Embedded Selforganizing Systems

Special Issue Topic: "Learner Centered Learning"

# Analysis of Success Factors of E-Learning

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***Abstract. E-learning is being considered one crucial method of education, and various models and methods are being used to test its implementation and accomplishments. Among many, the DeLone MacLean information success (IS) success model is the most widely used in the assessment of e-learning systems' success evaluation. The aim of this research was to study the effectiveness of the platforms used in e-learning at the Mongolian University of Science and Technology. In this study, we used the D&M IS Success Model to examine whether e-learning can be a successful transmitter of knowledge. Our intention was to assess the success of e-learning by the D&M IS Success Model, define the impact of current e-learning practice on individuals, and identify the factors that affect the quality. The survey covered 685 undergraduate and graduate students of the Mongolian University of Science and Technology. Results demonstrated that high-quality systems and information upsurge the individual impact. In addition, increased and continuous usage of e-learning systems plays a mediating role between system quality and individual impact. To ensure the continuous use and effectiveness of e-learning systems, special attention should be paid to factors such as service quality, systems' simplicity and flexibility, and customer satisfaction.***

***Keywords - information system, service quality, success model, individual impact***

## I. INTRODUCTION

Today, information systems play an important role in all areas of business, trade, health, and education. With the development of information technology, the use of electronic media for information dissemination has become a global phenomenon. Many claims that information technology increases competitiveness and provides access to effective information for organizational decision-making. Advances in information technology have created a new paradigm in the field of education, with the learning process being done remotely, not just in the classroom. New technologies provide access to media-based learning and other training services [1], and participants can access and use the service whenever and whatever they want [2]. Although, universities use e-learning systems, the level of implementation varies depending on the infrastructure, system and content development, and the quality of support services. The success of an information system depends on several factors, including the quality of the system, information, and services, as well as the level of user acceptance, use, and attitudes [3]. Researchers have studied the factors that affect users' intentions in terms of environmental, organizational, technological conditions. Assessing the success and effectiveness of e-learning systems implemented in universities will help to identify further development. For an e-learning system to be successful, it must have a positive impact on users [4]. Many models such as the DeLone and McLean IS success model (D&M IS Success Model), the Technology Acceptance Model (TAM) model, the IS success model, the UTAUT theory, the Task-Technology Fit model (TTF); the End User Computing Satisfaction model (EUCS), and the HOT Fit were tested to identify and evaluate the factors of success. Of these models, the success model proposed by Delone and MacLean has the advantage of expressing the effectiveness of e-learning comprehensively. In the context of a global pandemic, Mongolian universities have arranged e-learning using platforms such as MS Teams, Zoom, Google meets, Moodle, and social media. This has created a new paradigm in the education system and created the conditions and trends for further e-learning. The researchers argue that although e-learning has been successfully set, it is important to determine how effective they have been.

## II. LITERATURE REVIEW

*The DeLone and McLean IS success model (D&M IS Success Model)*

The Delon and McLean model for evaluating the success of the system and the factors that define is based on Richard Mason's mathematical theory of communication (1978). The model is based on three levels of information, in which:

1. Technical level or system accuracy and efficiency

2. The ability to convey information at the semantic level or purpose
3. Impact/level of impact or impact on the recipient

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DeLone and MacLean (1992) reviewed more than 180 research papers published between 1981 and 1987 and developed more than 100 measures to evaluate the success of information systems [6 ,7]. The first model (Fig. 1) was proposed in 1992 and has been expanded in 2003 (Fig. 2), adding future trends and net returns.

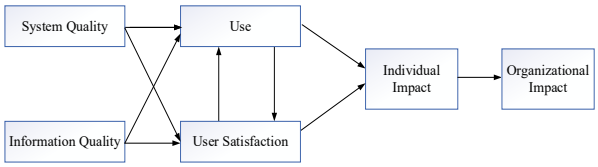


Fig. 1 DeLone and McLean IS success model (1992).

