Behavioural Informatics for Improving Water Hygiene Practice based on IoT Environment

Abstract: The development of Internet of Things (IoT) and latest Information and Communication Technologies (ICT) have changed the nature of healthcare monitoring and health behaviour intervention in many applications. Water hygiene and water conservation behaviour intervention as important influence factors to human health are gaining much attentions for improving sustained sanitation practice. Based on face-to-face delivery, typical behaviour intervention method is costly and hardly to provide all day access to personalised intervention guidance and feedbacks. In this study, we presented a behavioural information system and water use behaviour model using IoT platform. Using Expanded Theory of Planned Behaviour (ETPB) and adopted structure equation model, this study offers a solution for understanding the behaviour intervention mechanism and methodology for developing empirical model. A case study of behaviour intervention model is presented by utilising residential water conservation behaviour data collected in China. Results suggested that cultural differences have significant influences on the understanding of intervention drivers, promoting projects and increasing awareness, which could improve the behaviour intervention efficiency and further facilitate the improvement of water hygiene practice. The performance evaluation of water saving dimension is discussed as well in the paper.

Keywords: Internet of Things; Behavioural informatics, Intervention; Behaviour Modelling; Theory of Planned Behaviour

Introduction

Contaminated household environment and risky hygiene practices cause a big amount of disease burden in developing country. The lack of good water supply and prevalence of risky hygiene behaviour could cause life years lost, infectious diseases and plague, as well as large economic losses and negative publicity to governments. Overwhelming evidences suggest that predicting the behaviour change has significant positive influence on addressing these concerns [1]. This paper aims to enhance water hygiene practices through understanding water use behaviour in IoT enabled environment to further improve water demand and water quality management, which the optimal water operation and management will directly impact on the consumers' water hygiene practice and reduce the risk of causing the disease to improve the public health. This paper will provide the necessary tools for improve sanitation and substantial reduction in water supply needs, gain more attentions by the water utilities, food industry and academy, due to the consequence to human health and influence on fresh water ecosystems [2]. When residents use less water in a specific time, the more chlorine should be added to maintain the disinfection level of the clean water. Also, the demand and water use behaviour in different area could affect the operations (supply amount and treatment process) of different treatment works in the same water network. Thus, understanding of water use behaviour will benefit water demand management, and plays key role in water network management and reducing the vulnerability of freshwater supply (such as researches at Advizzo and iWidget). Moreover, the understanding of water use behaviour could contribute to optimize water demand and water quality management to improve the water hygiene practice for public health.

Belonging to the general healthcare practices research domain, the water hygiene and its behaviour intervention issues, are challenging tasks to clinicians and decision maker who are seeking to monitor behaviour and transfer medical advices in to intervention guidance [3]. Water related behaviour varies differently by areas, also, many water use related behavioural interventions have not yet been empirically investigated because they do not lead themselves to study under existing research paradigm [4]. Models including the Theory of Planned Behaviour [5], the theory of reasoned action and Schwartz's norm activation model etc., have been applied to investigate the conserving water issues during water scarcity period in many developed countries, such as USA [6], UK [7], Australia [8] and Greece [9]. However, there are lack of evidences that explain residential water conservation behaviour via theoretical viewpoints in different background especially in a multi-purpose methodology to generate empirical model. One of the few exceptions is Zhang and Brown [10] who found that household water using habits and behaviour (physical behavioural pattern) as well as a household' willingness to respond to water related strategies has positive influence on their water consumption amount. Chen et al. [11] studied the relationship between social-psychological and residential characters of water scarcity on the one hand and drinking water choices on the other. He found that personal health belief and other characters (income, education etc.) are affected domestic drinking water choices in Shanghai. These studies do not, however, address on the issues of that how water use behaviour change can be influenced and what the adaptability for a psychological theory is in different cultural background. Therefore, there is a need to develop understanding of the residential water conservation behaviour intervention mechanisms. This research thus tries to fill the gaps.

