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*Review Article*

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# Role of Technology to Improve the Effectiveness of University Canteen Systems

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## ABSTRACT
The university canteen system is an essential part of the campus environment, providing students and staff with a convenient and affordable source of food. However, many universities struggle to maintain efficient and effective canteen systems, leading to long queues, limited food options, and unsatisfactory service. The study seeks to identify the key challenges faced by traditional canteen systems in universities, to explore the potential benefits of using technology in university canteen systems, to analyse existing technologies used in university canteen systems and their effectiveness and to develop a framework that enhance the efficiency and user experience of university canteen systems. The study adopted a positivist research approach, making use of quantitative methods of data collection. The target population was university canteen managers and staff, university staff, and university students in Zimbabwe. In order to improve the performance of canteen systems, the project at hand provided a framework that uses technology to streamline operations, boost menu planning and customization, improve payment alternatives, and provide real-time feedback mechanisms to guarantee customer satisfaction. The study's findings show that university canteens ought to concentrate on developing a framework based on innovation and technology that places a priority on innovations that boost financial performance, including cashless payment systems because they increase the effectiveness of canteen systems.

## Introduction
The university canteen system is an essential part of the campus environment, providing students and staff with a convenient and affordable source of food [1]. However, many universities struggle to maintain efficient and effective canteen systems, leading to long queues, limited food options, and unsatisfactory service. To address these challenges, this research proposes the use of technology to improve the effectiveness of university canteen systems. A technological revolution has taken place in the world, changing how people live and work. Some see these changes as the start of a new era of change in terms of opportunity and progress. Computerization, robotization, and smart networks are collectively referred to as the Fourth Industrial Revolution [2]. University canteens must move with this revolution if they are to maximise efficiency. Internationally, there has been a growing trend towards using technology in the food service industry. Universities in developed countries have started implementing cashless payment systems, self-service kiosks, and digital menu boards in their canteens. These technologies can help streamline the ordering process and reduce wait times for customers.

## Background
African universities have faced several challenges in their canteens. In Kenya, 70% of the students showed a favourable attitude toward food safety and sanitation, and 80% of the students had appropriate levels of knowledge about food safety and cleanliness. The majority blamed a lack of equipment for the poor food safety and hygiene standards that were practised by 74% of those surveyed on average [3]. In Africa, there has been a similar trend towards using technology in the food service industry. For example, some restaurants in South Africa have implemented mobile ordering systems that allow customers to place orders from their smartphones. In addition, some universities in Africa have started using biometric authentication systems to reduce fraud and improve security in their canteens. In Zimbabwe specifically, there has been a growing interest in using technology to improve the efficiency of various industries. The government has launched several initiatives aimed at promoting innovation and entrepreneurship in the country's tech sector. The establishment of innovation hubs in all state universities is one such example. As such, there is potential for Zimbabwean universities to adopt innovative solutions for their canteen systems. The proposed framework will enhance inventory management, raise income for the campus canteen, cut wait times, reduce food waste, and increase customer happiness. Through the use of this framework, colleges can increase the effectiveness of their canteens while also enhancing the campus experience for students.

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**Problem Statement**

The problem addressed in this research is the inefficiency and inadequacy of traditional canteen systems in meeting the needs and expectations of customers, particularly in terms of speed, convenience, and quality of service. Despite the growing demand for healthier and more diverse food options, many canteens still rely on manual processes, outdated equipment, and limited menus that result in long waiting times, food waste, and customer dissatisfaction. This study aims to develop a framework that leverages technology to enhance the effectiveness of canteen systems by streamlining operations, improving menu planning and customization, enhancing payment options, and providing real-time feedback mechanisms to ensure customer satisfaction.

**The Study Sought to Achieve the Following Objectives**

- To identify the key challenges faced by traditional canteen systems in universities.
- To explore the potential benefits of using technology in university canteen systems.
- To analyse existing technologies used in university canteen systems and their effectiveness.
- To develop a framework that enhance the efficiency and user experience of university canteen systems.

**Hypotheses**

Hypothesis 1

**$H_0$:** The implementation of a technology-based framework in canteen systems will improve the efficiency and speed of food service, resulting in increased customer satisfaction.

**$H_1$:** The implementation of a technology-based framework in canteen systems will not improve the efficiency and speed of food service, resulting in increased customer satisfaction.