The main differences between the original and expanded models are

1. Added service quality that reflects the importance of service and support to the success of the information system.
2. The idea of measuring consumer attitudes was added as another measure of Use.
3. Consider individual influences and alternative forms of organizational influence as more effective net returns

DeLone and MacLean's original design was based on 1) system quality; 2) quality of information; 3) consumption / future trends; 4) customer satisfaction and 5) impact on the organization; 6) impact on the individual. These variables are not independent measures of success but are interrelated variables [8].

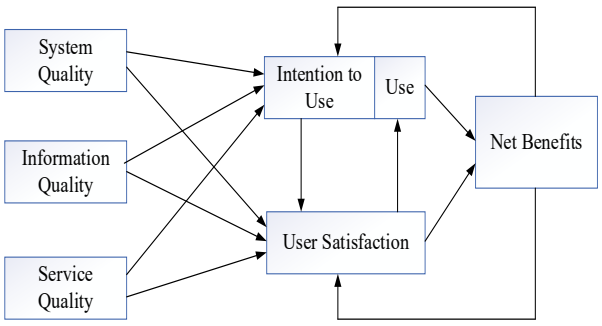


Fig. 2. Updated DeLone and McLean IS success model (2003).

The extended model comprised 6 variables named as 1) System quality; 2) Information quality; 3) Consumption/Future trends; 4) Customer satisfaction, 5) Service Quality; and 6) Individual Impact or Net Return [9]. Contents of the constructs are detailed as follows:

1. Systems quality: Features of the systems such as ease of use, flexibility, reliability, and ease of learning of the system used in training [5, 10].

developed more than 100 measures to evaluate the success of information systems [6, 7]. The first model (Fig. 1) was proposed in 1992 and has been expanded in 2003 (Fig. 2), adding future trends and net returns

2. Information quality: Coherence, clarity, accuracy, clarity, completeness, comprehensibility, applicability, timeliness, etc. [11].
3. *Service Quality: Responsiveness, accuracy, reliability*, responsible flexibility, technical skills, and staff sensitivity [12].
4. Use: The level, method, or extent of use of information system capabilities by staff and customers, frequency of use, nature of use, appropriateness of use, the scope of use, and purpose of use [13].
5. Customer Satisfaction: The level of customer satisfaction that results from consumption, positive perceptions, websites, and services [14, 15].
6. Net return: The success of individuals, groups, organizations, industries, and countries. For example, it contributes to economic development by improving decision-making skills, increasing productivity, increasing sales, reducing costs, improving profits, increasing market efficiency, increasing consumer interest, and creating jobs [16].

Based on the above discussion we propose a theoretical model, as depicted in Fig. 3, which emphasizes mediating effects of the Use, the Intention to Use, and the User Satisfaction constructs [17].

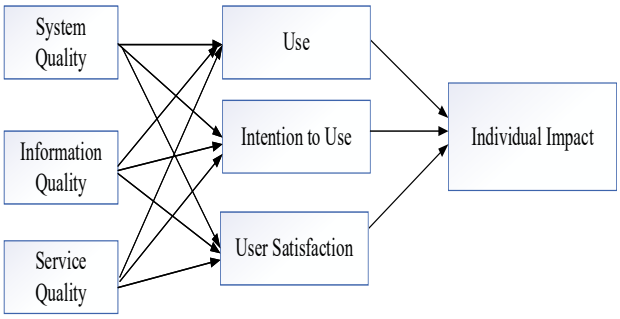


Fig. 3. The conceptual model

Based on this model, the following assumptions are made.
*H1: A quality e-learning system will increase the impact on the individual.*
*H2: The quality of e-learning information increases the impact on the individual.*
*H3: The quality of e-learning services will increase the impact on individuals.*
*H4: Consumption, future attitudes, or satisfaction increase the impact of e-learning systems, information, and service quality on the individual.*

## III. POPULATION AND SAMPLING

The sample size was calculated as follows:

$$m = \frac{Z^2 \times P \times (1-P)}{\varepsilon^2} \quad n = \frac{m}{1+\frac{m-1}{N}}$$

