Personal Information Technology Infrastructure Quality (PITIQ) Influence on Information and System Quality in LMS Success Models

Moh. Riky Saadilah*, Munir, Disman, and Puspo Dewi Dirgantari

Abstract—**The COVID-19 Pandemic has forced educational institutions, including in higher education level, to change teaching and learning process. They must carry out all teaching and learning processes using the Learning Management System (LMS). Information Technology Infrastructure (ITI) plays an essential role in LMS. Most studies have been focused on ITI based on organizational perspectives, and only few of them is based on personal resource. This study examined the impact of Personal Information Technology Infrastructure Quality (PITIQ) on the success of LMS. It used the DeLone and McLean model. The participants were 105 students using LMS in Indonesian public universities. This study also employed Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze the survey data. The results indicated that PITIQ provide a significant impact on both the LMS quality of the system and the LMS quality of information. Based on R-square results, the implications of variables in the proposed model were LMS System Quality (52.9%), LMS Information Quality (47.6%), Student Satisfaction (59.6%), the Use (17.0%), and Net Benefit (72.1%). The quality of the system and information from the LMS provider would not be well received if the PITIQ was of low quality. The system's quality and information quality affect student satisfaction with the LMS. Furthermore, students can experience the Net Benefits of LMS if they continuously use and are satisfied by LMS services.**

Index Terms—**Personal information technology infrastructure quality, Learning Management System (LMS) system quality, LMS information quality, use, student satisfaction, net benefit, DeLone & McLean model, Partial Least Squares Structural Equation Modeling (PLS-SEM)**

I. Introduction

The COVID-19 Pandemic interrupted education in over 150 nations. It affected 1.6 billion students [1]. Consequently, several countries have established some distance learning methods. As an emergency reaction, the educational response to COVID-19 was first focused on adopting online learning modes [2]. The action aims to reach out to all pupils. Unfortunately, it does not always succeed [3]. The educational response to the epidemic has developed [4]. Many nations currently have institutions that are partially or online [1].

The COVID-19 Pandemic has altered the teaching and learning process in higher education and the contact between students and lecturers [5]. Therefore, universities must carry out all teaching and learning using Learning Management Systems (LMS) technology. LMS may be the largest software following COVID-19. As of April 2020, 98% of higher education institutions had gone online [6]. The LMS market exploded in 2020 and is expected to continue growing well beyond 2021. These statistics demonstrate the significance of learning management systems in a post-COVID world.

LMS is a web-based technology utilized in online learning and teaching [7]. The LMS system allows for learning to take place anywhere at any time and for remote access to information. Currently, after almost two years of using LMS during a pandemic, it is deemed necessary to evaluate the success of using LMS [8, 9].

Evaluation of the LMS system is essential to ensure the successful delivery of instructional content, effective use, and positive impact on students [10]. Effective LMS implementation can prevent the Learning Loss. Several reports on LMS usage during the pandemic contained failures. Students' access issues to the LMS as a result of inadequate information technology infrastructure is one of the most significant obstacles [11]. Numerous universities fail to realize the anticipated benefits of Learning Management Systems (LMS) because they disregard the students' ITI [12, 13].

Academics have advanced various theories and models to explain the success of LMS [14, 15]. For example, the Delone & McLane (DM) framework is a popular model [16–19]. The framework contains the LMS System Quality (LSQ), LMS Information Quality (LIQ), Use (U), Students Satisfaction (SS), and Net Benefits (NB) as interrelated measures of system success [20, 21].

The success of LMS has been extensively studied in developed countries, where Information Technology Infrastructure (ITI) is no longer an issue [14]. There are less number of studies in developing countries [22]. The role of ITI in the success of e-learning has been overlooked. Technology is one factor that influences student satisfaction. Nguyen and Tran [23] found it when they observed e-learning factors in Vietnam. Selim [24] looked into the essential elements that make e-learning systems to be more widely accepted because of the Internet. Computer and network access are used to measure these constructs in this study. According to Ahmed [25], ITI significantly influences students' acceptance of hybrid e-learning courses. The ITI metric used in the study could only account for access to a computer. A new study by Alsabawy *et al.* [26] focuses on the Information and Communication Technology (ICT) Division's ITI service.

