Article

Acceptance Factors of Appropriate Technology: Case of Water Purification Systems in Binh Dinh, Vietnam

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Abstract: This study selects a case involving water purification systems in Binh Dinh, Vietnam, as an appropriate example to examine appropriate technology (AT) acceptance factors and derive possible insights into the stable settlement and development processes whereby to diffuse AT. This analysis administered questionnaires to users of water purification systems installed in five elementary and middle schools in Binh Dinh, from which 296 samples were collected for the final analysis. The original unified theory of acceptance and use of technology (UTAUT) was modified by incorporating the factors of physical support and educational support, and empirically studied using structural equation modeling. The findings revealed that all constructs significantly affect the behavioral intentions toward AT, of which performance expectancy and physical support have the most significant impact. Thus, understanding local needs and improving the quality of life by spreading AT are key in its acceptance and diffusion. Furthermore, sustainable technology is guaranteed only if human and economic support is accompanied by AT development that fits the local context and environment. Finally, the analysis results, that moderating effects differ by role, imply that educational support's influence varies between manager and student groups.

Keywords: appropriate technology; water purification systems; technology acceptance; empirical study; UTAUT model

1. Introduction

Humanity has evolved to unprecedented levels as a result of its technological advancements. Specifically, modern technology has significantly influenced all social aspects by improving human productivity and the quality of life. However, a wide technological gap simultaneously exists between developed and developing countries, which is difficult to bridge as innovative technologies are developed on a foundation of high-level technology. Nevertheless, one possible solution to reducing this gap is appropriate technology (AT), proposed by British economist E.H. Schumacher [1]. Since its introduction, AT has been widely discussed among engineers, researchers, and policymakers as a solution for the purported “others” deprived of modern technology and its benefits.

Commonly, AT is designed under restricted circumstances associated with the target community. As AT users tend to have limited general technology support, a comprehensive understanding of the target community is warranted during the development stage [2,3]. Specifically, all components must be locally supportable materials that can be sourced locally and are suitable to local conditions, and its instructions and functions should be easily understood. Furthermore, AT should aim to enhance social welfare, and not provide an economic benefit. Developing countries may find it increasingly difficult to exploit more advanced technology, primarily due to economic reasons and a limited access to investments and infrastructure [4]. In addition to AT's technical and economic aspects, it is important to consider social indicators to resolve problems that occur in the local community [5,6]. In other words,

while technical performance is important, such diverse factors as the supply of local components, maintenance, and usability should also be considered [7].

Moreover, AT generally involves a new and heterogeneous technology introduced to a local community. Once a new technology is introduced, the next essential step in its safe settlement is identifying the factors that determine its adoption. Theoretically, researchers can more heavily weight key factors and, in a practical sense, determining such factors could lead to locals' acceptance of AT without any resistance, which could positively influence diffusion. In this context, studying AT acceptance factors can provide practical implications in promoting its use.

However, previous literature merely studied AT's acceptance, and a majority of AT research topics focused on either theoretical concepts [4,8–12] or its engineering aspects [13–15]. Further, Uddin et al. [16] investigated Muslim communities' sociocultural acceptance of urine-diversion toilets in Bangladesh through surveys and interviews with the local population. The authors discovered that the financial implications were critical for locals, but only focused on the survey results rather than analyzing acceptance factors with a relevant theoretical background. In this sense, an empirical analysis on AT acceptance is needed.

Although an empirical study can provide objective results while deepening theoretical understanding, only a few AT-related empirical studies exist due to data limitations. Most previous studies involved qualitative approaches adopting interviews [7,17,18], case studies [7,10,19], and survey data [17,20]. Among them, survey data are the most frequently used research material in the technology acceptance research field. To investigate AT adoption factors, the survey questionnaires should be designed for those who live in the targeted community. As AT addresses practical issues, the empirical study's results can be implemented in actual situations and provide a theoretical contribution.

This study examines AT acceptance factors by employing a modified unified theory of acceptance and use of technology (UTAUT) model. Its empirical analysis includes a case involving social responsibility programs, with a specific focus on the use of water AT in Binh Dinh, Vietnam. To elaborate, water purification systems (i.e., well- and rainwater cleansing systems) were installed in five elementary and middle schools in August 2015, through collaboration with the Seoul National University (SNU), Korea–Vietnam Cultural Exchange Center, and Korea Hydro and Nuclear Power (KHNP). The survey was administered to locals in Binh Dinh and resulted in 296 samples, which were then empirically analyzed using structural equation modeling (SEM).

The remainder of this paper is organized as follows: Section 2 reviews the extant literature on AT and its theoretical background for the research model. Sections 3 and 4 present the collected survey data as well as the analysis procedure and results. Section 5 summarizes the results and contributions.

2. Literature Review

2.1. Appropriate Technology

The AT concept first appeared in E.F. Schumacher's 1973 book, *Small is Beautiful* [1], although AT was initially termed "intermediate technology." As technologies from industrialized countries are inappropriate in developing third-world countries, Schumacher emphasized the need for an intermediate technology. In fact, innovative efforts in industrialized countries have led to the development of capital-intensive, large-scale, and even environmentally damaging technologies that are inappropriate for low-income countries [4]. Thus, developing intermediate technologies can benefit a wider population and create jobs in rural regions, thereby resolving poverty-related problems in low-income countries. Additionally, this could help countries develop self-reliance and accountability. The term "intermediate technology" was later revised to AT to prevent a sense of inferiority [2].