*Where: m is the sample size when the number of populations is unknown; n is the sample size; Z- 95% probability level Z value (1.96); P-probability level (0.5); - sampling error (0.05); N-Population (20518 students)*

$$m = \frac{Z^2 \times P \times (1-P)}{\varepsilon^2} = \frac{1.96^2 \times 0.5 \times (1-0.5)}{0.05^2} = 384.1$$

$$n = \frac{m}{1+\frac{m-1}{N}} = \frac{384}{1+\frac{384-1}{20518}} = 376.9 \approx 377$$

The survey covered 685 students, which is higher than the estimated sample size (377), increasing the reliability of the sample. MS-Excel and IBM SPSS Statistics25 were used to process the survey results.

## IV. RESEARCH INSTRUMENT

A questionnaire with 56 items in 7 groups was developed to collect data from 685 undergraduate and graduate students of the Mongolian University of Science and Technology through forms.microsoft.com. Cronbach's alpha coefficient was used to test the reliability of the survey questionnaire. Reliability refers to the assessment of the degree of compatibility between the measurement variables of many subsections or the internal stability of measurement. In other words, the coefficient is a measure of the internal stability /reliability of the questionnaire and examines the relationship between the group and the set. Internal compatibility is acceptable if the Cronbach alpha value is at least 0.7. The results of the analysis show that the Cronbach alpha is at an appropriate level, which indicates the reliability of the questionnaire and the internal compatibility of the variables. (System quality-0.933; Information quality-0.867; Consumption-0.932; Future trends-0.942; Individual impact-0.958). Therefore, in the future, it will be possible to evaluate and analyze the model using the results of the survey.

## V. RESEARCH METHODOLOGY

***Mediator variable and mediating analysis:*** If a research study includes measures of a mediating variable as well as the independent and dependent variable, mediation may be investigated statistically [18]. In this way, mediation analysis is a method to increase the information obtained from a research study when measures of the mediating process are available. Most of the economic and social science research focuses on relations between two variables, X and Y, and much has been written about two-variable relations, including conditions under which X can be considered a possible cause of Y. The mediator variable is the simplest form that represents the addition of a third variable to this X → Y relation, whereby X causes the mediator, M, and M causes Y, so X → M → Y. In other words, a mediator variable is a variable that causes mediation in the dependent and the independent variables. In other words, it explains the relationship between the dependent variable and the independent variable. Mediation is only one of several relations that may be present when a third variable, Z (using Z to represent the third variable), is included in the analysis of a two-variable system. Mediation tests whether the effects of X (the independent variable) on Y (the dependent variable) operate through a third variable, M (the mediator). In this way, mediators explain the causal relationship between two variables or "how" the relationship works, making it a very popular method in social research [19,20,21]. There are three major approaches to statistical mediation analysis: (a) causal steps, (b) difference in coefficients, and (c) product of coefficients [22]. All of these methods use information from the following three regression equations:

$$y = a_0 + bx + \varepsilon_0$$
$$y = a_1 + b'x + cM + \varepsilon_1$$
$$M = a_2 + dx + \varepsilon_2$$

*where $a_0$ and $a_1$ and $a_2$ are intercepts, y is the dependent variable, x is the independent variable, M is the mediator, b is the coefficient relating the independent variable and the dependent variable, $b'$ is the coefficient relating the independent variable to the dependent variable adjusted for the mediator, c is the coefficient relating the mediator to the dependent variable adjusted for the independent variable, d is the coefficient relating the independent variable to the mediator, and $\varepsilon_0$, $\varepsilon_1$, and $\varepsilon_2$ are residuals.*

In this study, we used Andrew F. Hayes' Process procedure [23] regression analysis to estimate the effect of transmitter or mediator variables. We tested students' intention to use and actual use as mediating factors between system success factors and individual impact.