Hypothesis 2

**$H_0$:** The integration of digital payment systems and mobile ordering platforms in canteen systems will reduce wait times and increase convenience for customers, leading to higher sales revenue.

**$H_1$:** The integration of digital payment systems and mobile ordering platforms in canteen systems will not reduce wait times and increase convenience for customers, leading to higher sales revenue.

**Literature Review**

The study was centred on Queuing Theory. This theory is concerned with the mathematical analysis of waiting in lines or queues. It provides a framework for understanding the behaviour of queues and helps in optimizing their performance. Satyanarayana, etc claim that by optimising the servers with queue models, the system's quality can be raised and effectiveness [4]. Kuzu conducted a comparison of queue and traditional ways for ticketing system queue management implementation. The authors claim that putting queue management into practice greatly enhances service quality [5]. Yadav & Sohani estimated the food chain's service performance using the MM1 queuing model and explained how the system's service quality increases as the number of servers increases [6]. In addition, Service Quality Theory was taken into consideration [7]. This theory emphasizes the importance of meeting or exceeding customer expectations for service quality. It suggests that managing queues effectively can enhance customer satisfaction and loyalty. Moreover, Social exchange theory was applied in the study - This theory suggests that people engage in social interactions based on the expectation of mutual benefit [8]. Menu customization allows university canteens to provide a service that benefits the customer while also increasing revenue for the university.

**Conceptual Framework**

This research focused on how technology and customer service will relate to customer satisfaction. The technology component includes payment systems, inventory management, and mobile applications. The customer service component includes strategies for improving customer satisfaction through personalized service and efficient order processing. The independent variable is the technology-based framework. The dependent variable is the effectiveness of university canteens. Mediating variables include customer satisfaction, operational efficiency, and financial performance. The moderating variables will be demographic characteristics (age, gender, and educational level).

**Empirical Framework**

Design of Cashless Payment System with RFID to Improve Services of School Canteen [9]. This study proposes an intelligent canteen management system based on Radio Frequency Identification (RFID) technology. The system includes three modules: an ordering module, a payment module, and a feedback module. The authors conducted experiments to evaluate the effectiveness of the system and found that it significantly reduced waiting times and improved customer satisfaction. The gap with this technology is that it focuses on ordering and payments while not considering how these technologies can be fused in a wholesome framework that includes sustainability and inventory management.

**vCanteen:** A Smart Campus Solution to Elevate University Canteen Experience [10]. High crowd density during lunchtime has always been a concern that plagues the various university canteens. A technology dubbed "vCanteen" has been created to address this problem. It combines a crowd estimation method based on machine learning with an online meal ordering system and a virtual queuing system. The goal of vCanteen is to shorten wait times for food orders and give users real-time access to information about crowd density at university canteens. A multi-column convolutional neural network has been used to construct the crowd estimation method (MCNN). The crowd-estimating system was thoroughly explained in the study, including with error analysis and lessons gained.

E-Canteen Management System based on Web Application [11]. It has been noted that many canteens get extremely crowded during prime times. As a result, there are long lines at the billing and delivery locations. This causes accounting mistakes and time wastage. The authors developed a web application that allows for online meal ordering at the canteens to solve this issue. Each Registered Individual can use the program to view and place their meal orders ahead of their break time, and online payments are made possible. The user has the option of choosing a specific time slot for receiving meal delivery. There will be less waiting in line. Both food scarcity and human accounting inaccuracy can be reduced. This model is effective in developed countries where adequate technological infrastructure is available. This research intends to bring some of these aspects to developing countries like Zimbabwe.

Sustainability-Oriented Innovations in Food Waste Management Technology [12]. This article examines the application of technical improvements in the downstream value chain using an extensive case study. To address a new approach for businesses to address the challenge of food waste, this case study draws on a tech firm that offers services to some enterprises. Using technological advancements to measure and reduce waste through partnerships with other businesses can be a strategic and economical strategy to support an organization's open innovation initiatives. This framework, however, lacks important aspects in the form of hygiene and food quality. This research will address these issues.