However, the early AT concept was characterized as labor-intensive and small-scale, with a low capital input per worker, which also rendered it simple to use and repair as well as being environmentally friendly [9]. Simultaneously, responses to AT were antagonistic, as it restricted

low-income countries to technologies that were low in productivity and less efficient [4,21,22]. It is noteworthy that no universally accepted definition of AT exists, given its contingency on available resources, local preferences, timing, and location. These criticisms resulted in scholars proposing different approaches to AT. For instance, Ranis [23] claimed that AT should not be limited to labor-intensive technology; rather, it could include advanced or capital-intensive technologies. He defined AT as “the joint selection of processes and products appropriate to the maximization of a society’s objectives given that society’s capabilities.” Others [9,24] emphasized the philosophy of delivering the necessary scientific knowledge and practical skills to the target region, rather than defining AT as a technology itself. These factors could facilitate capacity- and knowledge-building in developing countries, given the technology’s ability to engage a wider population through the development of indigenous technological capabilities. To this effect, Murphy et al. [9] defined AT as “a strategy that enables men and women to rise out of poverty and increase their economic situation by meeting their basic needs, through developing their own skills and capabilities while making use of their available resources in an environmentally sustainable manner.”

The AT concept has evolved since the 1970s and 1980s, and several studies have attempted to define it [3,9,10]. In fact, AT has expanded beyond developing countries to those that are developed [25] to address, for example, economic or environmental issues. A recent definition of AT is “the use of technology and materials that are environmentally, economically, culturally, and socially suitable to the location in which they are implemented and conducted” [26–28]. With such changes in its definition, AT now includes both the hard and soft aspects of technology, or technology, knowledge-transfer mechanisms, and capacity-building with sociocultural implications [9].

Meanwhile, AT research has also diversified, with a majority largely focusing on engineering improvements to technological performance, describing the methods to effectively improve technologies and their usefulness to the local community. Undoubtedly, improving technical specifications is fundamental to AT research. However, AT should also involve a consideration of the entire process and the context of its implementation, and not only the technology itself. This created a demand among engineers for a social-scientific approach in AT research to understand social aspects as a whole within the technology transfer [9]. Researchers responded by comprehensively examining critical factors and AT perspectives that emphasized the social contexts of local regions [6,9,12,29,30]. They suggested technological, structural, and local behavioral aspects as general factors, and concrete, specific factors that included meeting local needs, utilizing local resources, accounting for cultural conditions, and knowledge transfer mechanisms, among many others. These studies extracted factors from cases that failed to resolve malfunctions in AT transfers, and successful cases that highlighted key aspects in area-based experiences. The core principles suggested in AT research include the local context, or site-specific research, and indigenous knowledge gained through actual experiences [9].

More recent research accounts for the end-user’s perspectives toward AT, although these studies appear to be limited [20,31,32]. Compared to the aforementioned research, these studies attempt to determine key factors by interviewing AT users, and discover that they differ from those considered important by planners and activists. Furthermore, they suggest that the first step to achieving sustainability goals involves identifying factors considered important by the end-users who recognize and adopt AT. For example, Kalungu and Filho [31] investigated smallholder farmers in Kenya to understand the differences in AT awareness and adoption across four sites, each with typical environmental conditions. The authors used data from household interviews and focus-group discussions to demonstrate that gender played a role in AT adoption, and knowledge transfers among farmers were the primary method to gain information. Drawing on these results, the authors recommended an extension of information systems and approaches to increase awareness. Zhou et al. [20] investigated the public acceptance of and interest in solar home systems (SHSs) with a focus on permanent residents in Malakand, located in the northern region of Pakistan. Their survey results reported that, despite a high interest in SHS, the public faced difficulties in adopting SHS because of costly solar panels as well as a lack of information and trust in the related organizations.

These findings offer valuable implications for SHS promotion in Pakistan, with particular emphases on the government's role and policies. Similar research on cassava-processing technology in Nigeria suggests a lack of infrastructure facilities, funds, and labor as key hindering factors [32].

2.2. Theoretical Background and Hypotheses

This paper applies a UTAUT model in its analysis, which explains the relationship between users' beliefs, attitudes, and behavioral intentions toward using the technology [33]. Specifically, the UTAUT model is applied to investigate factors that affect "context-based consumer technology use" [34].

The UTAUT model has been developed from the technology acceptance model (TAM), the latter being based on Fishbein and Ajzen's [35] theory of reasoned action (TRA). The TAM measures "ease of use" and "usefulness" to explain a user's acceptance of a technology [36,37]. Specifically, TAM was designed to predict the adoption and usage of information technology in organizational contexts [33,37]. Subsequently, many technology acceptance models have been developed, and the UTAUT is a synthesis of the following eight models: TRA, TAM, the innovation diffusion theory, the motivational model, the theory of planned behavior, a model combining the theory of planned behavior and TAM, the PC utilization model, and social cognitive theories [33,38,39]. Thus, the UTAUT model is better able to measure both social influence and cognitive processes than the original TAM [37]. The model has been proven to deliver more successful predictions [40] and has been widely applied to various fields, including information systems, marketing, social psychology, and management [41].

The UTAUT model consists of four main constructs (performance expectancy, effort expectancy, social influence, and facilitating conditions) and four moderating variables (gender, age, experience, and voluntariness of use) [33]. This model has proven to be more competitive than other existing models, and thus is the most widely used because of its robustness. Furthermore, it enables scholars to modify and extend the UTAUT model to understand technology adoption due to its simplicity [33,34,37,39,42].

This research conducts an empirical study using a factor analysis with a modified UTAUT model to determine AT acceptance factors. As it is important to analyze end-users' perspectives in sustainability-related AT activities, using the TAM will provide a comprehensive understanding of the factors affecting behavioral intention and actual technology usage. Moreover, AT is typically employed in non-organizational contexts and includes non-information technology [20,31,32], which is why the UTAUT model is more adequate than the TAM in analyzing AT acceptance factors. A successful AT also requires facilitating conditions such as infrastructure and knowledge transfer mechanisms [4,9,31].

