hospitals and clinics care for patients with minor diseases and usually have fewer resources in IT facilities such as computers and network systems to access the FeMS. Therefore, nurses from medical centers, local hospitals, and clinics displayed low participation rates in the survey.

As DeLone and McLean [34] suggested that each of the three quality dimensions has different weights depending upon the different users or different contexts, the most important quality in this study is service quality. In other

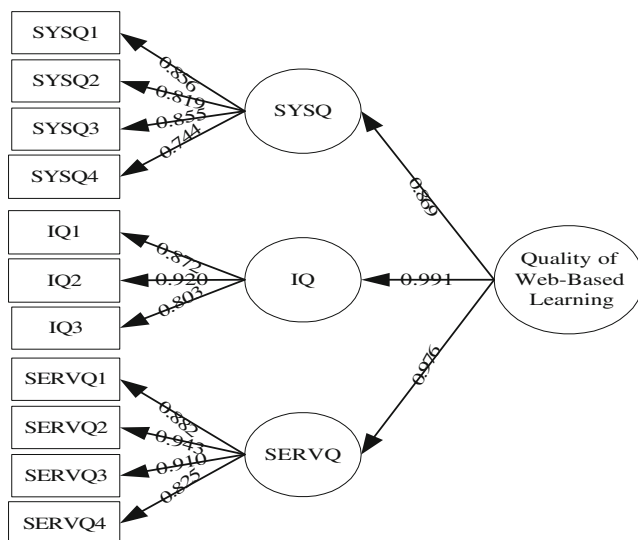


Fig. 2 Second CFA about the quality of web-base learning

words, respondents emphasized most are items such as reliability, assurance, responsiveness, and personalization. According to past studies, it has been shown that concerns on the features of web-based learning systems would be different because of gender. Female users would be concerned more about the help they can get while male users are concerned more about software and hardware issues [22]. With the obtained results of the study, we further found useful factors to reduce the difficulties of introducing female nurses to web-based learning, to improve the service quality of a web-based learning system, and to raise the satisfaction while lowering the frustration a learner has with the system.

Limitations

The obtained results of the study should be treated with caution. First, a bias exists because the sample was self-selected and only those experienced users answered the questionnaires. In addition, although web surveys are low cost and efficient, one of the most worrying threats is that a keen participant can respond multiple times to a survey and shift the average results in their favor [45]. Since this study used a static cross sectional approach, it may not reveal the dynamics of the e-learning system adoption processes. Therefore, more rigorous study is needed to further explore issues uncovered by this study. For instance, a longitudinal study would provide more insight into the adoption process.

Implications

Since providing nurses with practical continuing education can help them better target patient problems and perform well in daily work, how to build an effective way for nurses' continuing education has become an important issue. Web-based learning systems for nurses are viewed as feasible solutions, as web-based education continues to grow worldwide. DeLone and McLean [34] suggested that three dimensions, system quality, IQ, and service quality, would affect both users' use of IS and satisfaction about the IS, leading to impacts on individual productivity. For that matter, the obtained 11 indicators may be utilized to evaluate nurses' perceptions of a web-based learning system. By comparing nurses' satisfaction with the specific indicators, the administrator of the system can find directions to improve the system which then would enhance nurses' productivity. In addition, the obtained indicators could also be used as guidelines when building web-based learning systems. As the theoretical application of the obtained results of this study, the clarity of the three qualities would be helpful for other related research of IS adoption in healthcare industry.

In addition, according to the results of this study, website designers may consider providing more novice nursing-

related courses to nurse members of FeMS for self-study. Other than the popularity received from novice nurses, the most updated healthcare information such as in caring for victims of Avian Influenza are suitable for both novice and experienced healthcare professions. The FeMS is still in the infant stage of its development; therefore more rewards and recruiting activities are needed to increase the publicity of the web site for further usage.

Given that the female nurses are far more numerous than male nurses in many countries and the profile of nurses is found to be predominantly female in this study, and with female users concerned more about the help they can get compared to male users [22, 46–48], the suggestion to designers of web-based learning systems in nursing is to design with its users in mind and reflect in the service quality. The services of "help desk" on the web site need to be as user-friendly as human service, which is the best way to reduce learners' computer anxiety and frustration. The e-services should be listed together on the front of the homepage and highlighted. Centralizing downloadable materials and access to other government websites and tailoring information to meet personal needs are easy ways to direct learners to the information they are seeking. Meanwhile, site maintenance is very important, and often overlooked. Proper and frequent site maintenance would eliminate the confusion around alternative websites. It is suggested that learners can use the instrument developed in this study to select the best system for self-study, without being dispirited to further save time and to improve knowledge and skills needed for daily work.

The shortage of registered nurses has become a global problem [1]. With the rapid change in the working environment and the outbreak of newly emerging epidemics, there is a definite need to implement e-learning systems to train nurses in new technologies, knowledge, and services for complex patient care. However, has the large investment in e-learning gained user acceptance? As more and more web-based education grows on the Internet, the quality of the system needs to be monitored. As managing product quality has become a primary driver of innovation, product change and business processes the quality of the web-based learning system needs to be assured [30]. Lai et al. [49] found that the reason 65.4% of nursing students would not choose nursing as a career after graduation was significantly associated with their clinical abilities. Therefore, for those who choose nursing as a career, more continuing education channels should be provided to support them to deliver quality-nursing care and help them gaining confidence and enjoyment in their daily work.

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Appendix

Table 4 Items of quality measurement

Items
Q1. The web-based learning system is user friendly
Q2. The web-based learning system is easy to use
Q3. The display of web-based learning system is stable
Q4. The web-based learning system responds to my clicks fast enough
Q5. The web-based learning system makes it easy for me to discuss issues with other learners
Q6. The web-based learning system makes it easy for me to access the common materials in the learning community
Q7. The web-based learning system makes it easy for me to discuss questions with teachers
Q8. The web-based learning system makes it easy for me to share my experience in the learning community
Q9. The web-based learning system provides me many links to other useful web resources
Q10. The hyperlinks are easy to operate
Q11. The web-based learning system provides up-to-date content
Q12. The web-based learning system provides sufficient content
Q13. The content provided by the web-based learning system is easy to understand
Q14. The layout of the web-based learning system is visually comfortable
Q15. I like the layout of the web-based learning system
Q16. The layout of the web-based learning system is annoying. (***)
Q17. The web-based learning system provides me with a lot of enjoyment
Q18. Time seems to go by very quickly when I am using the web-based learning system
Q19. The “help desk” of web-based learning system will perform the service correctly at the first time
Q20. When I have a problem, the “help desk” of web-based learning system will show a sincere interest in solving it
Q21. The “help desk” is always courteous to me
Q22. The web-based learning system will instill confidence in learners
Q23. The web-based learning system can secure my learning record and materials
Q24. The “help desk” of web-based learning system will never be too busy to respond to my requests
Q25. The “help desk” of web-based learning system will give prompt service
Q26. The web-based learning system enables me to learn the content I need.
Q27. The web-based learning system enables me to choose what I want to learn.
Q28. The web-based learning system enables me to control my learning progress
Q29. As a whole, I am pleased with the web-based learning system **
Q30. As a whole, I am satisfied with the web-based learning system **

•Q1–28 Items used in the second CFA (negatively stated items are indicated by (***))

•Q29–30 items are criterion questions indicated by (**)

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