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Implementing QR Codes on Student ID for Transactions: TAM Testing Approach

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Abstract

The rapid advancement of technology has had a significant impact on contemporary life. One of the technologies commonly encountered is the Quick Response Code (QR-Code) and Barcode, both of which serve a similar function, that is, to store information represented in the form of squares and lines. Three squares at the corners of the QR-Code are key to ensuring accurate scanning. Universities are educational institutions that provide Student ID Cards as a means of student identification. This research aims to design a transaction system by utilizing QR-Code technology on Student ID Cards for parking and library transactions, as well as creating a transaction system using digitized Student ID Cards. This study employs the Technology Acceptance Model (TAM) testing method to measure the factors influencing users in utilizing the application. The system design successfully incorporates QR-Codes and can be used as a transaction tool. The TAM testing results from 75 respondents regarding system acceptance conclude that the Perceived Ease of Use (PEOU) variable will influence the Perceived Usefulness (PU) variable by 67.4% and affect the Behavioral Toward Using (BITU) variable by 55.1%.

Keywords: *Student Identity Cards, Quick Response Code, Parking Transaction System, Library Transaction System, Technology Acceptance Model.*

1 Introduction

The rapidly advancing technology has a highly significant impact on current life. The technologies emerging today are diverse but share a common goal: to simplify human activities such as processing, managing, and analyzing data and information [1]. Several institutions, including the government, also experience the positive impact generated by technological advancements [2]. One of those who also feel the impact of technology is higher education institutions [3].Quick Response Code (QR-Code), Radio Frequency Identification (RFID), and Barcode are some of the technologies that we often encounter. Among these three technologies, QR-Code and Barcode serve a similar function, which is to store information represented in the form of squares and lines. [4]. Although they serve a similar function, when compared to barcode, QR-Code has an advantage because barcode can only read information in horizontal (bar) form, whereas QR-Code can read information more flexibly and can store information in both bar and square forms. [4]. QR-Code also has a small print size, so it doesn't require much space for placement and is resistant to dirt and damage. It also has the ability to be read from various directions [5]. To generate the QR code, a matrix comprising rectangular data elements is employed, complemented by three orientation patterns strategically positioned at the corners of the symbol [6]. The three squares at the corners of the QR-Code serve as the key to scanning. QR-Code can store information in the form of letters, numbers, links, and its capacity depends on the input being encoded [7]. In addition to the drawbacks of barcode technology, RFID technology also has its disadvantages, one of which is its less affordable cost and its bulky size, making RFID tags easier to remove. [8]. RFID embedded in cards is also more challenging to access via smartphones because it requires a specialized scanner. [9].

Universities are educational institutions that provide Student ID Cards as a form of identification, and these cards are typically possessed by all students. The content of the Student ID Card includes student data such as name, student ID number, faculty, and program of study. However, currently, in some colleges and universities, student ID cards are only used as a means of identifying students.

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Similar to the National Identity Card that confirms the cardholder's Indonesian citizenship, the Student ID Card serves the same purpose, which is to signify that the cardholder is a member or student of a universities and remains active until the cardholder completes their studies at the universities [10].

The Technology Acceptance Model (TAM) is one of the testing techniques used to measure the system's acceptance level. TAM is employed to achieve specific objectives by identifying several variables [11]. The TAM testing includes five supporting variables, which are Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Behavioral Intention to Use (BITU), Attitude Toward Using (ATU), and Actual System Use (ASU). Among these five variables, there are three that influence each other, namely Perceived Usefulness (PU), Perceived Ease of Use (PEOU), and Behavioral Intention to Use (BITU). These three variables impact user behavior in system usage, leading to the conclusion that perceived usefulness and ease of use affect user habits in using the system [12].

The TAM testing method is a theoretical approach commonly used in research on innovation adaptation, and this method is widely employed to investigate various aspects of technology adoption among prospective system users [13].

2 Literature Review

Based on previous research, QR codes have been applied to student identity card as a tool to speed up the student attendance process [14][15][16], as a library member card to make it easier to get information related to loans and book returns [17][18][19][20] and also the QR-Code on a student's identity card can store information that will make it easier for the government to obtain important information from a student [21].