A modified UTAUT model is adopted to examine the crucial factors determining the acceptance of water purification systems in Binh Dinh, Vietnam. In addition to certain original factors in the UTAUT model, this study incorporated two constructs that are expected to be crucial to AT sustainability when adopted in local communities. These new constructs are extracted from grassroots innovations with visions and principles similar to those in the AT movement [43,44]. Figure 1 presents the research model tested in this study. In a modified UTAUT model, performance and effort expectancy as well as physical and educational support are hypothesized to be determinants of behavioral intentions. Furthermore, the facilitating conditions and behavioral intentions are hypothesized to be determinants of actual usage. Finally, the differences in roles between the manager group (teachers and technicians) and student group (parents and students) are assumed to moderate these determinants' influence on behavioral intentions.

Figure 1. Research model.

2.2.1. Performance Expectancy

Generally, performance expectancy is “the degree to which the user expects that using the system will help him or her to attain gains in job performance” [33]. Previous studies consider performance expectancy as an important predictor of the behavioral intention to use new technologies [45–49]. Among the various reasons for technology adoption, AT has an apparent usage purpose, unlike other technologies. By addressing practical problems, AT contributes to enhancing the quality of life. However, the AT’s benefits should be consistent with users’ perspectives; in other words, the incentive to use AT will decrease if users cannot discern its benefits. The UTAUT model’s performance expectancy variable is defined on the basis of this assumption. Specific to the AT context, performance expectancy implies the degree of users’ expectations from AT usage.

This study considers the importance of performance expectancy, and assumes this will positively affect the usage of water purification systems. Earlier studies demonstrated that performance expectancy positively influences users’ usage intentions [50,51]. Thus:

H1. *Performance expectancy positively affects users’ behavioral intentions toward using AT.*

2.2.2. Effort Expectancy

Effort expectancy denotes “the degree of ease associated with the use of the system” [33]. Although AT is designed to solve existing problems in developing countries while accounting for local conditions, users must still invest additional effort in using it. Adopting new technology often requires changes in user behavior. For instance, members of a local community who depend on raw water must adjust their ways of living if they decide to use water purification systems. However, if using AT is difficult or requires considerable effort, it becomes increasingly difficult to spread its adoption and maintain its sustainability. Studies have highlighted effort expectancy as another significant factor determining behavioral intentions [45,46,48,49].

Similarly, this study assumes that effort expectancy, which indicates the ease in using AT, will positively influence behavioral intentions toward the use of water purification systems. The resulting effort expectancy positively affects users’ behavior intentions [50–52]. Thus:

H2. *Effort expectancy positively influences users' behavioral intentions toward using AT.*

2.2.3. Physical Support

In the context of this study, physical support is “the degree to which an individual believes that an organization (or provider) will provide sufficient human and economic resources for AT implementation and maintenance.” It is often difficult to obtain the supplies, infrastructure, and skills needed for local AT implementation and maintenance [4]. One possible solution to this problem involves a continuous mutual partnership between the provider agent and local communities. This would allow community members to develop the confidence to request help during AT usage, which consequently affects individuals' behavioral intentions to use and adopt it [6,9,12,29].

Additionally, studies aiming to resolve AT failures emphasize that grassroots innovation originates from activist and organization networks [43,44,53]. Generally, various organizations—such as voluntary associations, cooperatives, and informal community groups—participate in grassroots innovation [43]. This diverse range of organizations provides access to various resources, such as grants or funding, voluntary input, mutual exchanges, and limited commercial activities [43]. Therefore, organizations that are external to local communities, but engage in processes—in the case of Binh Dinh, this is the provider agent—are key in grassroots innovation [44]. Specifically, the enrollment of actors and resources mediated by the agent are essential to AT activities.

The above discussion on networks highlights the role of physical support in AT activities [6,9,12,29,44]; thus, this study attempts to examine whether physical support affects the behavioral intentions to use and adopt AT:

H3. *Physical support positively affects users' behavioral intentions toward using AT.*

2.2.4. Educational Support

This study describes educational support as “the extent of an individual's belief in the systematic education received, and the transfers of knowledge to use, maintain, and repair the facility provided by the organization.” Several researchers have emphasized education's role in AT's sustainability [2,4,9,12,30,54]. While external organizational support is undoubtedly necessary in the initial stages, users must gain sufficient knowledge to use and maintain systems in the long term [9,24,31].

Similarly, grassroots innovation highlights the importance of education [19,55,56], as the former seeks socially inclusive innovation processes in terms of knowledge, processes, and outcomes [44]. Certain grassroots innovation approaches focus on learning processes toward sustainable development [19,53,55,56]; Pattnaik and Dhal [19] also suggest that training and practical applications are essential to promote grassroots innovation, particularly in rural areas.

Accordingly, this study aims to examine whether educational support affects the behavioral intentions to use and adopt AT. Thus:

H4. *Educational support positively affects users' behavioral intentions toward using AT.*

2.2.5. Facilitating Condition

The facilitating condition is “the level that an individual believes that organizational and technical infrastructure exists to support the use of a system” [33]. Regarding the water purification systems in Binh Dinh, local resources for implementation and maintenance are crucial to the support infrastructure and system usage [26]. Namely, the availability of local and cheap resources is also important in AT sustainability [27,28]. Further, a resource locus or local resource supply is considered a crucial component of endogenous renewal [57]. Users must be able to independently and promptly repair the system using local resources, in addition to using the facility. However, the high cost of components

hinders AT adoption in reality [20,32], and thus, affordability is another key issue preventing the system's long-term use.