In contrast, prior study on IT infrastructure focused on ITI

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Moh. Riky Saadilah, Munir, Disman, and Puspo Dewi Dirgantari are with Universitas Pendidikan Indonesia, Indonesia. E-mail: munir@upi.edu (M.), disman@upi.edu (D.), puspodewi@upi.edu (P.D.D.)

*Correspondence: riky@upi.edu (M.R.S.)

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as a university or organizational resource [27–29]. On the other hand, LMS necessitates the provision of ITI by students [1] to be used in remote learning from home [30].

Personnel Information Technology Infrastructure Quality (PITIQ) is the term that describes the ITI's quality. The student provides them access to information over the Internet, like LMS. The PITIQ has yet to be studied empirically concerning LMS success. The PITIQ's role in the success of LMS in universities was examined in this study. Thus, this study aims to reveal PITIQ on LMS success using the DeLone & McLean model.

II. Literature Review and Research Model Development

A. DeLone and McLean Model

Delone and McLean (DM) collected approximately 180 articles on indicators of information system success [31]. Subsequently, they conducted a comprehensive taxonomy using Shannon's mathematical theory of communication [32] and measurement of information output [33]. Success models for Information Systems are hypothesized by DM to have multiple interrelated and dependent dimensions. They include including system quality, information quality, use satisfaction, individual impact, and organizational impact. In 2003, based on feedback, DM updated the model by including a Service Quality metric and consolidating the results of the Individual Impact and Organizational Impact sections into a single metric called Net Benefits. In anticipation of the widespread development of e-commerce, DM invites studies to validate and to extend the model [34].

Studies can broadly accept the DM 2003 model to comprehend and evaluate the success dimensions of various information systems [35]. Saadilah *et al.* [36] conducted an e-banking study in Indonesia by using the DM 2003 model for mobile banking,. It shows that low Information Quality can have a detrimental effect on customer satisfaction. In connection with the study, Veeramooto *et al*. [37] conducted a study on e-government in Mauritius. The model is expanded to include the influential concepts of perceived risk and routine use of e-filing. The findings suggest that residents' commitment to e-filing is influenced by system quality, satisfaction, and habit. Based on their studies of e-learning, Fraihat *et al*. [10] concludes that the quality of the educational system, the quality of the support system, the quality of the learner, and the perceived usefulness of LMS are the four most important factors in determining LMS adoption.

The study did not overlook the validation of the LMS field using the DM model. Klobas and McGill [38] investigated the roles of student and instructor engagement in LMS success by using the DM 2003 model as a framework. Student participation significantly affect the benefits of LMS use for students. The students' involvement with the LMS site for a course offering is directly proportional to the reported benefits. A study conducted by Mtebe and Raisamo in sub-Saharan countries [39] modified the DM 2003 model by renaming information quality to course quality. The result reveals that course quality and system quality affects LMS usage.

Ohliati and Abbas [18] investigated the level of Student Satisfaction in Indonesian universities. With an R-Squared value of 0.847, this study concludes that differences in Information Quality (IQ), System Quality (SQ), Service Quality (SEQ), Perceived Usefulness (PU), Perceived Ease of Use, Usage (PEOU), and Communication Quality (CQ) contribute to the variation in users' levels of satisfaction (CQ). The study conducted by Seta [40] show an R squared value for Individual Impact (IM) of 55%, User Perceived Satisfaction (UPS) of 40%, and Use of 53%.

B. Personal Information Technology Infrastructure Quality (PITIQ)

An organization's ITI is its centralized network of servers, networks, storage devices, and other components necessary to run the company's various information technology applications [41]. Hardware, operating systems, communication networks, data, and Information Technology (IT) applications are the primary components of the IT technical infrastructure [42]. Personnel abilities in the IT sector are referred to as "IT human infrastructure" [43].