**Methodology**

Research methodology refers to the theory of how the research should be conducted, that is, the tools and techniques which will be used to collect and analyse data [13]. The study adopted a positivist research approach, making use of quantitative methods of data collection. The researchers used questionnaires to collect the data. The researchers weighed the advantages of questionnaire usage and discovered that it had high reliability and it gave a more realistic view [14]. Being original and relevant primary data's degree of accuracy is also high. Secondary data was obtained from newspapers and journals. The target population was university canteen managers and staff, university staff, and university students in Zimbabwe. The researchers calculated the sample size using the Cochran formula for an unknown infinite population: The Cochran formula is:

$$n_0 = \frac{Z^2 pq}{e^2}$$

Where:

- e is the desired level of precision (i.e., the margin of error), p is the (estimated) proportion of the population which has the attribute in question, and q is 1 - p. $n_0$ is the acceptable sample size

The z-value is found in a Z table. A 95% confidence interval was used and the Z score from Z tables was found to be 1,645. Therefore, the sample size that will be used for this research study was 45.

**Research Instruments**

The data collection instrument used was a questionnaire, comprising close-ended questions that were answered by the respondents to the best of their knowledge and experience in their positions at the target organisations. Selvamuthu and Das defined questionnaires as carefully designed instruments for collecting data by the specifications of the research questions [15]. A questionnaire is important because the responses are gathered in a standardized way, also it is relatively quick to collect information using it, and potential information can be collected from a large portion of a group. For this study questionnaires were preferred because they are less expensive compared to the other methods. A five-point scale the Likert scale was used in the questionnaire starting from 1 which was "strongly disagree" to 2 ("disagree") to 3 ("neutral") to 4 ("agree") then to 5 which was "strongly agree".

**Presentation of Results**

There were 27 complete questionnaires submitted. Figure 1 displays the respondents and the received questionnaires. Google Forms was used to collect the data, which was then exported to Google Spreadsheets and posted to the Warp PLS7.0. High statistical power of the Warp PLS 7.0 is helpful for developing or less developed theories; therefore, was ideal for the study [16]. Two sections present the study's results. The evaluation of the measurement model is presented in the first section, which also includes illustrations of the indicator loadings, composite reliability tests, convergent validity, and discriminant validity results. Last but not least, the evaluation of the structural model, collinearity tests, coefficient of determination (R2), and statistical significance are displayed. This order was significant since it is necessary to evaluate the measurement model before the structural model [16].

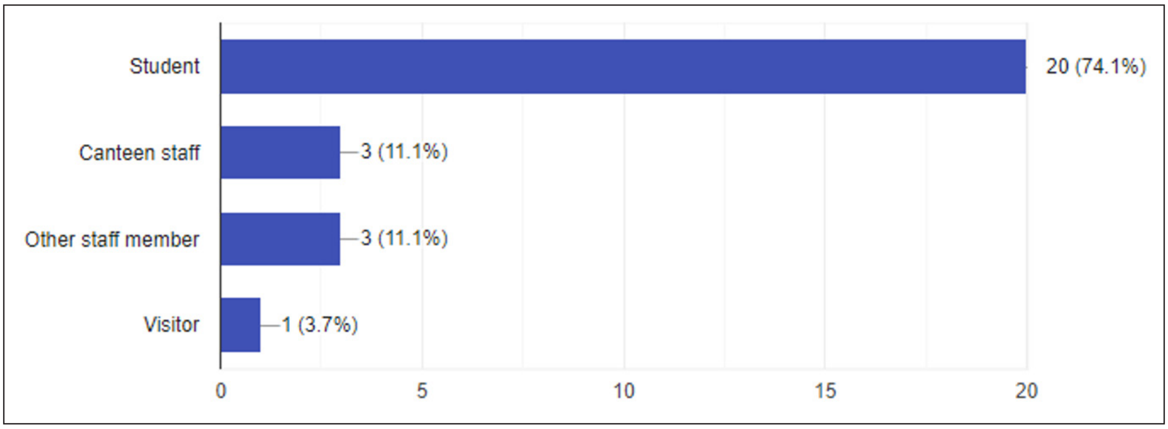


**Figure 1:** Various Designations of the Questionnaire Respondents

**Measurement Model Assessment**

The sections below show the findings used to evaluate the measurement model.

**Indicator Loadings**

Table 1 displays the factor loadings (and cross-loadings) of all indicator items to their corresponding latent constructs.