Quick Response Code (QR-Code), Radio Frequency Identification (RFID), and Barcode are commonly encountered technologies. QR-Code and Barcode have a similar purpose of storing information in the form of squares and lines. However, QR-Code holds an advantage over Barcode as it can read information more flexibly in both bar and square forms, whereas Barcode can only read information in a horizontal (bar) format [4]. QR-Code boasts a compact print size, requiring minimal space for placement, and exhibits resilience against dirt and damage. Additionally, it can be read from various directions, enhancing its versatility [5]. QR codes are a beneficial technology to implement in the education sector because it is more convenient for users to use their smartphone cameras to scan the code rather than manually typing the link [6]. A QR code uses a special mechanism to increase the reliability of encrypted data storage. In code created with the highest level of reliability, approximately 30% of the surface may be damaged or overwritten, but the information remains intact and can be interpreted accurately [22]. Aside from the drawbacks of barcode technology, RFID technology has its own disadvantages. One of these is the higher cost and bulkier size of RFID tags, making them more susceptible to removal [8]. Accessing RFID embedded in cards via smartphones is more challenging as it necessitates a specialized scanner [9].

The TAM testing involves five key variables: Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Behavioral Intention to Use (BITU), Attitude Toward Using (ATU), and Actual System Use (ASU). Among these, PU, PEOU, and BITU mutually influence each other, shaping user behavior in system usage [12]. Based on previous research, TAM identifies two pivotal variables, Perceived Usefulness (PU) and Perceived Ease of Use (PEOU), as having the most substantial impact on user behavior in system acceptance [23]. Comparing two established studies, the Theory of Reasoned Action (TRA) and the Technology Acceptance Model (TAM), both findings suggest that user behavior is influenced by habits, perceived usefulness, and perceived ease of use [24]. The model used for TAM will be shown in Figure 1.

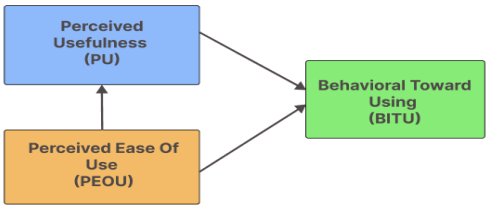

Figure 1. TAM Models

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Based on the theories that have been studied, both regarding the functions and advantages of QR-Codes, as well as the Technology Acceptance Model (TAM) methods, and considering the utilization of current student identification cards are not utilized as parking transaction tools. This research aims to develop a Smart Student ID application by implementing QR-Code technology on the Student Identification Card, enabling it to be loaded with credit for use in parking transactions and library access. Additionally, the TAM testing method will be employed to assess the system's acceptance level.

3 Research Method

Here is an overview of the conceptual framework for the development of this system. Figure 2 shows several stages, starting with the system design strategy, followed by TAM testing that will yield hypothesis test results, and finally, the development of QR-Code technology applied to web-based Student ID Cards.

