INVESTIGATING PERCEIVED QUALITY, USER ACCEPTANCE AND BEHAVIORAL INTENTION OF SOLAR POWERED VENDING MACHINES IN AN EDUCATIONAL CONTEXT

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ABSTRACT

The development of renewable energy technologies in educational institutions is emerging as a key approach to embedding sustainability and mitigating energy consumption in higher education. This research presents a rigorous investigation into perceived quality, user acceptance, and behavioral intention related to the use of solar-powered vending machines developed at North Eastern Mindanao State University – Bislig Campus (NEMSU–Bislig). The study utilizes the Quality–Technology Acceptance Model (Q-TAM) to explore user adoption behavior based on quality and attitudes. A descriptive research design was implemented in this study using stratified random sampling to ensure equitable representation among participants (students, faculty, practitioners). In sum, seventy-seven (77) participants completed the questionnaire with their responses informing the findings of user perceptions of the solar-powered vending machines. The findings reveal that the vending machines were considered to have high ratings with respect to features (M = 4.56), attractiveness (M = 4.42), and serviceability (M = 4.29), signaling that the consumers understand and appreciate the quality and usability of the product. The respondents were also favorable in their acceptance of the product with mean scores on the perceived attribute of usefulness at 4.53 and ease of use at 4.52, suggesting that they agreed with the environmental benefits, convenience, and a move towards a new product design. This study bridges a gap in the empirical literature about solar-powered vending systems in higher education thereby confirming their potential as a novelty in sustainable campus infrastructures. Findings of the study add to best practices for academic administrators, policymakers, and developers interested in advancing renewable energy in a higher education context.

Keyword: *solar-powered vending machines, renewable energy adoption, Q-TAM, technology acceptance, sustainability, higher education*

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1. INTRODUCTION

The growing demand for the integration of renewable energy and sustainability into higher education has compelled universities and colleges to explore creative models that connect environmental stewardship and technology. Today universities are not only learning environments, but function as living laboratories of sustainable innovative practice where the use of renewable energy technologies is incorporated into student learning and institutions can operate more efficiently. One of the newest and most practical examples of such engagement is the solar-powered vending machine (SPVM)—a multifunction station that provides Wi-Fi, cold drinking water, and smartphone charging, all powered by solar energy. These stations reflect the fusion of convenience, green technology, and educational opportunities in the higher education environment.

At North Eastern Mindanao State University - Bislig Campus (NEMSU - Bislig), sustainability practices using Solar PV models (SPVMs) were initiated within the institution to promote sustainability within their constituents and encourage the use of renewable energy technology. While renewable energy innovations and practices, such as sustainability, continue to emerge in the worldwide and national literature, a majority of current literature is emphasizing the technical viability, affordability, and engineering effectiveness [1] space, introducing a gap in the literature concerning the behavioral and perceptual realm of user interaction. There are little empirical studies that investigate how users perceive the quality, utility, and use of SPVMs, specifically in developing countries such as the Philippines, or educational institutions. Additionally, there are limited local studies that apply an integrated framework like Quality-Technology Acceptance Model (Q-TAM) that explain how quality perceptions result in renewable energy-associated technology acceptance and behavioral intention.

In order to reduce these gaps, this study makes use of Q-TAM to explore the role of perceived quality, specifically the attribute and reliability dimensions, in user acceptance and behavioral intention toward SPVMs at NEMSU–Bislig. Additionally, this study seeks to describe users' demographic characteristics, examine their perceptions of machine quality, to measure acceptance in terms of usefulness and ease of use, and behavior intention to their continued use and recommendation of the technology. Within this framework, the social role of the study is to identify areas of concern for improving SPVM functionality and the act of advancing the integration of sustainable, renewable energy solutions for higher education institutions. Therefore, this inquiry enhances the conversation on sustainability in education as well as advances policies related to the Renewable Energy Act of 2008 (RA 9513), the Energy Efficiency and Conservation Act of 2019 (RA 11285), and the United Nations Sustainable Development Goals (SDG 7 and SDG 4).

2. METHODOLOGY

2.1 Research Design

A descriptive-quantitative research design was utilized to measure the perceptions, acceptance, and behavioral intentions of users toward SPVMs. The use of a descriptive-quantitative design provided a systematic approach to gathering numerical data to detail and describe the users' acceptance and satisfaction of the SPVM.

2.2 Respondents and Sampling

Using stratified random sampling, the study was able to gather data with valid responses from seventy-seven (77) respondents encompassing student, faculty and industry types of groups.