**Table 1: Factor Loadings and Cross-Loadings**

| | Framwrk | Educ | gender | age | OpEf | CustSat | FinPerf | Effect | gender*Framwrk | age*Framwrk | Educ*Framwrk |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Frame1 | (0.687) | -0.025 | -0.138 | -0.322 | 0.249 | -0.095 | 0.249 | -0.121 | 0.023 | 0.985 | 0.544 |
| frame2 | (0.687) | 0.025 | 0.138 | 0.322 | -0.249 | 0.095 | -0.249 | 0.121 | -0.023 | -0.985 | -0.544 |
| Edu1 | 0.000 | (1.000) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| gender1 | 0.000 | 0.000 | (1.000) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Age1 | 0.000 | 0.000 | 0.000 | (1.000) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| OpEf1 | -0.038 | -0.353 | -0.084 | 0.433 | (0.760) | 0.053 | -0.150 | -0.225 | -0.105 | -0.105 | 0.191 |
| OpEf4 | -0.143 | -0.221 | 0.081 | -0.015 | (0.790) | -0.100 | 0.153 | 0.200 | 0.010 | 0.109 | 0.131 |
| OpEf5 | 0.236 | 0.736 | 0.000 | -0.527 | (0.601) | 0.065 | -0.012 | 0.021 | 0.118 | -0.011 | -0.412 |
| CustSat1 | -0.094 | -0.448 | 0.023 | 0.425 | -0.008 | (0.888) | 0.076 | -0.043 | 0.096 | -0.113 | 0.249 |
| CustSat3 | 0.094 | 0.448 | -0.023 | -0.425 | 0.008 | (0.888) | -0.076 | 0.043 | -0.096 | 0.113 | -0.249 |
| FinPerf2 | 0.213 | 0.027 | -0.095 | -0.320 | 0.356 | -0.058 | (0.880) | 0.108 | 0.289 | 0.265 | 0.018 |
| FinPerf3 | -0.213 | -0.027 | 0.095 | 0.320 | -0.356 | 0.058 | (0.880) | -0.108 | -0.289 | -0.265 | -0.018 |
| Effect2 | -0.070 | -0.074 | -0.099 | 0.008 | 0.145 | 0.048 | -0.034 | (0.937) | -0.026 | -0.030 | 0.217 |
| Effect3 | 0.070 | 0.074 | 0.099 | -0.008 | -0.145 | -0.048 | 0.034 | (0.937) | 0.026 | 0.030 | -0.217 |
| gender*Framwrk | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | (1.000) | 0.000 | 0.000 |
| age*Framwrk | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | (1.000) | 0.000 |
| Educ*Framwrk | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | (1.000) |

It is recommended that one strive for factor loadings over 0.70 since they indicate that the -construct adequately explains more than 50% of the variance of the indicator and hence provides satisfactory item reliability [16]. Table 1's results show all items loaded between a lower bound of 0.60 and an upper bound of 1.00 on their corresponding constructs (bolded factor loadings). In exploratory studies, a loading of 0.601 was deemed acceptable even though OpEf5 did not load at the suggested level of 0.70 [16]. OpEf5 was kept in the model even though its factor loadings were below those that were advised because it passed other quality checks.

**Reliability Tests**

For the purpose of evaluating internal consistency, the composite reliability was used. Cronbach's alpha, a less accurate reliability indicator for unweighted items, is preferable to the composite reliability High numbers indicate high levels of reliability when evaluating composite reliability [16]. Values of 0.95 and above, however, are troublesome since they show item redundancy, which lowers construct validity. High numbers could also be a sign of other issues, including straight-lining, which inflates correlations. As a result, scores between 0.60 and 0.70 are considered "acceptable in exploratory research" and values between 0.70 and 0.90 are considered "satisfactory to good" by [16]. Table 2 displays the findings of internal consistency reliability evaluations.