## VI. RESEARCH RESULTS

General information of respondents: 55.7% of the survey participants were female and 44.3% were male students, while students aged 17-22 accounted for 73.4% of the total participants. In terms of level of study, 77.6% are undergraduate students and 22.4% are advanced students (Fig. 4).

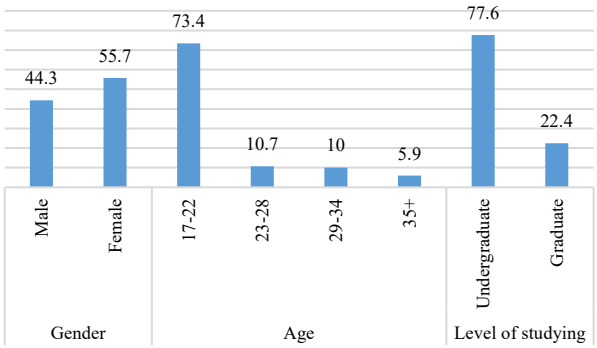


Fig 4. General information of the survey participants

Results of the component analysis: In the test, the Eigenvalue is calculated to be greater than 1 and the absolute value of the variable is greater than 0.6. The KMO (Kaiser-Meyer-Olkin) index is 0.974, indicating that the sample size is sufficient.

As a result, the Service quality and the User Satisfaction groups were excluded from the proposed model. This can be attributed to the fact that the need for e-learning systems has not originated based on the market demand or consumer choice, but on sudden need due to the global pandemic.

TABLE I. TABLE1. PRINCIPAL COMPONENT ANALYSIS RESULT MATRIX

| | Component | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| The e-learning system has made it easier to communicate with teachers | .819 | | | | |
| The use of e-learning has led to more presentations and discussions | .807 | | | | |
| With the use of e-learning systems, I have become more active in participating in seminars | .759 | | | | |
| The e-learning system makes it easier to communicate with other students | .759 | | | | |
| With the use of e-learning systems, homework and homework are better | .753 | | | | |
| E-learning systems can be used to get better grades | .696 | | | | |
| E-learning systems are used to keep up with peers | .673 | | | | |
| The e-learning system has improved the approach to the curriculum | | .702 | | | |
| The e-learning system has had a positive effect on my learning process | | .693 | | | |
| E-learning systems have increased my productivity | | .688 | | | |
| The e-learning system helped me improve my knowledge | | .673 | | | |
| The performance of the e-learning system is good | | .633 | | | |
| An e-learning system makes the task easier to complete | | .616 | | | |
| E-learning systems can store and transmit information at high speeds | | | .776 | | |
| Quick access to e-learning system | | | .753 | | |
| The security of the e-learning system is ensured | | | .720 | | |
| E-learning systems are constantly being improved | | | .708 | | |
| The user interface of the e-learning system is well organized | | | .700 | | |
| An e-learning system allows you to easily find the information you need | | | .698 | | |
| The operation of the e-learning system is reliable | | | .681 | | |
| E-learning systems are always available | | | .674 | | |
| An E-learning system is easy to use | | | .615 | | |
| There is interest in using e-learning systems in the future | | | | .710 | |
| Using an e-learning system is valuable to me | | | | .678 | |
| The use of e-learning systems is recommended for others | | | | .668 | |
| The information in the e-learning system is accurate | | | | | .802 |
| The information in the e-learning system is reliable | | | | | .691 |
| The information in the e-learning system is organized | | | | | .685 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

Hence, the original model proposed in the study was modified and the following results were obtained (Fig 5).