There is no significant discussion about the importance of ITI to the success of LMS systems. A study on the importance of the concept is carried out using inadequate flat and metric methodologies. Alduraywish [44] found that a well-developed ITI is crucial. The software that enables online classes is the focus of the ITI metrics. Other factors must be considered to measure these concepts, such as IT expertise, IT security, IT connectivity, and IT applications. They are not captured by the metrics. Selim [24] reveals critical success factors that influence the adoption of e-learning systems studied. They show that ITI plays an important role in determining the level of adoption of e-learning solutions. The study used only two metrics—computer access and computer network reliability—to evaluate this factor. The openness of students to take hybrid online courses is also heavily influenced by the quality of the underlying information technology infrastructure [25]. Access to computers is the only indicator of the ITI used in this study. The literature suggests that the previous study method only considered a subset of the complete ITI.

Previous studies are mostly focused only on the existing ITI within the organization [22, 26, 45–47]. The Technology Environmental Organizational Framework (TOE) [48], where technology as an advanced success of e-learning innovation [49, 50], includes internal and external technologies relevant to the organization. Internal technology in the context of the university as a LMS service provider is a collection of web-based technologies that process, store, and distribute teaching materials over the Internet. External technologies are a set of IT infrastructures to access, process, and display information or content from LMS. Unlike the internal technologies that are the responsibility of the organization, external technologies are usually the personal responsibilities of LMS service users. The term that individually manages IT infrastructure is called Personal Information Technology Infrastructure Quality (PITIQ). PITIQ refers to the quality of an individual's personal technology infrastructure, including hardware, software, security, brainware, and internet connectivity.

PITIQ has a significant impact on the quality of systems and information that are the dimensions of LMS success [26, 51]. If someone has a high level of PITIQ, they are more likely to have a reliable and efficient personal technology infrastructure, which can help them perform tasks more effectively. It can also increase their confidence in the information provided by the system.

C. LMS System Quality (LSQ)

DeLone and McLean [31] propose a definition of system quality as "those features of an information system that make it particularly well suited to the process of producing information". It measures the efficiency of the computer's processors, both hardware and software [52]. A high-quality system has these characteristics: it is user-friendly, adaptable, reliable, easy to learn, has intuitive features, is sophisticated, and responds quickly [20]. The relationship between system quality and user satisfaction has been studied extensively, according to a critical meta-review of the DeLone and McLean model [35]. System quality influences both online learning system adoption and student satisfaction [53, 54]. LSQ defines system quality as the characteristics of a Learning Management System (LMS) that contribute to its ability to efficiently disseminate instructional materials. It is hypothesized that increased usage and satisfaction will result from students' perception of the system as being clear, well-ordered, highly functional, relevant, and simple to use.

D. LMS Information Quality (LIQ)

According to DeLone and McLean [31], "information quality" refers to "the degree to which the system's output meets the user's needs in terms of accuracy, significance, and timeliness". Information quality is a proxy for the depth of intended meaning. E-learning system adoption and user satisfaction are both enhanced by high-quality information [55, 56]. When it comes to how information quality influences usage and satisfaction, previous evidence has been mixed [57, 58]. Previous studies into how information quality affects LMS usage and satisfaction are lacking, and this study aims to fill that void. When discussing an LMS, "information quality" refers to how effectively the platform equips students with relevant and applicable data. Since learning management systems are supposed to produce useful information and lessons, this factor was considered essential. As a result, it is hypothesized that better information will lead to greater adoption and satisfaction.

E. Student Satisfaction (SS)

The degree to which a computer program's students are satisfied by their experience with it is known as SS [59]. In a broader sense, the concept of SS with computer-based electronic devices can be applied to the concept of student satisfaction. The degree to which a student is pleased with the information provided by an information system is known as the student's level of satisfaction. The relationship between usage and student satisfaction is symbiotic. Students who have a positive experience Use are more likely to be satisfied. It is possible to look at a system's use construct from a variety of perspectives, including the uses of real and impressions. Counting the number of information requests or connection times made by students is used in some studies. Use measurement also includes the distinction between voluntary versus mandatory use, informed versus uninformed use, and effective versus ineffective use [60].

F. Use (U)

The quality of this framework has been evaluated, and our recommendation is to focus more attention on the factors that influence Net Benefits (NB) and resistance to technology, as well as on long-term use. It is important to remember that system use and SS are not a guarantee of improved NB [61]. LMS adoption has been the focus of several projects, as reported by Sabeh *et al.* [14], but no conclusions have been drawn about the consequences of use. A higher Net Benefit will result if Use is a pleasant experience. According to this study, use positively impacts Net Benefits in the LMS.