Thus, this study examines whether facilitating conditions under available internal resources affects the behavioral intention to use and adopt technology, as previous studies indicate that facilitating conditions positively affect actual usage [39,58]. Thus:

H5. *The facilitating conditions positively affect actual AT usage.*

2.2.6. Behavioral Intention and Actual Usage

A majority of technology-adoption studies [33,34,39,59] focus on new technologies yet to be introduced to the public, and accordingly estimate respondents' behavioral intentions to determine their willingness to adopt the technology. For example, Islam et al. [60] defined behavioral intention as an individual's intention to perform a given act, which can predict corresponding behaviors when an individual does so voluntarily. Thus:

H6. *Users' behavioral intention significantly and positively influences their actual AT usage.*

2.2.7. Moderator

The original UTAUT model proposed four key moderating variables [34]; among them, gender and age were important moderators in most previous studies [61–63], but this study offers a different tendency. This study investigated the moderating effect by role regarding the acceptance of water purification systems. Sun and Zhang [64] proposed the use of suitable moderating factors in their research questions and contexts in user technology acceptance, and explained that the use of moderators appropriate to the context can increase the model's explanatory power and consistency [64]. Previous studies have also indicated different tendencies by a variety of user groups in technology acceptance [41,65,66]. Specifically, Williams et al. [41] conducted a UTAUT literature review using various user groups, such as students, professionals, and general users, as control variables.

This study conceptualized performance expectancy, effort expectancy, physical support, and educational support to differently affect users' behavioral intentions toward AT adoption between manager and student groups. Further, the facilitating condition's effect on actual usage is moderated by role, in that the effect differs by the manager or student group.

3. Research Methodology

3.1. Sample and Procedure

This study selects water purification systems that were designed and implemented in Vietnam as an empirical case, as these local communities experienced water issues due to a lack of proper water purification. Since 2015, SNU has conducted social responsibility programs in collaboration with KHNP to install water purification systems in elementary and middle schools in Binh Dinh, Vietnam. Twice a year, SNU selects areas and supports local residents and students to improve their water quality and environmental hygiene by providing water purifying systems and establishing sustainable infrastructure to offer an abundant water supply. The program also aims to raise awareness about drinking water and sanitation and enhance the capacity of residents in Binh Dinh, Vietnam.

To identify the factors influencing AT acceptance, Binh Dinh residents were surveyed as beneficiaries of the water purification systems. The questionnaire was based on a modified UTAUT model and comprised 28 items. The survey was conducted twice, in October 2017 and January 2018, in five elementary and middle schools in Binh Dinh. Survey respondents included the school's teachers, students, parents, and technicians who used the water systems from August 2015 to August 2017 (Table 1). While teachers and students use the system, technicians are also in charge of maintaining the facilities. As students in the lower grades of elementary school would find it difficult to answer

the questions, their parents were asked to query their children in completing the questionnaire. The respondent composition varied because of the different class hours, vacation times, and other school conditions. Face-to-face interviews were conducted with teachers and technicians, while students and parents were administered questionnaires, which were collected after 3 to 4 days.

Table 1. Installation times and schools.

Time	School
August 2015	Truong tieu hoc so 3 phuoc an
January 2016	Truong tieu hoc phuoc nghia
August 2016	Truong trung hoc co so phuoc quang
January 2017	Truong tieu hoc so 1 phuoc quang
August 2017	Truong tieu hoc so 2 phuoc loc

All respondents voluntarily participated in the survey. Of the 412 questionnaires sent to the five schools, 336 (81%) were returned. The data winsorizing, including case and variable screenings, resulted in 40 being deemed incomplete; thus, the final analysis was conducted using data from 296 questionnaires. They were omitted due to missing values (i.e., too many missing values or no responses about demographic variables) and unengaged responses (i.e., duplicated or identical answers). Some missing values were replaced by the median imputation [67]. Tabachnick and Fidell [68] suggested excluding values that ventured outside the bounds of a ± 3.29 standard deviation away from the mean. Every factor, including demographic variables, went into the bound as a result of skewness and kurtosis. A frequency analysis was conducted to determine the sample characteristics (Table 2).

Table 2. Respondents' demographic profile.

Demographic Profile		Frequency	Percent (%)
Gender			
Male		125	42.22
Female		171	57.78
Age			
<20 years		123	41.55
20–30 years		21	7.1
30–40 years		69	23.31
40–50 years		56	18.92
50+ years		27	9.12
Role			
Manager Group	Teacher	111	37.5
	Technician	12	4.05
Student Group	Parent	50	16.89
	Student	123	41.56

3.2. Measurement

UTAUT has been proven to be excellent in explaining users' technology adoption by overcoming the TAM's limitation, in that the latter does not fully consider various exogenous variables' effects [37,40,41]. Therefore, this study employed a modified UTAUT model that adds certain variables from the original. Performance expectancy (PE), effort expectancy (EE), facilitating condition (FC), behavioral intention (BI), and actual usage (AU) were measured based on the work of

Venkatesh et al. [33] and related prior studies (see Table 3). Furthermore, physical support (PS) was measured as adapted from Seyfang and Smith [43], Murphy et al. [9], and related studies [6,12,44] based on grassroots innovation. Prior studies [4,9,53,55,56] were used to measure educational support (ES). Finally, Table 3 summarizes each construct's operational definitions.

Table 3. Definition of each construct.

Construct	Definition	Reference
PE	The degree to which the user expects that using the system will help him or her gain job performance	[33,45–49]
EE	The degree of ease associated with using the system	[33,45,46,48,49]
PS	The degree to which an individual believes that an organization (or provider) will provide sufficient human and economic resources for AT implementation and maintenance	[6,9,12,43,44]
ES	The extent of an individual's belief in the systematic education received and transfers of knowledge to use, maintain, and repair the facility provided by the organization	[4,9,53,55,56]
FC	The level that an individual believes that organizational and technical infrastructures exist to support a system's use	[20,27,28,32,33]
BI	An individual's intention to determine their willingness to adopt AT	[33,34,39,59,60]
AU	The actual AT use behavior	[33,34,39]

Note: PE, performance expectancy; EE, effort expectancy; PS, physical support; ES, educational support; FC, facilitating condition; BI, behavioral intention; AU, actual usage; AT, appropriate technology.