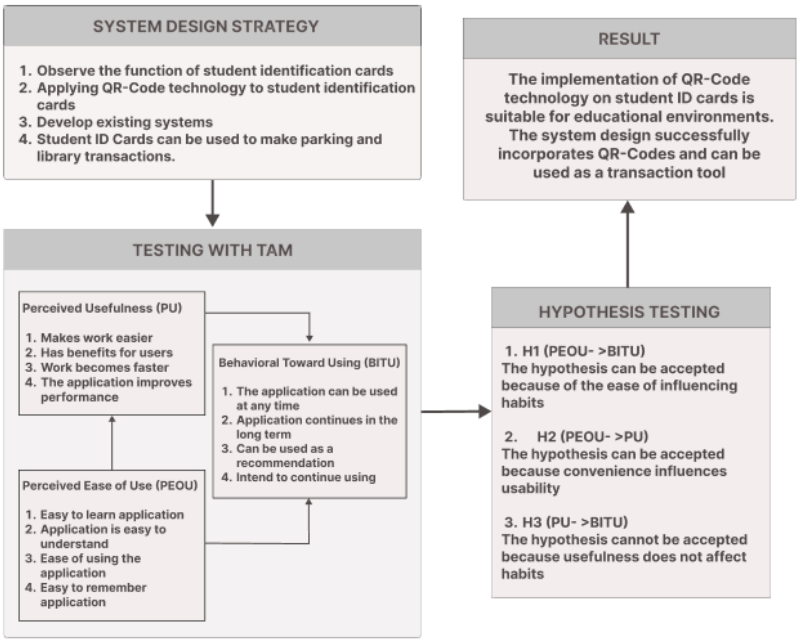

Figure 2. Framework

Here is an overview of application page in Figure 3. This page can only be accessed by the administrator. The administrator has access to all features on the parking page and the library page.

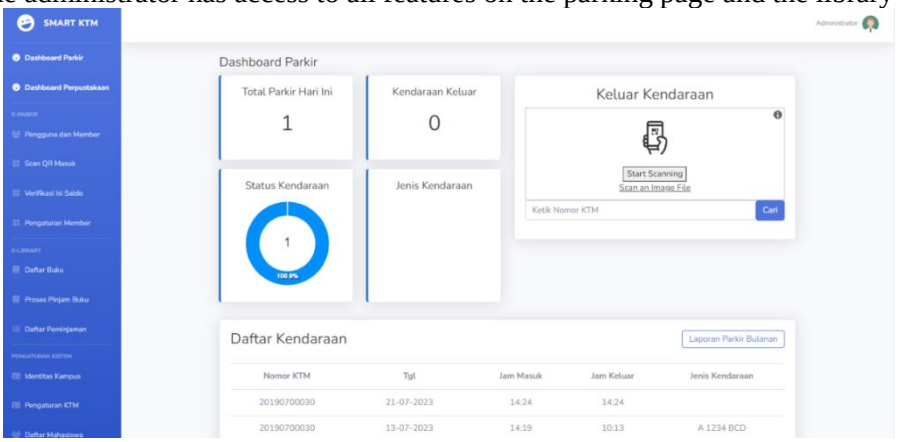

Figure 3. Administrator's main page

Figure 4 is a features that can only be accessed and viewed by students. On this page, students can view information about their financial transaction history, card balance, parking transaction history, and library transaction history.

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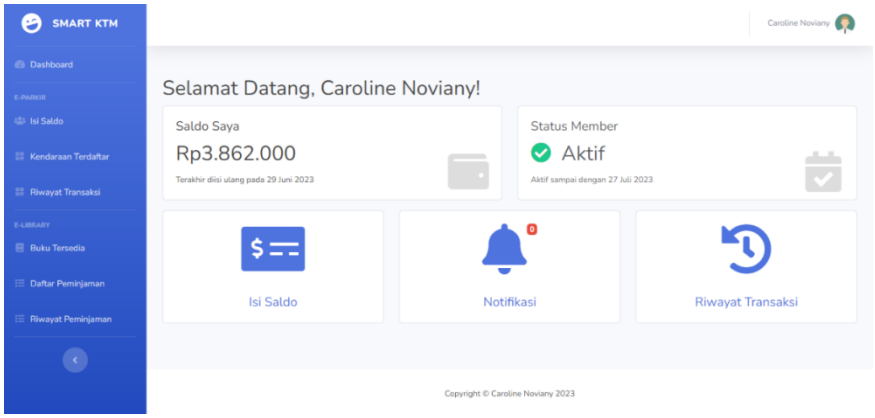

Figure 4. Student's main page

The data collection through questionnaires for testing was conducted for 8 days, starting from Saturday, July 1st, 2023, until Saturday, July 8th, 2023, and was completed by 75 respondents. The testing, using the Technology Acceptance Model (TAM), consists of several stages, namely:

a. Determination of variables:
   1) Perceived Usefulness (PU)
   2) Perceived Ease of Use (PEOU)
   3) Behavioral Intention to Use (BITU)

b. Determination of indicators[25] [26] shown in Table 1.