Table 1: Distribution of Respondents

Respondents	Sample size (n)	Percentage (%)
BTVTEd	20	25.97
BSEE	47	61.04
Faculty	5	6.49
Industry worker	5	6.49
Total	77	100

2.3 Instrumentation and Data Collection

An instrument using a structured questionnaire was developed to measure the five constructs based on the Quality–Technology Acceptance Model (Q-TAM) framework: (1) attribute quality, (2) reliability quality, (3) perceived usefulness, (4) perceived ease of use, and (5) behavioral intention, with each item rated on a five-point Likert scale, from “Strongly Disagree (1)” and “Strongly Agree (5).” The instrument was evaluated and vetted by experts and administered in a pilot study to ultimately demonstrate reliability.

2.4 Data Analysis

Data was analyzed using descriptive statistics and included mean, standard deviation, and frequency. Interpretations were based on Q-TAM constructs with related literature support.

3. RESULTS AND DISCUSSION

3.1 Perceived Quality of SPVMs

Table 2 shows that the respondents have a generally positive perception of the attribute quality of the solar-powered vending machines, with an overall weighted mean of 4.39 (“Agree”) with SD of 0.81. Among the three dimensions, features obtained the highest mean (4.56, “Strongly Agree”) and SD of 0.50, indicating that the multifunctionality, portability, compact size, convenient payment option, and device compatibility are highly valued by users. In particular, the statement on multi-functionality (Wi-Fi, cold drinking water, and smartphone charging in one unit) received the highest individual rating (M = 4.63, SD = 0.63), reflecting users’ appreciation for technologies that integrate multiple services in a single platform [2].

The performance dimension recorded a mean of 4.17 (“Agree”) and SD of 0.71, with the cold drinking water feature receiving the highest rating (M = 4.39, SD = 0.67) in this category. This suggests that consistent and reliable service delivery – especially for core functions—significantly contributes to perceived quality. While all performance items were rated positively, the slightly lower score for Wi-Fi stability (M = 3.92, SD = 1.02) signals room for improvement, as connectivity issues can influence user satisfaction and behavioral intent.

Table 2: Mean Distribution of the Respondents' Ratings on the Perceived Quality of Solar-Powered Vending Machines in terms of Attribute Quality

Attribute Quality	Mean	SD	Description
Performance			
1. The Wi-Fi vending feature provides a stable and fast internet connection.	3.92	1.02	Agree
2. The cold drinking water feature dispenses water at the desired temperature consistently.	4.39	0.67	Agree
3. The smartphone charging feature charges devices quickly and reliably.	4.00	1.06	Agree
4. The solar powered vending machines have a good and cost-effective performance capability.	4.36	0.67	Agree
Mean	***4.17***	**0.71**	***Agree***
Features			
5. The 3-in-1 vending machine multi-functionality addresses diverse user needs by offering Wi-Fi vending, cold drinking water, and smartphone charging in a single unit.	4.63	0.63	Strongly Agree
6. The machine's wheels make it portable and easy to move to different locations.	4.46	0.74	Agree
7. The machine's compact size makes it suitable for small spaces without being obtrusive.	4.53	0.64	Strongly Agree
8. The machine's coin slot payment option is convenient and easy to use.	4.62	0.61	Strongly Agree
9. The smartphone charging feature supports multiple device types, ensuring compatibility and convenience for a wide range of users.	4.57	0.52	Strongly Agree
Mean	***4.56***	**0.50**	**Strongly Agree**
Aesthetics			
10. The overall design of the 3-in-1 vending machine is visually appealing.	4.36	0.81	Agree
11. The machine's appearance fits well with its surroundings (e.g., campus environment).	4.47	0.77	Agree
12. I find the machine's design modern, elegant, attractive, and aesthetically appealing.	4.42	0.80	Agree
Mean	**4.42**	0.72	**Agree**
Weighted Mean	**4.39**	**0.81**	**Agree**

Legend:4.50 – 5.00 – Strongly Agree; 3.50 – 4.49 – Agree; 2.50 – 3.49 – Neutral; 1.50 – 2.49 – Disagree; 1.00 – 1.49 – Strongly Agree

The aesthetics dimension also scored highly (4.42, "Agree"), indicating that users find the machines visually appealing, well-fitted to the campus environment, and modern in design. Research shows that aesthetics can influence technology acceptance by enhancing perceived value and willingness to use, especially in public and shared spaces [3].

The high ratings across all attributes imply strong acceptance potential for the vending machines in educational settings. However, to further enhance user experience, attention should be given to improving Wi-Fi stability and maintaining consistent performance across all features. Such enhancements could increase both perceived quality and long-term user loyalty.