Responses to each construct were measured on a five-point Likert scale, which ranged from 1, or “strongly disagree,” to 5, or “strongly agree.” The demographic variables included sex, age, and role, which were measured using a nominal scale. The questionnaire was first drafted in Korean, and then translated into Vietnamese by administrative assistants at the Korea–Vietnam Cultural Exchange Center in Vietnam. The Vietnamese assistants accompanied the researchers on both survey visits (October 2017 and January 2018) to assist in not only explaining the survey's purpose and significance to the schools' principal, teachers, and technicians, but also interpreting the questions and answers. Appendix A details the questionnaire's measurement items.

Prior to the analysis, an exploratory factor analysis (EFA) was conducted to test the construct validity and extract the new factor structure. Seven factors were extracted using a maximum likelihood, and the EFA was conducted using a promax method with oblique rotation methods, as the oblique method rotates by permitting correlations among factors [69,70]. Furthermore, previous studies [70–72] have revealed the EFA's beneficial robustness and accuracy. Thus, one item each from the PE, PS, ES, and BI was eliminated through the EFA, and two items from the FC were eliminated. Appendix B presents the EFA's measurement results in detail.

The collected data were analyzed based on the SEM method with a maximum likelihood estimation, using SPSS 23.0 and AMOS 23.0 software. The SEM is a statistical method that combines path, regression, and factor analyses [73,74]. Characteristically, the SEM can simultaneously observe various complex causalities expected to exist among multiple variables, and includes latent variables that cannot be directly measured [75]. Each construct's measurement validity and reliability was evaluated using Cronbach's alpha and a confirmatory factor analysis (CFA). The CFA involves confirming the hypothesis structure under a situation in which prior knowledge or a theoretical background between variables and factors exists [75,76]. Therefore, the SEM and CFA approaches were applied to an analysis of the modified UTAUT model. The next section discusses the CFA, which was conducted to verify both convergent and discriminant validity. The overall fitness and path coefficient

were then calculated using an AMOS-based SEM. Additionally, the difference in results between the manager and student groups were then statistically compared.

4. Data Analysis and Results

4.1. Descriptive Analysis

Table 4 presents the results of the research model applied in this study. A PE value of 4.34 denotes high satisfaction among the local respondents, while the EE (2.62) and FC (2.90) values suggest a relatively low satisfaction. Reliability was tested using Cronbach's α : a value of 0.6 or higher denotes a reliable variable, and that between 0.8 and 0.9 suggests high reliability [77]. The results of the Cronbach's α analysis revealed a high internal consistency between variables.

Table 4. The constructs' descriptive statistics.

Construct	Mean	SD	Cronbach's α
PE	4.34	0.54	0.723
EE	2.62	0.80	0.834
PS	3.75	0.68	0.755
ES	3.98	0.69	0.781
FC	2.90	1.00	0.880
BI	3.99	0.58	0.784
AU	3.19	0.84	0.848

4.2. Assessment of Measurement Model

Drawing on Anderson and Gerbing's [78] and Schumacker and Lomax's [79] suggestions, this study analyzed the relationship among the model's variables. To examine the measurement model's reliability and validity, a CFA was conducted on the PE, EE, PS, ES, FC, BI, and AU, which assessed and validated their fit with the measurement model.

The model fit indices must be evaluated to validate the measurement model's goodness of fit [80]. Thus, X^2 statistics are applied to validate the goodness of fit, or to determine whether the model fits the observed data. However, X^2 statistics are sensitive to sample size [81]. Thus, the ratio of the X^2 statistics to the degree of freedom (X^2/df) is used to assess the model's fit; a value of less than 3 denotes a fit model [82]. Hooper et al. [75] introduced model fit as an absolute fit index, and suggested the following as incremental fit indices, including the recommended values for each index: the root mean square error of approximation (RMSEA), the goodness-of-fit (GFI) statistic, adjusted goodness-of-fit index (AGFI), root mean square residual (RMR), normed-fit index (NFI), and comparative fit index (CFI). Table 5 illustrates that all the model fit indices except the NFI satisfied a relatively strict standard of recommended values.

Table 5. Fit indices summary for the measurement and structural models.

Model Fit Indices	X^2/df	GFI	AGFI	CFI	NFI	TLI	RMR	RMSEA
Recommended value	<3	>0.90	>0.80	>0.90	>0.90	>0.90	<0.10	<0.08
Measurement model	1.829	0.910	0.877	0.946	0.889	0.932	0.043	0.053
Structural model	1.812	0.909	0.878	0.946	0.888	0.934	0.044	0.052

Note: GFI, goodness-of-fit; AGFI, adjusted goodness-of-fit index; CFI, comparative fit index; NFI, normed-fit index; TLI, Tucker-Lewis index; RMR, root mean square residual; RMSEA, root mean square error of approximation.

Generally, a measurement model is evaluated on the basis of convergent and discriminant validity. The assessment of convergent validity is based on the constructs' composite reliability (CR) and average variance extracted (AVE) [83]. Fornell and Larcker [83] proposed CR to measure indices' internal consistency and assess reliability, and suggested that a CR value of more than 0.70 is considered acceptable in terms of reliability [80]. The AVE is the size of the variance that measurement variables

use to explain construct concepts, and should be 0.5 or higher. A CR greater than the AVE is considered to denote validity. Discriminant validity indicates the correlation between the scale used to measure a concept and other scales, and is considered valid when the correlation between other constructs is less than the square root of the AVE. Additionally, the discriminant validity is tested through a maximum shared squared variance (MSV) and is deemed valid when the MSV is less than the AVE [80]. Table 6 presents the results for the reliability and validity analyses, and indicates that the variables satisfy all criteria.