**Table 2: Internal Consistency Reliability Assessments**

| | framwrk | OpEf | CustSat | FinPerf | Effect |
|---|---|---|---|---|---|
| Composite reliability | 0.642 | 0.763 | 0.882 | 0.873 | 0.935 |
| Average variance extracted (AVE) | 0.472 | 0.521 | 0.789 | 0.774 | 0.878 |
| Square root of AVE | 0.687 | 0.722 | 0.888 | 0.880 | 0.937 |

**Key**

Framwrk - Technology and innovation-based framework
OpEf - Operational efficiency
Custsat - Customer satisfaction,
FinPerf - Financial Performance,
Effect - Effectiveness of canteen systems

Table 2's findings show that all items performed satisfactorily on both the average variance extracted (AVE) and composite reliability tests. The range of the model's composite reliabilities for the various metrics is 0.642 to 0.935, which is almost equal to the well-recognized threshold value of 0.70 No variable in this study falls within the problematic range of 0.95 and above [16,17].

**Convergent Validity**

To demonstrate convergent validity, the AVE tests were performed [18]. Convergent validity refers to the model's capacity to explain the indicator's variance. suggest an AVE threshold level of 0.5 as a signal of convergent validity. This means the construct explains at least 50% of the variance of its items [16,19]. As shown in Table 2, measures of the four constructs have high levels of convergent validity. The framework variable, however, is barely below the cut-off point of 0.5. The variable passed other quality checks; therefore, the researchers didn't make any changes to it.

**Discriminant Validity**

Discriminant validity is 'the degree to which a construct is empirically different from other constructs in the structural model [18]. According to Fornell and Larcker, "each construct's AVE should be matched to the squared inter-construct correlation (as a measure of shared variance) of that same construct and all other reflectively measured constructs in the structural model". The shared variance for all model constructs must not be higher than their AVEs. An acceptable AVE should be "0.50 or higher, indicating that the construct explains at least 50 per cent of the variance of its items" [16]. The results for discriminant validity given in Table 2 complied with the recommendations made by Fornell and Larcker and Hair, etc that the AVE for each measure must be more than 0.50 to demonstrate discriminant validity

[16,18]. Additionally, all of the AVE square root values are bigger than their respective correlations, satisfying the Fornell-Larcker Criterion's requirement for discriminant validity. The AVE square roots are consistently larger than the AVE values, demonstrating the discriminant validity of the scales.

**Structural Model Assessment**

The following sections show the findings of the structural model assessment.

**Collinearity Tests**

When variables are highly linked, the analysis's findings may be diminished correlated [20]. With the use of the variance inflation factor (VIF), collinearity can be quantified. High VIF is not, however, commonly classified in any way. For instance, thought that VIF values greater than 5 indicated likely collinearity problems across the predictor components. Further stating that even lower VIF values of 3-5 may signal collinearity issues and recommending values close to 3 or lower [16]. While see values between 5 and 10 as troublesome while those above 10 reveal strong multicollinearity, deemed VIF above 10 to be worrisome [21,22]. Low VIF values that are close to 1 are therefore often acceptable [23].

**Table 3: Correlations Among l.v. Error Terms With VIFs Correlations among l.v. error terms with VIFs**

| | (e)OpEf | (e)CustSat | (e)FinPerf | (e)Effect |
|---|---|---|---|---|
| (e)OpEf | (2.) | 247 | 0.637 | -116 |
| (e)CustSat | 0.247 | (1.) | 0.059 | 0.042 |
| (e)FinPerf | 0.637 | 0 | (2.) | 0 |
| (e)Effect | 0. | 0.042 | 0. | (1) |

**Notes:** Variance inflation factors (VIFs) shown on diagonal. Error terms included (a.k.a. residuals) are for endogenous l.vs.

The results of collinearity tests (Table 3) using the VIF criterion showed that all the VIF values are close to 1 meaning that they are all acceptable.

**Coefficient of Determination ($R^2$)**

Since collinearity was not an issue, the R value of endogenous constructs was also looked at. High values of the $R^2$, which spans from 0 to 1, indicate a high explanatory power. $R^2$ values of 0.75, 0.50, and 0.25 are regarded as substantial, moderate, and weak, respectively, even though $R^2$ interpretation depends on context [16]. The findings showed that OpEf has a weak explanatory power because its $R^2$ value was below 0.25. $R^2$ values for CustSat and FinPerf ranged from 0.25 to 0.5. This indicates that the variables' explanatory power was moderate. With an $R^2$ value of 0.72, which is nearly 0.75, the Effect variable has a significant explanatory power [24].

