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THE INFLUENCE OF MOBILE APPLICATION-BASED LABORATORY INFORMATION MANAGEMENT SYSTEMS ON CUSTOMER LOYALTY

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ABSTRACT

The trend of mobile application development is not only focused on the business to consumers (B2C) industry dominated by mobile e-commerce applications. Still, it has also become a trend in the business-to-business (B2B) industrial sector. Several studies show the significant influence of this mobile application on customer loyalty. As a part of the business-to-business (B2B) industry, the third-party accredited laboratory services have the challenge to maintain and manage customer loyalty in today's era of intense competition. Nowadays, the Laboratory Information Management System (LIMS) function is not just testing operational tools from the sample receiving to testing report. More than that, it must have the ability as a customer relationship management tool. Therefore, one of the LIMS optimizations is providing a mobile application version. This study aims to identify the influence of a mobile application-based Laboratory Management Information System on customer loyalty as one of the accredited third-party testing laboratory solutions, primarily to manage customer retention. The study shows that the variable information accessibility and customer engagement of mobile application-based Laboratory Management Information System significantly affect customer loyalty.

Keywords: *Lims, Mobile Application, B2b, Customer Loyalty*

1. INTRODUCTION

According [1], the mobile application as a digital service channel for the industry in the B2B sector has increased. B2B market leaders have used mobile apps to increase customer engagement, reduce purchase time, and increase customer loyalty. A survey [2] shows that 63% of IT decision-makers in the B2B sector indicate that the primary use of B2B mobile applications is customer loyalty. In addition, based on research conducted by The Boston Consulting in collaboration with Google [1], mobile applications in the B2B industry have moved and affected the revenues of these market leaders by an average of more than 40%. Therefore, the main concern of the B2B industry in considering implementing mobile applications is customer satisfaction and loyalty.

Shifting the business activity habits of stakeholders, in this case, users in the B2B industry sector is almost similar to B2C, namely the shift of customer activity to a mobile device-based platform through mobile applications. This condition makes the B2B industrial sector must quickly catch the signal of change. Various mobile applications have been developed by the B2B industry, which generally provides comprehensive access to product information and ease of service. The mobile application was developed as a leading technology in terms of customer relationship management (CRM), where communication channels with customers are integrated through mobile application media. The features developed in the B2B mobile application are closely related to the overall needs of its customers, so the factors that affect customer satisfaction and customer loyalty through the mobile application need to be further identified. The characteristics of B2B customers are indeed very unique. Although B2C and B2B have something in common, there are some important differences wherein B2B has longer business relationships, more complex services, and more often, and some customer decision-makers are done in the procurement section. Given that customer experience is personal, this is a significant challenge. In addition, decision-making in the context of B2B is less emotional than in B2C but relatively rational based on experience.

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As a part of the business-to-business (B2B) industry, the third-party accredited laboratory services have the challenge to maintain and manage customer loyalty in today's era of intense competition. For example, in Indonesia, based on data from [1], there are 1500 accredited testing labs, 350 calibration labs, and 75 medical labs, which continue to increase every year. As a result, the testing lab customers become fragmented and saturated. Therefore, every testing lab provider must carry out various innovations to face the competition, which is getting tougher. The utilization of Laboratory Information Management System (LIMS) in lab testing providers is not only a solution of operational tools from the sample receiving to testing report. More than that, it must have the ability as a customer relationship management tool. One solution for the testing lab to manage customer relations and retention is to provide LIMS in the mobile application version.

This study aims to identify the influence of a mobile application-based Laboratory Management Information System on customer loyalty as one of the accredited third-party testing laboratory solutions, primarily to manage customer retention. This research is a case study in one of the accredited third-party laboratory service providers whose market segmentation is the business-to-business (B2B) industry sector. As a testing service provider, besides the reliability factors, credibility, and accuracy of test results, including competitive price factors, another important aspect is customer management to build customer experience and engagement.

2. LITERATURE REVIEW

2.1 Laboratory Testing Industry

The testing laboratory is one of the facilities of conformity assessment that is very important in the supply chain of a product and the examination, diagnosis, verification, and validation of a disease or human health. The existence of testing laboratories, especially third-party testing laboratories, is regulated and supervised by national and international recognition agencies, in this case, accreditation bodies, both government and private. The testing laboratory industry is an industry that has been growing since the 18th century and is worth billion dollars. As an example, according to data from [3] by 2020, the food safety testing business reached US $ 17.4 billion and is predicted to increase to US $ 25.8 billion by 2027. Nowadays, due to the high increment of testing lab providers globally, the market share of testing bisnis will become more saturated and the competition more intense.