Table 6. Construct reliability, convergent validity, and discriminant validity.

Factor	CR	AVE	MSV	PE	EE	PS	ES	FC	BI	AU
PE	0.747	0.502	0.253	0.709						
EE	0.836	0.562	0.350	−0.046	0.750					
PS	0.772	0.534	0.319	0.353	0.079	0.730				
ES	0.791	0.558	0.319	0.503	0.006	0.565	0.747			
FC	0.882	0.789	0.350	0.053	0.592	0.258	0.168	0.888		
BI	0.794	0.565	0.297	0.473	0.155	0.545	0.528	0.267	0.751	
AU	0.858	0.605	0.258	0.202	0.308	0.282	0.373	0.441	0.508	0.778

Note: CR, composite reliability; AVE, average variance extracted; MSV, maximum shared squared variance; Factor correlation matrix with $\sqrt{\text{AVE}}$ on the diagonal.

4.3. Structural Model Assessment and Hypotheses Testing

The AMOS 23.0 software suite was used to test the SEM and verify the hypotheses. The goodness-of-fit validation used in the measurement model was also applied to verify the optimal status of the construct concepts and variable composition. As Table 5 demonstrates, all indices except the NFI satisfy a reasonable fit as proposed by Browne and Cudeck [84]. The NFI is valued at 0.888, which is less than the strict standard of 0.9 or higher, but greater than the acceptable level of 0.85. As it is difficult to derive satisfactory indices for all criteria in the SEM [85] and the model has no absolute acceptability standard [81], the analysis results are considered to satisfy the general standard and sufficiently adequate to validate this study's hypotheses [86–88].

Table 7 presents the SEM model's results for hypothesis validation; the path coefficients suggest that all hypotheses are supported. The PE ($\beta = 0.372, p < 0.001$), EE ($\beta = 0.082, p < 0.05$), PS ($\beta = 0.274, p < 0.001$), and ES ($\beta = 0.186, p < 0.01$) positively and significantly affect BI, thus supporting H1, H2, H3, and H4. It is noteworthy that compared to the other constructs, the PE more significantly contributes to BI. Furthermore, the FC ($\beta = 0.289, p < 0.001$) and BI ($\beta = 0.553, p < 0.001$) also significantly influence actual AT usage. However, in comparison to the FC, the BI more considerably affects the AU, which supports H5 and H6. In other words, this research model explains BI with a 42% variance and AU with a 34% variance. Of all the constructs, the PS best explains BI, with a 37% variance, and the FC has the highest explanatory power for AU, with a 39% variance.

Table 7. Path coefficients, their significance, and hypothesis results.

	Path	Path Coefficient	Results
H1	PE → BI	0.372 ***	Supported
H2	EE → BI	0.082 *	Supported
H3	PS → BI	0.274 ***	Supported
H4	ES → BI	0.186 **	Supported
H5	FC → AU	0.289 ***	Supported
H6	BI → AU	0.553 ***	Supported

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 8 presents the analysis results for the hypotheses regarding moderator effects. For the influence of PE on BI and the effect of FC on AU, moderator effects were found to significantly

influence both manager and student groups. Next, the others revealed differences between manager and student groups. In the manager group, the EE ($\beta = 0.124$, $p < 0.05$) and ES ($\beta = 0.291$, $p < 0.05$) significantly affect BI within a 5% significance level, unlike in the student group. Alternatively, the PS ($\beta = 0.251$, $p < 0.01$) significantly influences BI within a 1% significance level in the student group; however, the other constructs' effects occur outside of the 1% significance level, thus rejecting the hypotheses.

Table 8. Path coefficients, their significance, and the manager and student groups' hypothesis results.

Path	Manager Group (Teacher, Technician)		Student Group (Parent, Student)	
	Path Coefficient	Results	Path Coefficient	Results
PE → BI	0.224 *	Supported	0.142 *	Supported
EE → BI	0.124 *	Supported	−0.009	Not supported
PS → BI	0.135	Not supported	0.251 **	Supported
ES → BI	0.291 *	Supported	0.106	Not supported
FC → AU	0.122 *	Supported	0.384 ***	Supported

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

5. Discussion and Conclusions

5.1. Key Findings and Discussion

This study examined the factors determining AT acceptance among the residents of Binh Dinh, Vietnam, with an aim to provide and spread sustainable AT. Since 2015, SNU has installed well- and rainwater purification systems in Binh Dinh to secure clean, safe drinking water for students and teachers in local schools. These efforts include continuous water quality testing, filter replacement, pipe repairs, and the supplying of power. The social responsibility programs in Binh Dinh were successful in terms of the maintenance, provision, and spread of AT, and are considered best practices that can serve as a basis to analyze the factors influencing technology acceptance.

This study's results also confirmed that residents are satisfied with and willing to accept AT. The most important factor influencing the willingness to accept AT is performance expectations. As with most previous studies using the UTAUT model [45–49], it was confirmed that AT performance is the most important consideration in AT adoption. The water purification technology in Binh Dinh closely relates to residents' daily lives, and it is important to enhance performance expectations through facility installations. Compared to other constructs, effort expectancy and behavioral intentions indicate fewer contributions. Unlike the earlier AT concepts [9], water purifying facilities are extensive, and their construction process requires a substantial labor force. As Buatsi [24] described, installation and provision of water purification facilities promotes social welfare by delivering the scientific knowledge and practical skills needed based on an area's geographical and environmental properties. However, the present results suggest that the installation process is not simple, and local residents' efforts are inadequate to influence behavioral intentions, although this still contributes to AT acceptance, similar to previous studies [50–52].