Moreover, limited by the face to face delivery method, the behaviour intervention of water hygiene is costly and hardly to cover large amount users with 24 hours' access of the intervention guidance and the intervention process management information [12]. Despite the IoT environment allows the provision of healthcare behavioural information to every user and monitoring all the participants' actions with the capacity of tracking and screening the users remotely [13, 14, 15]. Current IoT healthcare systems have not shown enough capability to understand water related behaviour intervention in psychological viewpoints. Azzawi et al. [16] and Prochaska [17] systematically reviewed the current healthcare information system, and concluded that most healthcare related IoT systems mainly concerned physical actions/behaviours by using sensor devices, RFID (Radio-Frequency Identification) [18, 19, 20] or other methods. In line with this finding, Jun et al. [21, 22] and Sultan et al. [23] conducted comprehensive survey of IoT based healthcare system and supported above findings in different digital platforms. Less evidences are proved that the psychological behavioural intervention could be effectively monitored in IoT environment. By way of an IoT based behavioural data collection and feedback, this paper, therefore is aiming to present an information system for psychological behavioural data management, behavioural intervention model extrapolation and dynamic behaviour modelling. Integrated with behaviour intervention models, this research can offer tailed intervention information to all users and reduce the delivery cost of current behavioural intervention project. It also provides methodology for how to manage health related behavioural data in IoT environment and how to generate empirical and computer models based on IoT data.

The behaviour intervention model, which can test the past behaviour and self-efficacy as predictor in the whole theory, is based on an expanded version of TPB, and will be different from the original TPB model in the water industry application. Using the corresponding ETPB questionnaire and data collection from smart meters in IoT environment, this study provides empirical evidences about the residential behavioural information toward water conservation strategies during the whole intervention process. Additionally, the model examines the cross-country applicability with respect to the theory application by using model simulation results. This research will ideally provide a first knowledge base for public water conservation strategies and policy development that aim to increase water hygiene project engagement. The structure of this paper is organized as follows. Section 2 presents an overview of IoT based behavioural intervention system architecture. Methodology and data are described in Section 3. Section 4 presents the case study of residential water conservation behavioural intervention. Discussion and conclusion are made in Section 5.

2 Related Work

Extensively research has been done about behavioural intervention. Thomas et al. [24] analysed recent studies published coding behaviour change models for health promotion and through his finding, most commonly behavioural intervention research methods are based on psychological behavioural change theories, including Theory of reasoned action/planned behaviour (TPB), TTM (The Transtheoretical Model), HBM (Health Belief Model) and Social Cognitive Model (SCM) and so on. Theory of Planned Behaviours (TPB) as one of the major predictive social and behaviour models was developed as an extension of the Theory of Reasoned Action (TRA) model and it is a model. The TPB considers the proximal determinant of behaviour is person's intention which is based on attitude (overall evaluations towards performing the behaviour), subjective norms (social pressure from important referents to perform a behaviour) and perceived behavioural control (control on individual believe) [25]. There is systematic and meta-analytical evidence in relation to changes in health behaviour, the predictive performance of both the TRA and the TPB are in most superior to that of the Health Belief Model [26].

Despite its significance in environmental research, to date, the TPB research became more controversial about its sufficiency and the need for external variables which assist the improvement of intention prediction (see examples [27, 28]). Research findings above have proposed additional predictors to improve the TPB perdition power in intention and behaviour [27,29]. Interestingly, on conceptual level, various divergent water conservation frameworks also exist on adding external determinants (or predictors) to specific behaviour (see examples [30 - 33]). Lam [33] also argued that TPB alone is not sufficient as a basis for understanding people' intention to conserve water. In the safety and water use area, similar arguments about TPB theory could also been found in literature. Inauen [34,35] reviewed thirteen models for predicting behavioural intervention in safe water use area and concluded that TPB has limited prediction capability and there are more constructs, which should be considered to improve its prediction ability. Consequently, some other constructs to TPB will need to be added in order to increase the utility and predictive power for residential water conservation behaviour. The behavioural model applied in this research will add two external constructs and exam the modelling result through case study result. Moreover, according to Hofstede's individualism-collectivism dimension, different individuals from different background may show variable behavioural relations in the TPB model. With the application of IoT environment, many users from different background will participant the intervention process. To increase the modelling accuracy, there is a need to put ETPB variables configuration into consideration in this study. General hypothesis for ETPB framework is present in section 3.2 and a model configuration case is given in case study section 4.

3 Architecture

Specified by International Telecommunication Union (ICU), IoT framework is defined into five different layers: perception layer, access layer, internet lay, service management layer and application layer. In this study, the perception layer is consisted of water meter, GPS/sensors and mobile/internet end user platform. The water meter collected water usage readings at different water end use points. GPS/sensors (via mobile phone) are designed to collect and send geographic data to the server. Internet and mobile platform (application) is designed to collect and feedback water use behaviour data, and provide information for all the related water conservation project. The smart water meters are a native long-range solution based on 169MHz smart metering frequency band with a transmission range of up to 1 – 1.5 km to a concentrator.