G. Net Benefits (NB)

The LMS net benefits enables the study to assess it contribution to the success of individuals, teams, organizations, industries, and nations [21]. A few examples include being able to access information 24 hours a day and making better decisions, as well as increasing output and efficiency on specific tasks [62]. To measure success, we must look at net benefits, which reflect the balance between positive and negative effects on our customers, suppliers, employees, organizations, markets, industries, economies, or even societal systems or systems of value [20]. In addition, even though the net benefit was the most crucial variable, system use, student satisfaction, system quality, and information quality measurements cannot be analyzed and understood without these other variables. The term "net benefits" in this study refers to the LMS benefit that students use.

H. Research Model and Hypothesis

The independent variable in this study is PITIQ. The dependent variable is the DM model, namely LSQ, LIQ, U, SS and NB. According to the research model presented in Fig. 1, there is a relationship between the five dimensions of the DM model and the PITI. The hypothesis is tested in light of our literature review and research model. There is a strong relationship between PITI and LSQ, according to H1. H2: The hypothesis states that PITI and LIQ have a strong relationship. According to H3, there is a strong link between LSQ and U. In H4, LSQ and SS have a close bond that cannot be understated, while in H5, a strong correlation between LIQ and U can be concluded. H6: The correlation between LIQ and SS is significant, and, in H7, there is a strong correlation between SS and NB. Lastly, according to H8, there is a significant connection between U and NB.

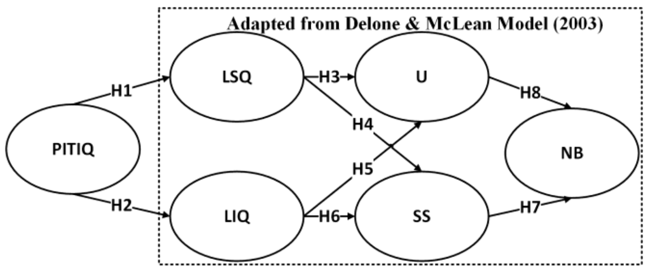

Fig. 1. Research model.

III. Research Methodology

This study employed a quantitative approach obtained with data from respondents' direct responses via questionnaires to investigate more specific information about the benefit description and LMS student satisfaction.

A. Constructs Operationalization

The measuring dimensions in this study were borrowed and altered from earlier investigations. Adaptability, availability, dependability, reaction time, and usability were the dimensions utilized for LSQ [63]. LIQ dimensions include completeness, clarity, personalization, relevance, and security [63]. Dimensions of Use (U) include the kind of use, navigation patterns, number of site visits, and number of transactions completed [64], while Dimensions of PITIQ contain internet connection, component, and application [41, 42, 65].

The remaining six sections used five Likert scale items ranging from strongly agree to strongly disagree with assessing PITIQ, LSQ, LIQ, U, SS, and NB. Table I shows the items and their sources.

TABLE I: Item Source

Code	Items	Source
PITIQ	8	[41, 42, 65]
LSQ	5	[63]
LIQ	5	[63]
U	3	[64]
SS	3	[34, 66, 67]
NB	4	[21, 68]

B. Sampling and Method of Data Collection

This survey aims to students who use LMS at public universities in Indonesia. To determine the minimum sample size we used the Soper A-priori Sample Size Online Calculator for SEM [69]. By using the parameter anticipated effect size 0.15, desired statistical power level 0.80, number of latent variables 6, number of observed variables 28 and probability level 0.50, the minimum sample size requirement is 89. To collect sample data, a survey is carried out using Google Forms so that students can easily fill out question items from anywhere.

There were 105 participants, 59.70% male and 40.30% female, who filled in questionnaires via Google Forms. The number of participants has fulfilled the minimum sample required for this study as many as 89 people. The participants' age was grouped into 17–27 years (37.50%), 28–38 years (25.00%), 39–49 years (29.20%), and over 50 years (8.30%). In terms of the program, the participants were undergraduate (39.05%) and postgraduate (60.95%) programs. Table II shows the respondent's profile in greater detail.