Furthermore, physical support was proven to be as important as performance expectancy in influencing AT acceptance. Water purification systems' installation requires human resources with technological expertise and understanding about the equipment, as well as financial support. Furthermore, AT literature has explained local communities' difficulty in independently accepting AT due to the community's lack of skills, tools, and infrastructure [4]. They emphasized that communities must cooperate with an external organizational network to facilitate AT adoption [6,9,12,29]. The result of physical support can be interpreted as empirical proof of this local belief. Moreover, SNU is a major agent in securing a human network, and plays a key role in installing, providing, and maintaining these facilities. Apparently, efforts by SNU researchers and KHNP engineers to enhance the Vietnam project's technological completion resulted in physical support significantly impacting behavioral

intentions. The findings for educational support also confirmed SNU's crucial role. The result also empirically proves prior studies' [4,9,12,30,54] emphasis on the importance of educational effects in accepting AT. Furthermore, the primary components in managing and maintaining water purification systems involve understanding the system's principles and installation process. To this effect, SNU has educated the teachers and technicians about their water purification systems through the creation and sharing of manuals, for example. Additionally, they have monitored the facility and delivered information through interpreters from the Korea–Vietnam Cultural Exchange Center. They also allocated time to share the technology and conducted courses for the students and their parents regarding the effects and usage of water purification facilities.

This study also investigated the effects of facilitating conditions on actual usage to determine whether the local population considered it important to utilize local resources in an environmentally responsible manner to maintain these facilities. This is because the materials and tools—including water tanks, pipes, and pedestals—are procured in Binh Dinh, although the technology and knowledge originate with SNU. In other words, the provision of AT, as noted in previous studies [26–28,57], should be based on an understanding of local resources, geographical conditions, and social contexts. This study also confirmed that behavioral intention significantly relates to actual usage.

Finally, the findings for the moderating effects imply that the manager and student groups demonstrate different tendencies toward the water purification system. The hypothesis validation for effort expectancy, physical support, and educational support indicates that the two groups have a different understanding about the water purifying facility's installation and principles. Generally, the facility is installed as follows: rainwater and well water are stored in a tank, transported through pipes, and clean, filtered water is distributed. The varying hypothesis validation by group can be interpreted as differences in understanding this installation process. Specifically, educational support was found to significantly influence these differences. The agent group equipped the manager group, which was in charge of facility management and maintenance, with systematic, intensive education. The manager group was also provided manuals to sustain this educational effect. Once the agent group left the site, they monitored the facility and transferred the necessary knowledge through the Korea–Vietnam Cultural Exchange Center. Alternatively, the agent group invested less educational effort for the student group. Namely, they only delivered practical knowledge about the water purification system's purpose and principles during the hours allocated to sharing this technology. In summary, the provided training differed between the two groups, given not only the large scale of the water purification system to be used by the public facilities (schools), but also that this was built through a collective effort and not on an individual level.

5.2. Limitations and Implications

As is often the case with research analyzing statistics based on questionnaires, it is difficult to generalize the acceptance factor analysis' results. Much of the AT literature emphasizes the importance of technological transfers that account for environmental, geographical, social, and cultural factors, as well as an understanding of the relevant technology. In this context, the provision of water purification systems can be considered an AT that satisfies local needs for clean water as well as a practical solution to the water issues in Vietnam, a country with two distinct seasons (dry and wet) and lime-rich soil. The results imply that the successful acceptance and spread of AT requires the sharing and delivery of technological knowledge as well as human and financial support, although these vary by area and community. Nevertheless, this study contributes to AT literature through its unique use of a modified UTAUT model to conduct an empirical analysis.

This study can serve as a foundation for future empirical studies on AT sustainability. In fact, many ATs have vanished or local populations have discarded them within several years, reiterating the critical role of continuously evolving sustainability. Specifically, despite locals' understanding of AT and their approving of its benefits, AT efforts will be futile if the community deems them unusable.

Thus, AT acceptance should be secured before seeking sustainability; to this effect, understanding the factors determining AT acceptance can provide a key insight in establishing more sustainable use.

To overcome the limitation of the disability of generalization, future research should be conducted in different regions and with different technologies. This research was conducted in one specific region—Binh Dinh, Vietnam—with one specific technology: water purification systems. Results from diverse regions and technologies could support the generalization and classification of AT acceptance factors. Furthermore, consistent studies should be conducted in the same regions to promote sustainable AT activities. Each variable's effects may vary as time passes after AT implementation, and understanding this factor would help in discovering how to sustainably use and manage AT in developing countries.

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Appendix A. The Study's Measurement Items

Performance Expectancy

- PE1. I believe water purification systems are cleaner and more sanitary than existing water fountains.
- PE2. I believe that water purification systems will improve my health.
- PE3. I believe the water purification systems can provide enough water to drink.

Performance Expectancy

- EE1. I can easily install water purification systems.
- EE2. I can easily understand the water purification system's installation process.
- EE3. I believe that the management of water purification systems is convenient.
- EE4. I believe that water purification systems can be easily maintained and repaired.

Physical Support

- PS1. SNU provides sufficient human resource support for the installation of water purification systems.
- PS2. SNU provides sufficient economic support and materials for the installation of water purification systems.
- PS3. SNU provides sufficient economic support and materials for the maintenance of water purification systems.

Educational Support

- ES1. SNU provides systematic education on the installation of water purification systems.
- ES2. SNU provides systematic education on the management and maintenance of water purification systems.
- ES3. The water purification system educational materials provided by SNU are easy to understand.

Facilitating Conditions

- FC1. The materials and tools to install water purification systems are readily and locally available.

FC2. The materials and tools to maintain and repair water purification systems are readily and locally available.

Behavioral Intentions

BI1. I intend to continuously use water purification systems.

BI2. I will continue to pay attention to water purification systems.

BI3. I will explain to and inform those around me (family, colleagues, friends, and relatives) about water purification systems.