The IoT based behavioural intervention information system contains data collection and data feedback component. Data is collected via RFID, sensor, wearable device and internet platform. The data for modelling use is made up by expanded Theory of Planned Behaviour questionnaire data (behavioural data) and water usage data. Processed by Structure Equation Model, the system then generates empirical ETPB model with variable identification result. Following by artificial neural network water consumption behavioural model, the system provides all the users with the prediction of their future water usage and their water behavioural intervention pattern. To increase the effectiveness of the whole intervention process, the intervention guidance, in the meantime, is translated by persuasive strategies and gaming mechanism to increase the user acceptance. The system will classify the behaviour via scoring result and feedback the specific behavioural intervention suggestions to the user including “you can do much better than you through via these tips of water conservation” for increasing the subjective norm, “you can install this device to help you save water in a rush time” if the score is low for answering the “how confidence when save water in a rush time”. Corresponding local water conservation policy and activities are pushed to the targeted users as well to enhance their water conservation behaviour. Figure 1 presents the IoT- based behavioural information system architecture.

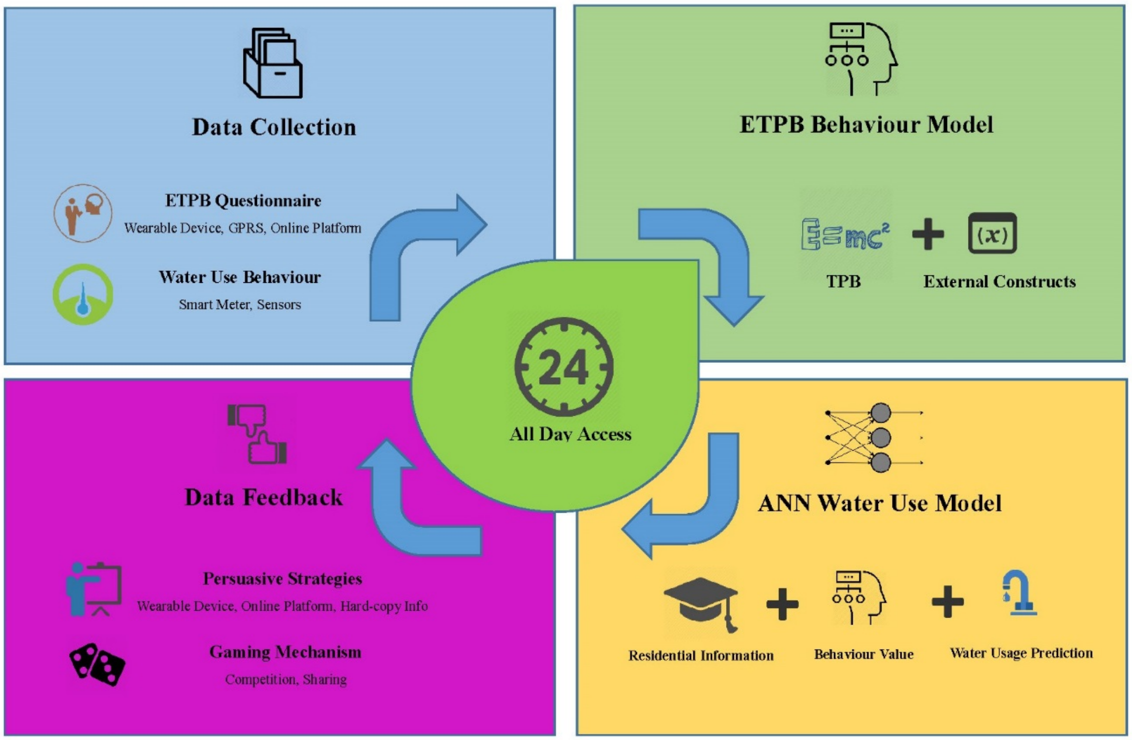


Figure 1. IoT based behavioural information system

3.1 Data Collection

The construction for the Expanded Theory of Planned Behaviour questionnaire was generally followed the procedures in Fishbein and Ajzen's discussion [36]. TPB 7-point Likert scales (1 = strongly disagree to 7 = strongly agree) have been applied previously in water conservation behaviour research with similar research purpose, and they have established an acceptable reliability [37, 38]. Apart from the behavioural data, residential character data such as income, education, number of residents are also included in the questionnaire to collect data supporting the ANN water use modelling. In this study, we apply wearable devices and online platform to investigate water use psychological behaviour. Users could access through mobile application or report the location/tag use information through this platform. Water use data is mainly collected from smart meters install for every household and taps need monitor.