2.2 B2B mobile application trend

According to the report [2] adoption of mobile applications in the B2B sector began to surge in 2018 and continues to show impressive growth with no signs of slowing. In fact, the demand for B2B mobile applications is expected to push the market to $140 billion by 2023. Some of the things that are driving the increasing trend of mobile applications in the B2B sector stated by [3] are as follows:

a) Personalization drives sales and loyalty

b) B2C Experience

c) Services are fully available 24 hours/7 days

[3] It also suggests that businesses that don't prioritize mobile apps miss out on real opportunities. [4] explain that going forward, B2B companies see digital interactions as two to three times more important to their customers than traditional sales interactions. From some of the foundations of the theory, it can be conclude that mobile applications in corporate services in the B2B sector can improve business performance and customer loyalty.

2.3 Laboratory Information Management System (LIMS)

According to [5] the Laboratory Management Information System (LIMS) is included in one of the software that serves to store and manage information obtained during the testing process in the laboratory. The system controls and manages samples, standards, test results, reports, laboratory staff, lab equipment, and laboratory workflow automation. Integrating laboratory management information systems with other information systems can enable the faster and real-time transfer of data from the laboratory to the user. The task of the Laboratory Management Information System today is not only the requirements of laboratory management but also process management, data security and data transfer and it all becomes very important. [6]. Modern LIMS consists of complex and interrelated computer programs and infrastructure that support a wide range of laboratory information processing needs. LIMS provides management reports and other data the laboratory needs to mobilery out its operations and to support sustainable improvement and quality initiatives [7]. Modern LIMS should also have built-in functionality for other necessary activities, such as regulation, billing, or quality assurance [8].

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2.4 Customer Loyalty

According to [9] loyalty is a certain attitude and behavior. Loyalty is essential and reflects a customer's positive response to buying back a particular product or service [10]. The statement of [6] reinforces that loyalty is defined as repeated purchases, long-term commitments, intentions to continue relationships, and the possibility of not switching from other suppliers. Some modern studies use a composite approach to understand B2B customer loyalty. B2B customer loyalty is observed as a combination of psychological attitudes, such as similarity, satisfaction or repetitive buying behavior, that can be measured in the number or frequency of purchases.

[11] Introduce two approaches to defining and measuring loyalty:

1. **Loyalty based on behavior.** Behavioral loyalty can be expressed through continuous, fixed and measurable purchases with reference to customer buying behavior**.**
2. **Loyalty based on attitude**. Loyal customers are committed and have a strong preference for a particular supplier, which means that loyalty attitude must be measured by mapping out a customer's buying beliefs, feelings and intentions.

It's important to understand what factors affect customer loyalty and what factors must be considered in customer loyalty to last a long time. According to [12], [13], [14] and [12] in [15] there are at least three main factors that affect customer loyalty as presented in figure 1 below, namely Customer Relationship Management (CRM), Customer Satisfaction and Customer Experience. Furthermore, Vilkaite-Vaitone and Skackauskiene (2020) show that powerful factors that positively affects on customer loyalty from the two service industries are service personalization, price, service quality, and the attractiveness of service delivery environment, reputation, competitiveness, services culture, and economic well-being.

Figure 1. Three main factors that affect customer loyalty [10]

2.5 Customer Satisfaction

A study by [11] revealed that customer satisfaction is the most dominant indicator and is positively correlated with customer loyalty. The research of [12] shows that many authors in the context of different online services conclude the satisfaction of using electronic media has a direct, significant, and positive impact on the loyalty of those media users.

According to [6] customer satisfaction is the feeling of pleasure or disappointment of someone who appears after comparing the performance (results) of the product thought to the expected performance, and according to [13] Satisfaction is an attitude that is decided based on the experience gained. Thus, satisfaction is an assessment of the characteristics or privileges of a product or service or the product itself, which provides a level of consumer pleasure related to fulfilling consumer consumption needs.