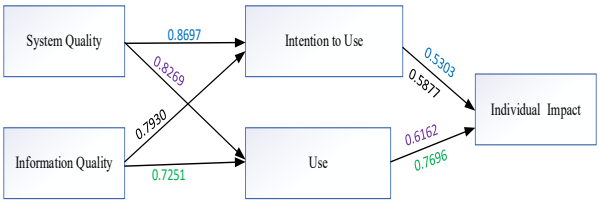


Fig 5. E-learning model

*Consumption as a mediator:*

The system quality explains 46.91% of the variations in consumption ($R^2$ = 0.4691) and 50.94% ($R^2$ = 0.5094) of the impact on individuals. In terms of *system quality*, the F statistic is 551.34, p = 0.000, indicating that *use* is determined statistically, and the t parameter of the factor parameter is t = 23.48, p <0.000. Although the *quality of the system* has a statistically significant effect on the individual (0.2707 t = 8.59), the results show that good use increases the benefit to the individual (0.8869 t = 25.45). In terms of indirect effects, the impact parameters of the "*Use*" variable are 0.6162, the standard error is 0.035, and the confidence interval (BootLLCI and BootULCI) is between 0.5437 and 0.6871. Because there is no zero in this range, the Use can be a statistically significant mediator in the relationship between *system quality* and *individual impact*.

The information quality explains 38.42% of the variations in *use* ($R^2$ = 0.3842) and 43.79% ($R^2$ = 0.4379) of the *impact on individuals*. In terms of *information quality*, the F statistic is 383.76, p = 0.000, which indicates that the *use* is determined statistically significant, and the statistic t of the factor parameter is t = 19.6, p <0.000. Although the *quality of the information* has a statistically significant effect on the individual (0.2370 t = 8.24), it is small, but *good use* increases the *benefit to the individual* (0.7950 t = 21.89). The impact parameter of the "use" variable is 0.5580, the standard error is 0.037, and the confidence interval (BootLLCI and BootULCI) is between 0.4871 and 0.6286, indicating a statistically significant transmitter in the relationship between *information quality* and *individual impact*.