Instead of using the full-questionnaire, we promoted the simplified question items and easy understanding answers. All the constructs are directly measured using just one single item (such as "how confident you feel you can manage you water conservation activity for this week?" replace the original detailed measurement in the questionnaire). Corresponding direct measurement are following the TPB questionnaire design method (direct measure) published by Ajzen in 1991 [5]. the user will be invited to fulfil a complete detailed questionnaire for every two months.

3.2 Behaviour Intervention Modelling

As discussed above in Section 2, we present the expanded Theory of Planned Behaviour modelling basis and the model is innovative by adding two external variables to increase the prediction power and accuracy. Water conservation regarding to water hygiene, should not only depend on local condition, but also be influenced by historical water use background and freshwater availability in the past [39]. Additionally, another factor called past behaviour, past action, pro-environmental behaviour, self-reported past behaviour or habit, has been added in TPB for improving the explanation of environmental behaviour [28, 37, 40, 41]. Ouellette and Wood [42] argue that our actions are not determined by reasoning but by habitual and automatic processes which measured by a past action was engaged. Other authors, by the contrast, have been sceptical of the influence of all independent variables in TPB on intention [343, 44, 45]. In this case study, as residential water conservation habit in the mostly research areas are kept, and likely to affect the influence of attitude, subjective norms and PBC on intention, however, whether the affection is attenuation remains unknown. Our aims, therefore, is to explore its prediction power to water conservation intention and its attenuation affection on TPB variables by adding "past behaviour" in TPB.

Summarizing, this research added past behaviour and self-efficacy in TPB framework as an extension version to understand how residential water conservation behaviour changes. Figure 2 depicts the proposed expanded theory of planned behaviour. Figure 3 illustrates the structure equation expression of ETPB. By following the general rule of TPB behavioural hypothesis, which is more positive attitude, greater PBC and subjective norm will strengthen the individual' intention to perform a behaviour, thus, construct correlations are expressed as hypothesis in ETPB:

H1. As attitude towards water conservation became more positive, the residential intention to save water and adopt conservation activity increases.

H2. As subjective norm towards water conservation became greater, the residential intention to save water and adopt conservation activity increases.

H3. As PBC towards water conservation became greater, the residential intention to save water and adopt conservation activity increases.

H4. As self-efficacy about water conservation became more positive, a residential intention to save water and adopt conservation activity increase.

H5. As past behaviour towards water conservation became more positive, a residential attitude, subjective norm, PBC and self-efficacy on intention towards water saving increase.

Finally, not only for the direct effects of past behaviour on water conservation intention, but also the indirect effect that between TPB variables will be investigated. Thus, we hypothesized that

H6. As the controlling of past behaviour about water conservation became greater, a result of attenuating influence of attitude, subjective norms, PBC and self-efficacy on intention increase.

H7. Past behaviour indirectly influences water conservation intention through TPB variables (attitude, PBC and Subjective norms).