2.6 Customer Relationship Management (CRM)

In general, mobile applications developed by B2B have a main function as a digital customer relationship management (CRM) tool. CRM is the strategic process of selecting the most profitable customers to serve and shaping the interaction between the company and that customer. The ultimate goal is to optimize customer value for the company in the present and future. [17]. [18] explain at least 3 types of CRM based on its characteristics as presented in Table 1.

Table 1. Types of CRM based on their characteristics

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CRM Type	Dominan Characteristic
Strategic	Strategic CRM is a core customer-centered business strategy that aims to win and retain profitable customers.
Operational	Operational CRM focuses on automating processes that relate directly to customers, such as sales, marketing, and customer service.
Analytic	CRM analytics is how organizations convert customer-related data into actionable knowledge or information for both strategy and tactical purposes.

Furthermore, [11] conclude that CRM is a core business strategy that integrates internal processes and functions and external networks to create and deliver value to targeted customers to gain profits. It is based on high-quality customer-related data as well as being enabled by information technology. The use of information technology including mobile applications as one of the technologies used in CRM is known as e-CRM. e-CRM basically, managing customer relationships with electronic means [19]. According to [20] e-CRM is a business model of relationship marketing centered on technology strategies, which combines traditional CRM with electronic market business applications.

The use of CRM or e-CRM is very important for the industry because it is closely related to customer management in order to increase customer loyalty. Some research as done by [21], [22], [23], [24], [25], and [26] CRM and e-CRM have a significant effect on service quality, customer satisfaction, and loyalty. The dimensions of CRM or e-CRM that affect customer satisfaction and loyalty are summarized from the following researchers:

Table 2. CRM/e-CRM Dimmension

No.	Reseracher	Dimension
1.	[27]	▪ Information Accessibility ▪ Services ▪ Security ▪ Trust
2.	[28]	▪ Customer Services ▪ Mobile Services Optimation ▪ Reward Program ▪ Customization
3.	[29]	▪ Pre-services Transaction ▪ During-services Transaction ▪ Post-services Transaction
4.	[30]	▪ Information quality ▪ Ease of Navigation ▪ Customer Services Efficiency

2.7 Engagement

Customer engagement is a behavioral manifestation of the brand or firm beyond transactions [31]. According to [32] mobile apps are becoming a go-to tactic for retailers because they promise highly convenient digital engagement. Digital engagement refers to non-transactional shopping activities available online, such as easy access to consumer reviews, online chat services, and alternative products suggested by website recommendations. Study conducted by [33] showed that customer engagement and brand trust positively influenced brand loyalty. Furthermore, a recent study by [37] on the influence of several digital channel variables established under the Information System Success Model and Technology Acceptance Model (TAM) on customer loyalty shows that only engagement variables positively affect customer loyalty. This engagement variable consists of interactivity, simultaneity and direct contact.

2.8 Previous Research

There has been no previous research specifically discussing the impact of the implementation of mobile application-based laboratory management information systems on customer satisfaction and loyalty, impacting B2B customers. Some of the latest research that is relevant as a foundation of this research theory is [35], which explains some of the theoretical and managerial implications associated with the adoption of B2B mobile applications as well as research [36] examining Return on Engagement Initiatives (RoEI) on B2B mobile applications. In addition, a recent study by [37] on the influence of several digital channel variables established under the Information System Success Model and

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Technology Acceptance Model (TAM) on customer loyalty become a major reference of this study, especially in defining variables and the main construct of the research model. As well as some theoretical foundations related to factors that affect customer satisfaction and loyalty, researchers adopted several research models related to the influence of the application of digital channels, including mobile applications and CRM or e-CRM, on customer satisfaction and loyalty.

3. METHOD

3.1 Sample and Data Collection

This study was conducted through an analysis of customer survey data from one of the B2B testing service providers that will implement a mobile application-based laboratory information management system. The survey conducted in November 2021 obtained 50 completed responses. Table 3 presents the statistics about the respondent's profile.