Table 1. Determination Of Indicators

Variables	Indicators
Perceived Usefulness (PU)	Simplifies tasks Benefits the users Speeds up work Enhances application performance
Perceived Ease of Use (PEOU)	Easy to learn application Easy to understand application Ease of use for the application Easy to remember application
Behavioral Intention to Use (BITU)	The application can be used anytime. The application continues in the long term. Can be recommended. Intend to use continuously.

c. Create questionnaire questions based on variables and indicators shown in Table 2.

Table 2. Questionnaire Questions

Questions	Variables
Smart Student ID application facilitates monitoring of parking users and book borrowing by staff.	PU-1
The Smart Student ID application makes it easier for me to purchase a parking membership and access information about the	PU-2

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library's available books	
The Smart Student ID application speeds up parking and book borrowing transactions.	PU-3
The Smart Student ID application helps improve my performance by making book borrowing and parking transactions faster.	PU-4
The Smart Student ID application is easy to use.	PEOU-1
The Smart Student ID application is easy to learn.	PEOU-2
The features within the Smart Student ID application are well-organized for comfortable use.	PEOU-3
The steps in using the Smart Student ID application are easy to remember.	PEOU-4
Intending to use the Smart Student Id application for parking and book borrowing transactions.	BITU-1
Desiring to continue using the Smart Student ID application to facilitate transactions within the university environment.	BITU-2
Recommending the Smart Student ID application for use at the university.	BITU-3
Having the intention to use the Smart Student ID application because it makes transactions within the university environment easier.	BITU-4

Questionnaire will be distributed based on the indicators and questions that have been created to find out the respondents' views regarding the application that has been created, then the respondents' answers will be processed using SmartPLS.

4 Results and Analysis

The first step in TAM testing is to calculate the Outer Model values.

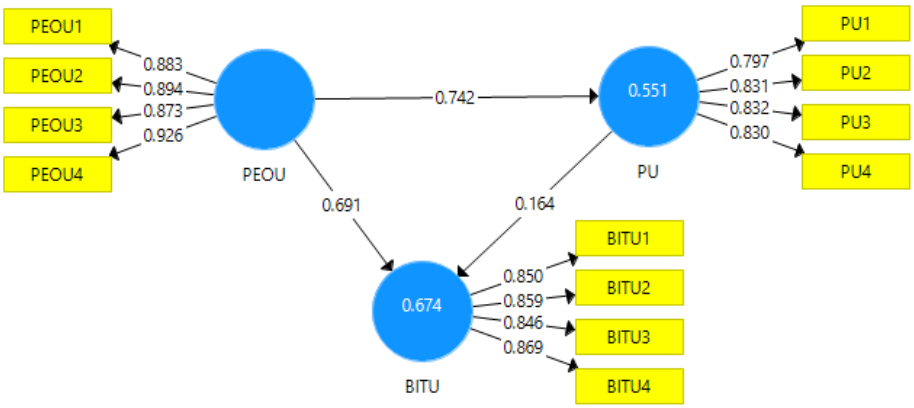

Figure 5. Results of Path Analysis.

In the figure 5, there are the results of the Path Analysis showing the values of Outer Loadings, Composite Reliability, and Path Coefficients in the form of a diagram. The next step is to

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conduct the Average Variance Extracted (AVE) test and calculate the Cross Loadings values can be seen in Table 3.

Table 3. AVE Test Results

	(AVE)
BITU	0.733
PEOU	0.799
PU	0.677

Based on the AVE testing results, each variable has a value ≥ 0.50 [27], and it can be concluded that all the variables used are valid in terms of convergence.

Table 4. Cross Loading Test Result

	BITU	PEOU	PU
BITU1	0.850	0.642	0.498
BITU2	0.859	0.704	0.578
BITU3	0.846	0.709	0.61
BITU4	0.869	0.724	0.624
PEOU1	0.703	0.883	0.682
PEOU2	0.652	0.894	0.613
PEOU3	0.722	0.873	0.619
PEOU4	0.816	0.926	0.728
PU1	0.523	0.585	0.797
PU2	0.582	0.614	0.831
PU3	0.588	0.644	0.832
PU4	0.532	0.596	0.83

From the results of cross-loading tests in the Table 4, the value of an indicator towards its own variable should be higher than its value towards other variables. The next test is conducted by examining the Fornell-Larcker criterion results in Table 5, which is the square root of the AVE of a variable against all variables, and it should have the highest value.