TABLE II: Characteristics of Respondents

Total Respondent n = 105		Total	Percentage
Gender	Male	63	59.70%
	Female	42	40.30%
Age	17 sd 27 year	39	37.50%
	28 sd 38 year	26	25.00%
	39 sd 49 year	31	29.20%
	>50 year	9	8.30%
Program	Undergraduate	41	39.05%
	Graduate/Postgraduate	64	60.95%

C. Data Analysis Method

Structural Equation Modeling (SEM) with (Partial Least Squares) PLS, a statistical technique, was used in this study. Using PLS, you can evaluate the measurement model's quality as well as the relationships between its various constructs at the same time (structural model). In the presence of abnormal data and a small or medium number of samples, PLS can still model latent constructs [70]. PLS uses Ordinary Least Squares (OLS) to estimate the path and iteratively analyzes variables to determine the path. Items from measurement and hypothesis testing are evaluated using Smart PLS 3.2.9 in this study.

IV. Findings and Discussion

A. Model Fit

This study employs the Standardized Root Mean squared Residual (SRMR) [71] and the Normed Fit Index (NFI) or bentler and bonett index [72] to evaluate model fit. The result of the model fit test presented in Table III illustrates how the theoretical model explains the present circumstance. Nonetheless, PLS-SEM is utilized in exploratory research, so the fit measure is only utilized for model projections [73].

TABLE III: Model Fit

	Estimated Model
SRMR	0.079
NFI	0.705

The measurement results of the SRMR value of 0.079 indicate that the model fit, because the resulting value is still below the threshold 0.080 [74, 75]. In addition, the measurement results of the NFI value of 0.705 are close to the 0.90 threshold [75, 76], which means they are still acceptable but can be significantly enhanced [76, 77].

B. Measurement Model

The validity and reliability of the individual indicator variables are evaluated in terms of their ability to measure the target latent constructs within the measurement model. Convergent validity, construct reliability, and discriminant validity were employed to evaluate the model's validity and reliability. The measurement items' relationship to their theoretical constructs is examined by convergent validity. Fornell and Larcker [78] propose using factor loadings, composite reliability, internal consistency reliability, and Average Variance Extracted (AVE) to evaluate convergent validity.

The studies [79, 80] have found that the Outer Loadings must be greater than 0.708 for an excellent indicator to be reliable. Table IV shows that loadings are higher than 0.708. Only in the constructs of U1 and SS3 the loading values were less than 0.708. The model did not include these two items. It indicates that the model's internal consistency is strong if Composite Reliability (CR) values are greater than 0.7 [81]. Convergent validity was examined with the help of the Average Variance Extracted (AVE) method. To account for more than half of the variance in an indicator, the AVE must be greater than 0.50 [82–85].

TABLE IV: MODEL MEASUREMENT RESULTS ON LMS

Construct	Item	Loading[a]	AVE[b]	CR[c]	RhoA[d]
PITIQ	PITIQ1	0.742	**0.641**	**0.934**	**0.927**
	PITIQ2	0.722			
	PITIQ3	0.800			
	PITIQ4	0.810			
	PITIQ5	0.826			
	PITIQ6	0.844			
	PITIQ7	0.884			
	PITIQ8	0.765			
LSQ	LSQ1	0.711	**0.649**	**0.902**	**0.872**
	LSQ2	0.877			
	LSQ3	0.838			
	LSQ4	0.824			
	LSQ5	0.768			
LIQ	LIQ1	0.946	**0.830**	**0.961**	**0.952**
	LIQ2	0.930			
	LIQ3	0.883			
	LIQ4	0.929			
	LIQ5	0.863			
U	U2	0.901	**0.842**	**0.914**	**0.836**
	U3	0.934			
SS	SS1	0.921	**0.856**	**0.923**	**0.834**
	SS2	0.930			
NB	NB1	0.917	**0.834**	**0.953**	**0.936**
	NB2	0.905			
	NB3	0.928			
	NB4	0.903			

*Item issued: item indicator < 0.708: U1 and SS3
a. All Factor Loading Items > 0.708 indicate Indicator Reliability [79, 80]
b. All Average Variance Extracted (AVE) > 0.5 indicates Convergent Reliability [82,78]
c. All Composite Reliability (CR) > 0.7 indicates Internal Consistency [81]
d. All Rho_A > 0.7 [80]

The model's results found proper internal consistency, variable reliability, and convergent and discriminatory validity. As a result, the structural model can be evaluated using this model.