Table 3. Information about the respondents

Age	Frequency	%
20-29 years	22	44%
30-39 years	21	42%
40-49 years	6	12%
> 50 years	1	2%
Gender	**Frequency**	**%**
Man	25	50%
Women	25	50%
Job Level	**Frequency**	**%**
Manager Level Up	12	24%
Staff	38	76%
Industry Type	**Frequency**	**%**
Manufacturing/Production	42	84%
Trading (Export, Import, Retailer)	7	14%
Services	1	2%
Services Experience	**Frequency**	**%**
> 3 years	32	64%
2-3 years	6	12%
1-2 years	5	10%
<1 year	7	14%

3.2 Research Model

The research model on this study presented in Figure 2 below

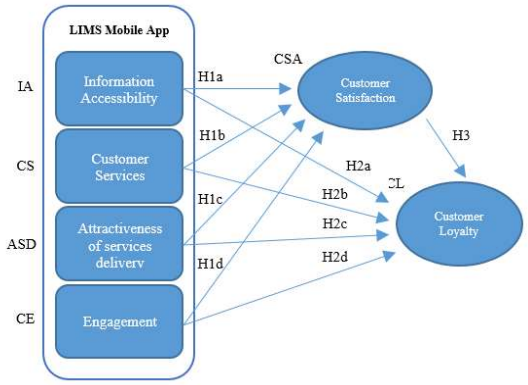

Figure 2. Research Model

The hypotheses proposed in this study are as follows:

- H1 - The influence of LIMS-based car applications affects customer satisfaction, where:
  a. *H1a: Information Accessibility affects customer satisfaction*
  b. *H1b: Customer Services influences customer satisfaction*
  c. *H1c: Attractiveness of Services Delivery influences customer satisfaction*
  d. *H1d: Engagement influences customer satisfaction*
- H2 - The influence of LIMS-based mobile applications affects customer loyalty, where:
  a. *H2a: Information accessibility affects customer loyalty*
  b. *H2b: Customer services affect customer loyalty*
  c. *H2c: Attractiveness of Services Delivery affects customer loyalty*
  d. *H2d: Engagement affects customer loyalty*
- H3 - Customer Satisfaction due to the implementation of the Mobile Application-based Laboratory Management Information System affects customer loyalty

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3.3 Measure

Scale measure was adapted from the existing literature. The scale items were measured on a 5-point Likert scale, ranging from 1 –"totally disagree" to 5 –"totally agree". Structural equation modeling was assessed using partial least squares (PLS) modeling (SmartPLS 3.0 software).

4. DATA ANALYSIS & RESULT

4.1 Measurement Model

Construct validity and reliability were examined by confirmatory factor analysis. Construct validity was assessed by the examination of convergent validity (threshold ≥ 0,7). If we refer to [34] convergent validity still accepted if loading factor ≥ 0.5. As displayed in Table 4, all indicators are showing outer loading factor more than 7.

Table 4. Loading factor

	ASD	CE	CL	CS	CSA	IA
ASD_1	0.890					
ASD_2	0.950					
ASD_3	0.928					
ASD_4	0.913					
CE_1		0.959				
CE_2		0.946				
CE_3		0.947				
CL_1			0.933			
CL_2			0.940			
CL_3			0.864			
CSA_1					0.888	
CSA_2					0.955	
CSA_3					0.933	
CS_1				0.903		
CS_2				0.940		
CS_3				0.889		
IA_1						0.902
IA_2						0.910
IA_3						0.886
IA_4						0.866
IA_5						0.864
IA_6						0.895
IA_7						0.864

According to discriminat validity assessment, see Tabel 5, all variable are comply with the criteria discriminant validity. The results showed that each item-to-construct loading was greater than that of any other constructs, what could be inferred that the indicators are not interchangeable. Following Fornell–Larcker criterion, AVE is used to test discriminant validity. The square root of the AVE was higher than the variable inter-correlations. A measurement instrument and related dataset are considered to have acceptable discriminant validity if the square-roots of the AVEs for each latent variable are higher than any of the correlations between that latent variable and other latent variables [35].

Tabel 5. Discriminant validity

	ASD	CE	CL	CS	CSA	IA
ASD	**0.921**					
CE	0.792	**0.950**				
CL	0.578	0.763	**0.913**			
CS	-0.467	-0.348	-0.178	**0.911**		
CSA	0.815	0.855	0.692	-0.367	**0.926**	
IA	0.881	0.891	0.739	-0.376	0.840	**0.884**

Construct reliability was assessed by the evaluation of internal consistency. Internal consistency was assessed using Cronbach's alpha (threshold: 0.70), composite reliability (CR, threshold: 0.70) and average variance extracted (AVE, threshold: 0.50). According to construct validity and reliability result in Tabel 6, all variabel showing value ≥ 0.7 and according to AVE also have value ≥ 0.5. It mean all variable are reliable.