Table 5. Fornell-Larckel Criterion Test Result

	BITU	PEOU	PU
BITU	0.856		
PEOU	0.813	0.894	
PU	0.677	0.742	0.823

Based on the results of cross-loadings and the Fornell-Larcker criterion, the variables along with the indicators used can be declared valid in terms of discrimination [28]. The next step is to analyze the structural system, which involves calculating R-Square and Q-Square [27] shown in Table 6.

Table 6. R-Square Test Result

	R Square
BITU	0.674
PU	0.551

Based on the R-Square test results, the BITU variable with an R2 value of 0.674 is influenced by PEOU and PU 67.4%, while the PU variable with an R^2 value of 0.551 is influenced by PEOU by 55.1%.

Table 7. Q-Square Test Result

	SSO	SSE	Q^2 (=1-SSE/SSO)	Predictive Relevance
BITU	300.000	155.586	0.481	Medium
PU	300.000	189.994	0.367	Medium

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From the calculations in the Table 7, the BITU variable has a value of 0.481, and the PU variable has a value of 0.367. Therefore, it can be concluded that the values of both variables are acceptable because $Q^2 > 0$, and the statistical model used has a medium predictive value[27].

The final stage is hypothesis testing. In this testing, the first step is to calculate the t-table value using the formula:

Degree of freedom (DOF) = n - k (n (Number of respondents), k (variables used))

Once you have obtained the DOF value, hypothesis testing can be conducted.

Table 8. Hypothesis Test Result

	T Statistics (|O/STDEV|)	P Values
PEOU -> BITU	7.251	0.000
PEOU -> PU	14.861	0.000
PU -> BITU	1.402	0.162

Based on the hypothesis testing results in Table 8, it can be concluded that the PEOU variable influences BITU and PU because the T Statistic values are greater than the t-table values of 1.934[29], and the P values are below 0.05[27]. However, the PU variable does not influence BITU because the T Statistic value is above the t-table value, and the P value is above 0.05.

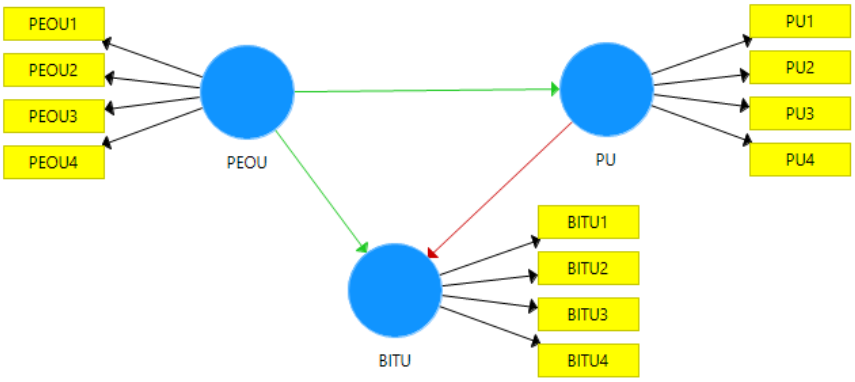

Figure 6. Hypothesis Test Result

Visually represented in Figure 6 above, where green arrows indicate mutual influence, while red indicates no mutual influence.

5 Conclusion

The conclusions drawn from this research are that the implementation of QR-Code technology on student ID cards is suitable for educational environments. The system design successfully incorporates QR-Codes and can be used as a transaction tool. The TAM testing results from 75 respondents regarding system acceptance conclude that the PEOU variable influence the PU variable by 55.1%. PEOU and PU affect the BITU variable by 67.4%. The results of the TAM testing lead to the conclusion that not all three variables used mutually influence each other. This was obtained from the hypothesis testing results, where PEOU influences BITU and PU, while PU does not influence BITU. In future research, it is anticipated that the system can be further developed for use in other transactions within the university environment, such as cafeteria payment transactions.

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