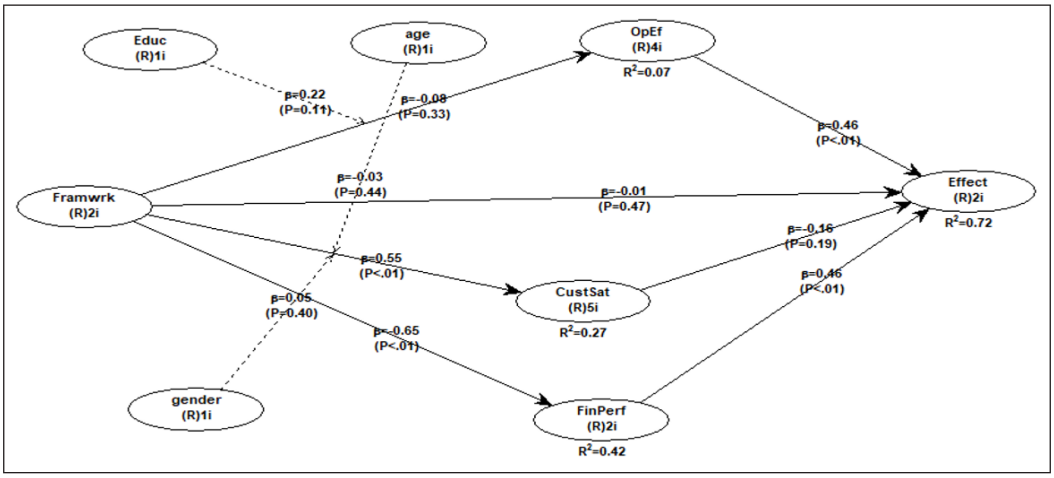


**Figure 2: SEM Model with R2 Values**

**Hypothesis Testing: Statistical Significance**

Figure 2 shows that some of the hypotheses were accepted and some were rejected.

- Framework did not influence the OpEf (β=0.08; p=0.33).
- Framework did not influence the Effect (β=0.01; p=0.47).
- Framework has a positive and significant influence on CustSat (β=0.55; p<0.01).
- Framework has a positive and significant influence on FinPerf (β=0.65; p<0.01).
- FinPerf has a positive and significant influence on Effect (β=0.46; p<0.01).
- CustSat did not influence on Effect (β=0.16; p=0.19).
- OpEf has a positive and significant influence on Effect (β=0.46; p<0.01).

**Table 3: Summary: Hypothesis Testing Results**

| Hypothesis | Path | Path coefficient | P-value | Decision |
|---|---|---|---|---|
| H1 | Framwrk->OpEf -> Effect | 0.46 | <0.01 | Accepted |
| H2 | Framwrk -> Effect | 0.01 | 0.47 | Rejected |
| H3 | Framwrk->CustSat -> Effect | 0.16 | 019 | Rejected |
| H4 | Framwrk-> FinPerf-> Effect | 0.46 | <0.01 | Accepted |

**Study Conclusions**

In order to improve the performance of canteen systems, the project at hand provided a framework that uses technology to streamline operations, boost menu planning and customization, improve payment alternatives, and provide real-time feedback mechanisms to guarantee customer satisfaction. The study's findings show that university canteens ought to concentrate on developing a framework based on innovation and technology that places a priority on innovations that boost financial performance, including cashless payment systems because they increase the effectiveness of canteen systems. The framework ought to give special attention to operational efficiency because it has been demonstrated to increase the effectiveness of canteen systems. Examples of this include mobile applications that let consumers order food and cut waiting times. The framework shouldn't be centred on consumer pleasure, the study's other conclusion stated. Instead, a successful canteen system will lead to increased consumer satisfaction.

**Limitations and Future Studies**

This study was constrained by a number of reasons. Time was the first restriction. Due to the short time available for data gathering, fewer colleges were represented in the data than would have been ideal. The sample taken did not encompass all of the nearby universities. The absence of technology knowledge among all players in the university canteen systems is another restriction. It may be difficult for other students and employees of canteen systems to respond in a way that takes into account the suitable technology that improve canteen systems. Future research may become more varied and concentrate on user approval and pleasure. They could consider whether all parties involved in university canteens would find the technology-based structure acceptable. Future research should examine long-term sustainability to establish the upgradability and scalability of innovation- and technology-based frameworks.

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