TABLE V: HTMT COEFFICIENT

	LIQ	LSQ	NB	PITIQ
LSQ	0.817			
NB	0.835	0.621		
PITIQ	0.727	0.801	0.522	
SS	0.694	0.690	0.738	0.621
U	0.459	0.244	0.627	0.262

Discriminant validity refers to the degree to which different constructs' measures differ from one another. The Cross loading and Fornell-Larcker criteria for evaluating the measurement model's discriminant validity are deemed inadequate [84]. Alternatively, a number of studies have begun employing Heterotrait-Monotrait (HTMT) analysis to determine the discriminant validity. HTMT is the mean of the bivariate or cross-item correlations between the constructs [86]. The HTMT coefficient between two constructs should not be greater than 0.85 at most [87]. Table V shows that there are no discriminant validity problems with the model because the inter-construct correlations are less than 0.85.

C. *Structural Model*

To determine if the measurement model and its results are accurate, the research model was put through its paces by examining the predictive power of the model and the structural model's significance. Structural models could be evaluated for their accuracy in forecasting using R-Square Adjusted. By doing so, the study could determine how much variation in an affected variable (endogenous) could be explained by the influencing variable (exogenous). R-Square Adjusted was used when a model had multiple endogenous constructs.

Based on the results of the coefficient of determination test in Fig. 2, the adjusted R-square value was 0.721 (72.1%), which was deemed as strong [88]. The result implies that the ability of the independent variables in this study affected the dependent variable by 72.1%. The remaining 0.279 (1−0.721) was explained by variables other than the independent variables in this study—the R-Squared Adjusted Model for Endogenous Use: 0.170. According to the findings, the ability of the exogenous variables to explain Use was 17.0%, which was considered weak [88]. The R-Square Adjusted Model was 0.596 for the SS endogenous construct. There was a moderate correlation between 59.6% of the variance in U explained by LIQ, LSQ, and PITIQ, for LSQ is 0.529 and LIQ is 0.476 [88].

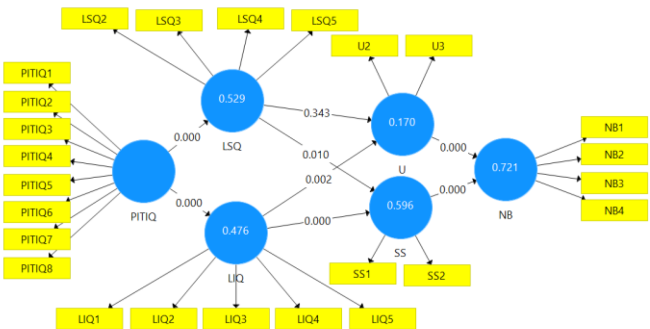

Fig. 2. Statistic model.

The hypothesis or path significance was tested using a bootstrapping algorithm with a standard error of 0.05 and 1000 sample iterations. It was possible to use the estimated bootstrap distribution coefficient as a proxy for the parameter's population standard error because it provided an estimate of the sample distribution and its standard deviation. Each indicator's weights were calculated using the t value, which was used to determine how significant they were [85]. To test the hypothesis, the t-value of the path coefficient was used. The hypothesis is accepted if the t-value is more significant than 1.96.

A positive impact on LSQ's endogenous constructs could be seen in H1 and H2 ($\beta = 0.727$, ***$p = 0.000$) and LIQ ($\beta =$

0.690, ***$p < 0.000$), according to Table VI. Hypothesis H4, H5, H6, H7, and H8 were supported. Hypothesis H3 was thus rejected because it failed to account for U in a statistically significant way.