Actual Usage

AU1. I have participated in the installation of water purification systems.

AU2. I have participated in the management and maintenance of water purification systems.

AU3. I use water purification systems.

AU4. If a problem occurs with the water purification systems, it will be solved and handled without any special help.

Appendix B. The Exploratory Factor Analysis Results

Table A1. Total variance explained by exploratory factor analysis.

Factor	Initial Eigenvalue			Extraction Sum of Squared Loading			Rotation Sum of Squared Loading
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	5.979	27.175	27.175	2.887	13.124	13.124	4.013
2	3.425	15.568	42.743	4.288	19.491	32.615	3.166
3	1.744	7.929	50.672	2.001	9.096	41.711	2.959
4	1.428	6.492	57.164	1.627	7.397	49.108	3.405
5	1.231	5.595	62.759	0.929	4.224	53.332	3.277
6	1.085	4.933	67.692	0.950	4.318	57.650	3.389
7	0.940	4.273	71.965	0.684	3.110	60.760	3.005
8	0.726	3.300	75.265				
9	0.643	2.923	78.188				
10	0.591	2.686	80.874				

Table A2. Pattern matrix of exploratory factor analysis.

Measurement Variable	Factor						
	1	2	3	4	5	6	7
PE1	−0.062	−0.028	0.631	−0.052	0.091	0.016	0.089
PE2	−0.001	0.029	0.911	0.006	−0.016	−0.083	−0.069
PE3	−0.018	−0.031	0.594	−0.053	−0.048	0.115	−0.005
EE1	−0.026	0.795	−0.008	−0.022	−0.019	0.063	−0.014
EE2	−0.048	0.687	−0.015	0.051	−0.069	0.046	−0.035
EE3	0.014	0.784	0.012	−0.046	0.050	0.005	0.041
EE4	0.041	0.748	−0.012	−0.028	0.050	−0.112	−0.005
PS1	−0.038	−0.017	−0.090	0.820	0.023	0.036	−0.005
PS2	0.251	0.030	0.110	0.626	−0.102	−0.171	0.088
PS3	−0.128	−0.037	−0.053	0.773	0.081	0.063	−0.039
ES1	0.035	−0.035	−0.048	−0.059	0.840	0.001	0.030
ES2	0.074	−0.022	0.091	0.014	0.692	−0.024	0.020
ES3	−0.041	0.087	0.003	0.149	0.605	0.055	−0.087
FC1	−0.018	−0.057	0.004	−0.025	−0.005	0.033	1.036
FC2	0.040	0.174	−0.007	0.055	−0.008	0.020	0.671
BI1	0.011	−0.005	0.160	0.164	0.077	0.404	−0.005
BI2	−0.073	0.016	−0.064	−0.037	0.018	0.934	0.075
BI3	0.196	−0.017	0.105	0.008	−0.029	0.664	−0.053
AU1	0.696	−0.004	0.044	0.039	−0.083	0.140	−0.013
AU2	0.749	0.100	−0.012	0.021	−0.023	0.064	−0.020
AU3	1.011	−0.063	−0.125	−0.076	0.048	−0.004	−0.039
AU4	0.611	−0.029	0.053	−0.012	0.117	−0.137	0.079

Table A3. Structure matrix of exploratory factor analysis.

Measurement Variable	Factor						
	1	2	3	4	5	6	7
PE1	0.168	−0.015	0.651	0.267	0.371	0.291	0.103
PE2	0.200	−0.034	0.863	0.325	0.388	0.300	0.006
PE3	0.154	−0.037	0.593	0.219	0.259	0.313	0.023
EE1	0.233	0.786	−0.020	0.080	−0.026	0.144	0.402
EE2	0.166	0.668	−0.035	0.090	−0.057	0.111	0.322
EE3	0.290	0.805	0.015	0.098	0.037	0.140	0.463
EE4	0.235	0.738	−0.048	0.039	−0.013	0.018	0.389
PS1	0.222	0.074	0.271	0.797	0.413	0.402	0.173
PS2	0.430	0.206	0.327	0.639	0.302	0.276	0.328
PS3	0.137	0.004	0.300	0.769	0.441	0.399	0.093
ES1	0.286	−0.022	0.352	0.377	0.802	0.330	0.122
ES2	0.328	0.002	0.449	0.431	0.761	0.355	0.140
ES3	0.226	0.048	0.366	0.472	0.682	0.374	0.070
FC1	0.417	0.492	0.087	0.230	0.131	0.202	0.998
FC2	0.408	0.554	0.085	0.256	0.128	0.212	0.796
BI1	0.302	0.072	0.445	0.477	0.420	0.592	0.138
BI2	0.333	0.168	0.321	0.414	0.358	0.881	0.219
BI3	0.469	0.116	0.434	0.422	0.374	0.770	0.157
AU1	0.746	0.237	0.278	0.310	0.252	0.432	0.315
AU2	0.795	0.341	0.224	0.291	0.258	0.385	0.371
AU3	0.928	0.231	0.151	0.211	0.280	0.332	0.342
AU4	0.629	0.185	0.227	0.219	0.293	0.198	0.319

Table A4. Correlation matrix of exploratory factor analysis.

Factor	1	2	3	4	5	6	7
1	1.000	0.320	0.286	0.330	0.336	0.420	0.433
2	0.320	1.000	−0.016	0.120	−0.009	0.149	0.533
3	0.286	−0.016	1.000	0.420	0.490	0.435	0.084
4	0.330	0.120	0.420	1.000	0.526	0.506	0.244
5	0.336	−0.009	0.490	0.526	1.000	0.434	0.135
6	0.420	0.149	0.435	0.506	0.434	1.000	0.192
7	0.433	0.533	0.084	0.244	0.135	0.192	1.000

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