*Intention to use as a mediator:*

System Quality explains 43.7% ($R^2$ = 0.4370) of variations of the *intention to use* and 49.31% ($R^2$ = 0.4931) of *individual impacts*. In terms of *system quality*, the F statistic is 374.07, p = 0.000, which indicates that the trend for *intention to use* is statistically significant, and the t parameter of the factor parameter is t = 19.34, p <0.000. Although the *quality of the system* explains the impact on the individual statistically (0.3972 t = 9.4), it is relatively small, but the desire to use it in the future shows that the benefit to the individual will increase (0.8585 t = 21.63). The impact parameter of the "Intention to Use" variable is 0.4613, and the confidence interval (BootLLCI and BootULCI) is between 0.3805 and 0.5376, indicating that the variable is a statistically significant mediator in the relationship between *system quality* and *individual impact*.

```
Run MATRIX procedure:

***************** PROCESS Procedure for SPSS Version 3.5.3 *****************

          Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2018). www.guilford.com/p/hayes3

**************************************************************************
Model  : 4
    Y  : F12_mean
    X  : F2_mean
    M  : F11_mean

**************************************************************************
OUTCOME VARIABLE:
 F12_mean

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .8875      .7877      .2304   1155.7659     2.0000   623.0000      .0000

Model
             coeff         se          t          p       LLCI       ULCI
constant    -.1124      .0811    -1.3865      .1661    -.2717      .0468
F2_mean      .2707      .0315     8.5972      .0000     .2088      .3325
F11_mean     .7452      .0261    28.5787      .0000     .6940      .7964

************************** TOTAL EFFECT MODEL ****************************
OUTCOME VARIABLE:
 F12_mean

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .7137      .5094      .5315    647.8597     1.0000   624.0000      .0000

Model
             coeff         se          t          p       LLCI       ULCI
constant     .1324      .1225     1.0805      .2803    -.1082      .3729
F2_mean      .8869      .0348    25.4531      .0000     .8185      .9553

************** TOTAL, DIRECT, AND INDIRECT EFFECTS OF X ON Y **************

Total effect of X on Y
      Effect         se          t          p       LLCI       ULCI       c_ps       c_cs
      .8869      .0348    25.4531      .0000     .8185      .9553      .8528      .7137

Direct effect of X on Y
      Effect         se          t          p       LLCI       ULCI      c'_ps      c'_cs
      .2707      .0315     8.5972      .0000     .2088      .3325      .2603      .2178

Indirect effect(s) of X on Y:
            Effect     BootSE   BootLLCI   BootULCI
F11_mean     .6162      .0359     .5437      .6871

Partially standardized indirect effect(s) of X on Y:
            Effect     BootSE   BootLLCI   BootULCI
F11_mean     .5925      .0302     .5322      .6514

Completely standardized indirect effect(s) of X on Y:
            Effect     BootSE   BootLLCI   BootULCI
F11_mean     .4959      .0250     .4451      .5442

********************** ANALYSIS NOTES AND ERRORS ************************

Level of confidence for all confidence intervals in output:
  95.0000

Number of bootstrap samples for percentile bootstrap confidence intervals:
    1000

------ END MATRIX -----
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Fig 6. Results of mediator analysis */Andrew F. Hayes Process procedure regression analysis/*

The Information Quality explains 36.3% ($R^2$ = 0.36.34) of the variations in *intention to use* and 69.2% ($R^2$ = 0.6923) of the *impact on individuals*. The F statistic of the "Information Quality" variable is 351.7, p = 0.000, which determines the *intention to use* the statistical significance, and the t statistic of the factor parameter is t = 18.7, p <0.000. The impact of information quality on individuals is explained statistically (0.3180 t = 9.5). Although the *quality of the information* alone can explain the *impact on the individual* at 31.8%, a constant

or increased individual's *intention to use* it in the future will increase the individual's benefit or 78.4%. (0.7841 t = 21.45). The impact parameter of the "Future Use" variable is 0.4661, and the confidence interval (BootLLCI and BootULCI) is between 0.3992-0.5335, which is a statistically significant mediator in the relationship between *information quality* and individual impact.

Good systems and information quality have been shown to increase the individual's impact by stabilizing the student's use of e-learning platforms and increasing their willingness to use them in the future. On the other hand, even if the system and the information are of good quality, it will have little effect on the individual if the student does not want to use it or is willing to use it in the future. This indicates the need to focus on stabilizing the use of the e-learning platform and stimulating interest in its use. The results of the study are demonstrated in the following table (Table 2).

TABLE II. TABLE 2. CONFIRMATION OF PROPOSED PREDICTIONS

| Hypothesis | Result |
|---|---|
| *H1: A quality e-learning system will increase the impact on the individual.* | Supported |
| *H2: The quality of e-learning information increases the impact on the individual.* | Supported |
| *H3: The quality of e-learning services will increase the impact on individuals.* | Rejected |
| *H4: Consumption, future attitudes, or satisfaction increase the impact of e-learning systems, information, and service quality on the individual.* | Partially supported |

## CONCLUSION AND RECOMMENDATIONS

In the face of the global pandemic, it is interesting to see whether e-learning systems can be a transmitter of knowledge. Therefore, this study aimed at determining effects of e-learning on students or individuals in our country. As a result of the research, it is possible to identify areas for further development of e-learning.

Analyses demonstrate that regular use can increase the impact on individuals. This illustrates that the quality of the system and information is key to the success of e-learning. Encouraging individual use and motivation for future use, on the other hand, increases the personal impact of e-learning systems. In addition, service quality and customer satisfaction indicators have become insignificant due to the need to use e-learning in response to the pandemic. In order to increase the use of e-learning systems according to market law, there is a need to focus on improving service quality indicators such as responsiveness, accuracy, reliability, responsible flexibility, technical skills, and staff sensitivity, thereby increasing satisfaction.

Therefore, tertiary education institutions need to focus on improving the quality of information, supporting the use of learning platforms, and making the information available to students more effectively. Developing long-term e-learning strategies to support effective quality education for individuals appears to be a priority for universities. In the current situation, it is necessary to make good use of the platforms such as MS Teams, Zoom, Google meets, and Moodle, which are in widely used Mongolian universities, to improve operations, improve teacher technical education, and develop programs and content to meet student needs.

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