Table 6. Construct Reliability & Validity

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
ASD	0.940	0.942	0.957	0.847
CE	0.947	0.952	0.966	0.903
CL	0.899	0.900	0.937	0.833
CS	0.897	0.903	0.936	0.830
CSA	0.916	0.921	0.947	0.857
IA	0.953	0.957	0.962	0.781

4.2 Structural Model

Figure 3 presents the structural model results. According to significant path coefficients, the summary of investigated hypothesis and result is described in Table 7.

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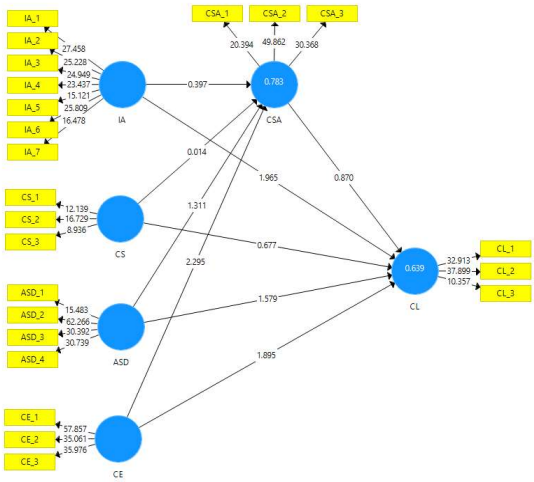

Figure 3. The Test Result Of The Research Model

Table 7. Summary of investigated hypothesis and result

Item	Hypotheses	P Value	Fulfilment of hypotheses
H1a	Information accessibility has positive effects on customer satisfaction	0.346	not supported
H1b	Customer services has positive effects on customer satisfaction	0.495	not supported
H1c	The attractiveness of services delivery has positive effects on customer satisfaction	0.095	not supported
H1d	Customer engagement has positive effects on customer satisfaction	0.011	**supported**
H2a	Information accessibility has positive effects on customer loyalty	0.025	**supported**
H2b	Customer services has positive effects on customer loyalty	0.249	not supported
H2c	The attractiveness of services delivery has positive effects on customer loyalty	0.057	not supported
H2d	Customer engagement has positive effects on customer loyalty	0.029	**supported**
H3	Customer satisfaction has positif effect on customer loyalty	0.192	not supported

The research has shown that variable information accessibility of mobile application-based laboratory information systems has no significant effect on customer satisfaction but significantly affects customer loyalty. This result is contrary with the research of [37] when variable ease of use - which is relevant with the variable information accessibility - does not affect on customer loyalty but its effect on engagement. However, research shows that variable customer engagement significantly affects customer satisfaction and loyalty. This result inline with research conducted by [37], when customer engagement positively affects to customer loyalty. Interestingly, variable customer services and the attractiveness of service delivery have no significant effect on customer satisfaction and loyalty. Furthermore, one big question needs to be identified further: customer satisfaction has no significant effect on customer loyalty when most previous research shows that customer satisfaction significantly affects customer loyalty.

5. DISCUSSION AND CONCLUSION

The current paper aimed to examine the influence of mobile application-based laboratory information systems (lims) on customer loyalty testing. The research model was adapted from different relevant previous research. The suggested model connects the characteristic of mobile application-based lims and all features as indicators of selected variables (information accessibility, customer services, attractiveness of services delivery, and engagement). The analysis showed interesting results; according to the validity and reliability test, all indicators comply with the threshold. The result also showed that customer engagement with indicators interactivity, simultaneity, and direct contact adapted from [37] significantly affects customer satisfaction and loyalty, strengthening the prior research. However, the result shows contrary results with the relevant previous study [37], especially in the variable of information accessibility, which is similar to variable easy of use. From this research, information accessibility has a positive effect on customer loyalty, whereas from the previous result is has no effect to customer loyalty. Finally, the result shows important information, in line with the research question, that mobile app-based LIMS influences customer loyalty, especially all related features relevant to information accessibility and engagement. The findings of the research have certain managerial implications. It means strengthening the mobile app-based LIMS with information accessibility and customer engagement

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relevant features shall be a priority. Furthermore, the limitation of sample size and also the selection of variables and survey indicators during this research shall be improved. It is recommended to find and measure more relevant variables of mobile apps to explain B2B customer loyalty.

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