The results in Table 3 show that respondents generally perceive the solar-powered vending machines as reliable, with an overall weighted mean of 4.24 ("Agree") and SD of 0.88. Among the three dimensions, serviceability received the highest mean score (M = 4.29, SD = 0.79), indicating that users believe the machines are easy to maintain, install, and repair. This suggests that accessibility of maintenance and the ability to quickly address issues enhance perceptions of quality and dependability—factors that are crucial in sustaining long-term user acceptance [4]. The reliability dimension scored 4.13 ("Agree") with SD of 0.67, with the highest rating for overall dependability (M = 4.34, SD = 0.68). While the cold drinking water feature scored relatively high (M = 4.25, .SD = 0.75), the Wi-Fi vending feature received the lowest mean in this category (M = 3.79, SD = 0.91), indicating occasional interruptions that may need improvement. Prior studies note that reliability is a key driver of user satisfaction and behavioral intent, and any disruptions—especially in frequently used features like internet connectivity—can lower acceptance levels [5].

Table 3: Mean Distribution of the Respondents' Ratings on the Perceived Quality of Solar-Powered Vending Machines in terms of Reliability Quality

Reliability Quality	Mean	SD	Description
Reliability			
1. The Wi-Fi vending feature works without frequent disconnections or interruptions.	3.79	0.91	Agree
2. The cold drinking water feature operates without breakdowns or malfunctions.	4.25	0.75	Agree
3. The smartphone charging feature consistently charges devices without issues.	4.16	0.93	Agree
4. The solar powered vending machines are dependable and reliable.	4.34	0.68	Agree
Mean	**4.13**	**0.67**	***Agree***
Serviceability			
5. The Wi-Fi vending feature is easy to troubleshoot and repair if issues arise.	4.23	0.79	Strongly Agree
6. The cold drinking water system can be serviced or maintained without significant downtime.	4.36	0.65	Agree
7. The smartphone charging feature is easy to repair or replace if damaged.	4.29	0.79	Strongly Agree
8. The solar powered vending machines are easy to maintain, install, and repair.	4.29	0.79	Strongly Agree
Mean	**4.29**	**0.64**	**Strongly Agree**
Perceived Quality			
9. Overall, I believe the Wi-Fi vending feature is of high quality.	4.18	0.93	Agree
10. Overall, I believe the cold drinking water feature is of high quality.	4.39	0.73	Agree
11. Overall, I believe the smartphone charging feature is of high quality.	4.26	0.93	Agree
12. The overall quality of the solar powered vending machine meets or exceeds my expectations.	4.35	0.79	Agree
Mean	4.30	**0.79**	**Agree**
Weighted Mean	**4.24**	**0.88**	**Agree**

Legend:4.50 – 5.00 – Strongly Agree; 3.50 – 4.49 – Agree; 2.50 – 3.49 – Neutral; 1.50 – 2.49 – Disagree; 1.00 – 1.49 – Strongly Agree

The perceived quality dimension scored 4.30 ("Agree") with SD of 0.79, with users expressing high confidence in the cold drinking water feature (M = 4.39, SD = 0.73) and overall machine quality (M = 4.35, SD = .075). These results suggest that the vending machines meet or exceed most user expectations, particularly in terms of performance stability and build quality. As research shows, high perceived quality can strengthen both trust in the technology and intention to continue its use [6]. The findings indicate that the machines are viewed positively in terms of reliability and serviceability, with only minor performance gaps—especially in Wi-Fi stability—that, if addressed, could further boost user satisfaction and long-term acceptance.

3.2 User Acceptance

Table 4 indicates a very high level of user acceptability for the solar-powered vending machines, with a weighted mean of 4.52 ("Strongly Agree") and SD of 0.69. Both perceived usefulness (M = 4.53, SD = 0.55) and perceived ease of use (M = 4.52, SD = 0.70) scored within the "Strongly Agree" range, suggesting that users find the machines both beneficial and convenient to operate. Among the usefulness indicators, the highest rating was for environmental contribution (M = 4.65, SD = 0.56), showing that users value the machines' eco-friendly nature alongside their practical functions. The cold drinking water feature (M = 4.58, SD = 0.57) and overall comfort and convenience (M = 4.57, SD = 0.68) were also highly rated, aligning with prior findings that sustainability and convenience strongly drive technology adoption in public service contexts [7].

In terms of ease of use, all indicators received strong agreement except for the statement on requiring little assistance (M = 4.40, SD = 0.96), which still falls under "Agree" but suggests that some users might still need guidance, especially first-time operators. The highest ease-of-use ratings were for the cold drinking water feature (M = 4.62, SD = 0.57) and the overall accessibility of the Wi-Fi vending feature (M = 4.51, SD = 0.69). Prior studies confirm that intuitive design and minimal operational complexity are critical for enhancing user acceptance and promoting repeated use [8].