Table VI has shown that H1, i.e., PITIQ, affected LSQ. The high-quality PITIQ could increase acceptance of system quality on the side of LMS users. It happened because the LMS application was web-based [7], and web-based applications had a client-server architecture [20, 89]. In this architecture, LSQ was the quality of the system on the server side. To receive a sound quality system, the user must have a high-quality Internet connection with adequate speed and bandwidth capacity. LMS content with multimedia, of course, required a large bandwidth capacity. In addition, the quality of the receiving device (client computer) and the quality of user knowledge in operating applications to access the LMS at PITIQ was also imperative. Computer devices with small screens were not convenient to receive rich content from LMS [90].

H2 is the effect of PITIQ on LIQ. User (students) access LIQ on the LMS server side. The information is sent through an electronic channel provided by the student. If the quality and capacity of the electronic channel are inadequate, the user cannot receive information or LMS content properly. The Internet is an electronic channel that has a worldwide coverage area. The better the quality of the Internet on the user's side, the better the LIQ. The result of this study is in line with research conducted by Vicente [91]. Besides that, the quality of the computer on the student's side as a device used to process and display information or content from the LMS server is also important. Devices that do not meet the standard cannot process information properly. For example, if the LMS provides multimedia content, the computer must be able to process the content so that students can receive the information.

The result of H3 is the effect of LSQ on U, indicating that the quality of the system does not affect increasing usage. The COVID-19 pandemic has forced universities and students to use LMS as a distance learning medium. The use of LMS is no longer optional but mandatory [68], even with the low quality of the system. It is also possible that the cause is the presence of a mediating variable between LSQ and U. However these results are in accordance with research conducted by Salam *et al.* [92] and Al-Fraihat [10].

H4, the effect of LSQ on SS, indicates that the quality of the system can increase student satisfaction. This is following the research conducted by Ram ŕez-Correa *et al.* [93]. LSQ needs to be evaluated regularly by universities by involving students to ensure the availability, reliability, and ease of use of the LMS are met so that user satisfaction is achieved, in this case, students.

The results of H5, namely the effect of LIQ on U, indicate that the quality of information can increase usage. In this study, the quality of information positively affects usage. These results follow the investigation research conducted by Mtebe and Raisamo [39]. However, this result contradicts the research conducted by Al-Fraihat *et al*. [10] stated that the quality of information has no significant effect on usage. Presentation of unattractive information on teaching materials, unclear information, and grammar that is difficult to understand results in reduced quality of information.

The effect of LIQ on SS (H6) indicates that the quality of information can increase user satisfaction. The following research by Almarashdeh [94] shows that the quality of information has the most dominant influence on student satisfaction because the quality of information is related to the delivery of electronic teaching and learning materials from lecturers. The quality of information that is easy to understand can increase student satisfaction in using the LMS.

H7 effect of SS on NB shows students satisfaction can increase net benefits. In Al-Fraihat *et al.* [10], student satisfaction positively and significantly affects Net Benefits.

H8, which is the effect of U on NB, shows that the use of the system can increase NB. Research conducted by Cidral *et al.* [56] explained that their research on the effects of Use on the benefits of E-Learning. Therefore, universities must require the use of LMS for students and lecturers, with adequate PITI quality requirements.

Table VI summarizes the f^2 [95] evaluation of the structural model. Effect size f^2 is a measure of the influence of one construct on another. Small to large Effect Sizes characterize all significant structural paths for SS and NB in this model.

TABLE VI: HYPOTHESIS RESULTS

Hypothesis	β	**Result**	$\mathbf{f^2}$	**Effect Size (ES)**
H1: PITIQ → LSQ	0.727***	Accepted	1.121	large
H2: PITIQ → LIQ	0.690***	Accepted	0.907	large
H3: LSQ → U	−0.059	Rejected	0.002	none
H4: LSQ → SS	0.279**	Accepted	0.072	small
H5: LIQ → U	0.458***	Accepted	0.095	small
H6: LIQ → SS	0.532***	Accepted	0.263	medium
H7: SS → NB	0.718**	Accepted	1.566	large
H8: U → NB	0.253***	Accepted	0.194	medium

Notes: ES > 0.350 : large; 0.150 < ES ⩽ 0.350 : intermediate; 0.020 < ES ⩽ 0.150 : small [70, 96]. β: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.001$.