Table 4: Mean Distribution of the User Acceptability of Solar Powered Vending Machines

Indicators	Mean	SD	Description
Perceived Usefulness			
1. The Wi-Fi vending feature is useful for my internet needs	4.39	0.83	Agree
2. The cold drinking water feature is useful for staying hydrated.	4.58	0.57	Strongly Agree
3. The smartphone charging feature is useful for keeping my devices powered.	4.44	0.80	Agree
4. Overall, solar powered vending machines contribute to making the environment cleaner and safer.	4.65	0.56	Strongly Agree
5. Overall, I find solar powered vending machines useful that brings comfort and convenience.	4.57	0.68	Strongly Agree
Mean	4.53	**0.55**	Strongly Agree
Perceived Ease of Use			
6. The Wi-Fi vending feature is easy to access and use.	4.51	0.69	Strongly Agree
7. The cold drinking water feature is easy to operate.	4.62	0.57	Strongly Agree
8. The smartphone charging feature is easy to use.	4.53	0.72	Strongly Agree
9. Overall, I require little assistance to use the 3-in-1 solar powered vending machines.	4.40	0.96	Agree
10. Overall, I feel positive and comfortable when using the 3-in-1 solar powered vending machines because of its user-friendly and intuitive design.	4.55	0.70	Strongly Agree
Mean	**4.52**	**0.70**	Strongly Agree
Weighted Mean	**4.52**	**0.69**	**Strongly Agree**

Legend:4.50 – 5.00 – Strongly Agree; 3.50 – 4.49 – Agree; 2.50 – 3.49 – Neutral; 1.50 – 2.49 – Disagree; 1.00 – 1.49 – Strongly Agree

The strong ratings across both usefulness and ease-of-use dimensions indicate that the machines are well-received by users in the educational setting. These findings suggest a high likelihood of continued adoption, especially if minor operational barriers for new users are addressed through clear instructions, visual guides, or onboarding support.

3.3 Behavioral Intention

The results in Table 5 show that the respondents have a strong behavioral intent to use the solar-powered vending machines, with a weighted mean of 4.39 ("Strongly Agree") and SD of 0.93. The highest individual score was for the cold drinking water feature (M = 4.49, SD = 0.64), followed closely by the intention to recommend the machines to others (M = 4.42, SD = 0.81) and the intention to use the multifunctional machine overall (M = 4.40, SD = 0.75). These findings suggest that the practical benefits, especially hydration convenience, and the novelty of having multiple services in one unit contribute significantly to continued use and advocacy.

Although still rated positively, the Wi-Fi vending feature (M = 4.34, SD = 0.93) and the smartphone charging feature (M = 4.31, SD = 0.84) received slightly lower means, which may indicate that these functions, while useful, might not be as essential to all users compared to the cold drinking water feature. This aligns with previous research showing that users' behavioral intentions are strongly tied to the perceived usefulness and necessity of specific functions [9].

Table 5: Mean Distribution of the Level of Behavioral Intent to Use Solar-Powered Vending Machines

Indicators	Mean	SD	Description
1. I intend to continue using the Wi-Fi vending feature of the solar powered vending machines.	4.34	0.93	Agree
2. I intend to continue using the cold drinking water feature of the solar powered vending machines.	4.49	0.64	Strongly Agree
3. I intend to continue using the smartphone charging feature of the solar powered vending machines.	4.31	0.84	Agree
4. Overall, I intend to use the 3-in-1, multifunctional solar powered vending machines.	4.40	0.75	Strongly Agree
5. I intend to recommend 3-in-1, multifunctional solar powered vending machines to others.	4.42	0.81	Strongly Agree
Weighted Mean	**4.39**	**0.93**	**Strongly Agree**

Legend:4.50 – 5.00 – Strongly Agree; 3.50 – 4.49 – Agree; 2.50 – 3.49 – Neutral; 1.50 – 2.49 – Disagree; 1.00 – 1.49 – Strongly Agree

The high ratings demonstrate strong potential for sustained adoption and positive word-of-mouth promotion of the vending machines in the educational context. To further strengthen behavioral intent, addressing performance reliability issues—especially in the Wi-Fi and charging functions—could increase user confidence and encourage broader usage across all features [10].

4. CONCLUSIONS

The research ultimately shows that solar-powered vending machines are considered high-quality, easy to use and environmentally friendly innovations in higher education. Perceived quality, especially in the areas of features and serviceability generally, has a substantial influence in terms of acceptance and behavioral intention. Not only do SPVMs provide a practical service, they also act as an educational service to raise awareness about renewable energy. Further improvements in user support service and Wi-Fi connectivity would help to foster further user acceptance. The implications support the role of universities as change agents for sustainability in computing technology-driven solutions in accordance with RA 9513, RA 11285, and SDG 7.

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