V. CONCLUSION

This study has developed and validated a model of LMS success for developing countries. The model is built based on the theoretical basis of the DM and ITI models to determine the antecedents that affect LSQ and LIQ in LMS. This study differs from other studies since it employed ITI in the personal domain. The survey instrument of the study can be used in future studies to assess the success of the LMS from the perspective of a lecturer. Various stakeholders can use the taxonomy. It includes PITIQ, LSQ, LIQ, Use, satisfaction, and NB, to better understand the success of LMS in educational institutions and take the necessary steps to improve its effectiveness.

This study also has several limitations. Firstly, the study was conducted in Indonesia. therefore, its generalizability may be limited. Future studies can take other settings across developing countries. Secondly, this study only measures the impact of PITIQ on LSQ and LIQ. Future studies can measure the impact of PITIQ on Use, SS and NB. The model can also be validated across the context of other Internet web-based information systems.

APPENDIX: QUESTIONNAIRE

Name	:					
Program	:	○ Bachelor	○ Masters	○ Doctor		
Gender	:	○ Male	○ Female			
Age	:					
Devices Used to Access the LMS	:	○ PC Desktop	○ Laptop	○ Tablet	○ Smartphone	
Duration of Using the Internet in a Day	:	○ 1 to 2 Hours	○ 2 to 3 Hours	○ 3 to 4 Hours	○ 4 to 5 Hours	○ > 5 Hours
Most Frequently Used Locations to Access LMS	:	○ Home	○ Campus	○ Office	○ Boarding House	○ Other
Name of your College/University	:					
[Strongly disagree 1.] - [2] - [3] - [4] - [5. Strongly agree]		1	2	3	4	5
PITIQ						
1. LMS can be accessed using all types of available Internet networks		○	○	○	○	○
2. Internet network security used to access the LMS is adequate		○	○	○	○	○
3. Internet network to access the LMS is reliable		○	○	○	○	○
4. Internet network to access the LMS has adequate speed		○	○	○	○	○
5. LMS can be accessed from any location		○	○	○	○	○
6. I am used to using a PC/Laptop/Notebook/Tablet/Smartphone for studying		○	○	○	○	○
7.I'm comfortable using a browser app (Google Chrome/Firefox/Opera/Microsoft Edge) to access the LMS		○	○	○	○	○
8.The device (PC/Laptop/Notebook/Tablet/Smartphone) used to access the LMS is adequate		○	○	○	○	○
LSQ						
1. LMS is easy to use		○	○	○	○	○
2. LMS is easy to access		○	○	○	○	○
3. LMS has a well-structured navigation menu		○	○	○	○	○
4. LMS Always Accessible		○	○	○	○	○
5. LMS Has Interesting Features For You		○	○	○	○	○
LIQ						
1. LMS Provides the Information/Content You Need		○	○	○	○	○
2. LMS Provides Information/Content Relevant to Learning.		○	○	○	○	○
3. LMS Provides Complete Information/Content		○	○	○	○	○
4. LMS Provides Easy-to-Understand Information/Content		○	○	○	○	○
5. LMS Provides Latest Information/Content		○	○	○	○	○
Use						
1. I Often Use LMS		○	○	○	○	○
2. I Depend On The LMS System		○	○	○	○	○
3. I Only Use LMS When Needed To Study		○	○	○	○	○
SS						
1. I Don't Have A Positive Attitude Towards LMS		○	○	○	○	○
2. I think LMS is very useful		○	○	○	○	○
3. Overall I am satisfied with LMS performance		○	○	○	○	○
NB						
1. LMS Has a Positive Impact on Learning in the Courses I Follow		○	○	○	○	○
2. Overall LMS Has Good Performance		○	○	○	○	○
3. Overall LMS has Succeeded		○	○	○	○	○
4. LMS Is Important and Valuable For Me in Improving Learning Performance		○	○	○	○	○

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

MRS contributed to the conception of the study, wrote drafts and original software, and conducted formal analyses; M contributed to study concepts, wrote original drafts, supervised and managed projects; D contributed to the investigation, data analysis, and methodology; PDD contributed to the analysis and preparation of the manuscript. All authors have approved the final version.

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