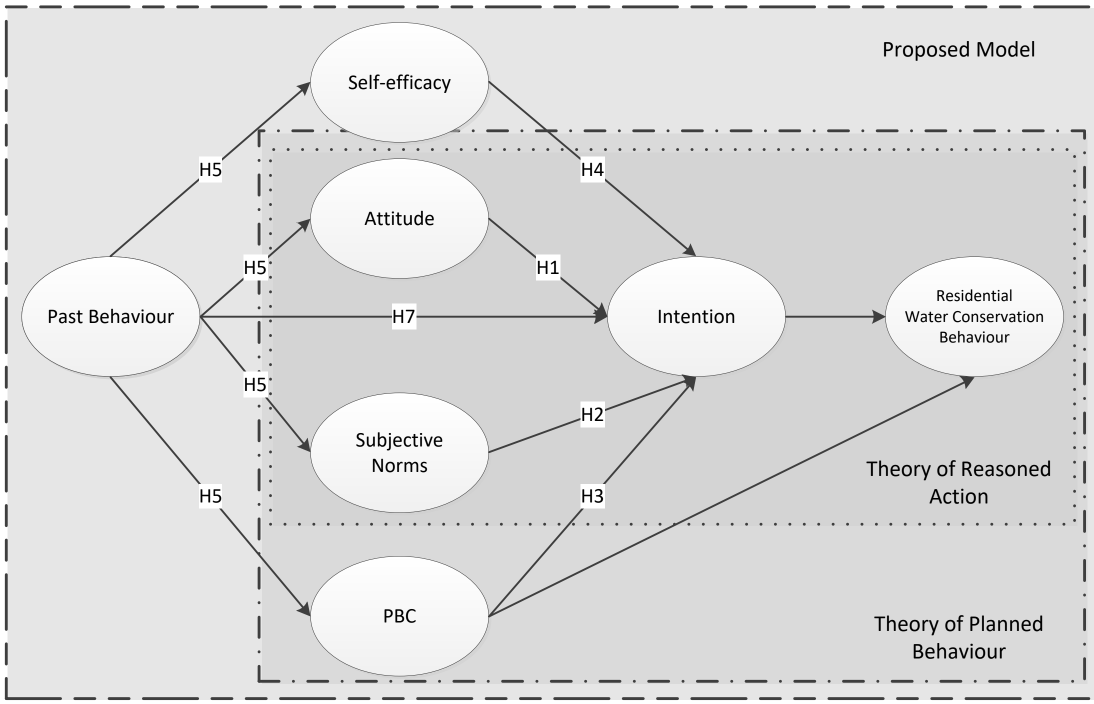


Figure 2. Expanded TPB model for residential water conservation behaviour based on TRA and TPB

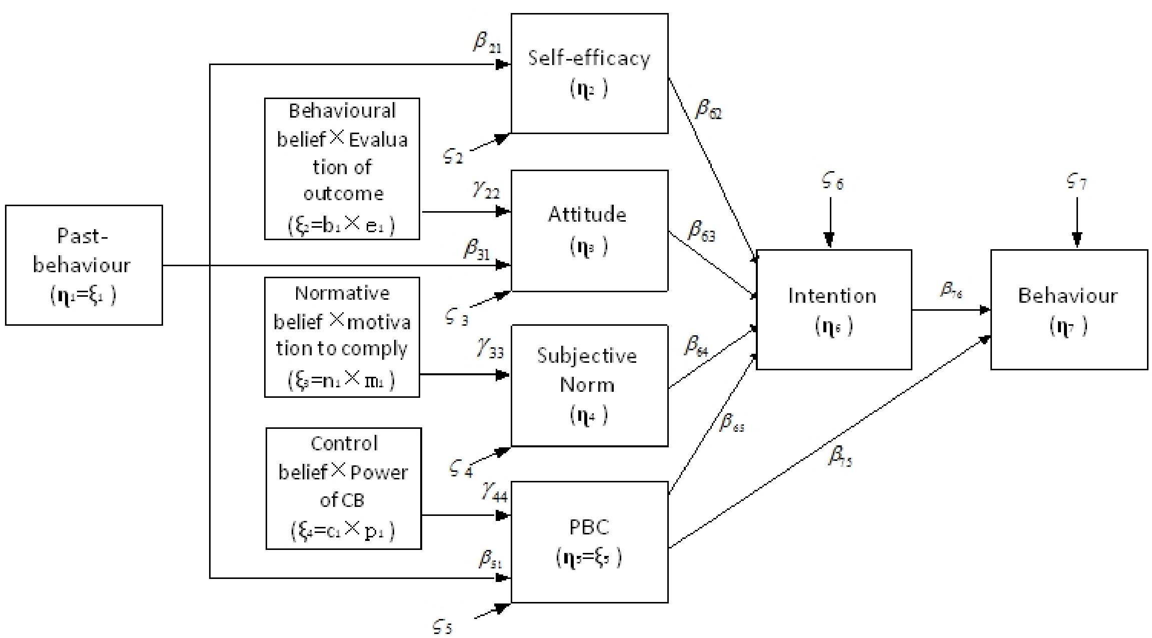


Figure 3. ETPB Structure Equation expression

The ETPB model mainly uses the Structural Equation Modelling (SEM) which will make the behavioural model to become a mathematical representation. According to the SEM method, this research will limit us to a special case of it called path analysis. The path analysis model choice a vector η of endogenous variables and a vector ξ of exogenous variables is expressed in Equation (1). Equation (2) is the detailed matrix expression of the past analysis equation.

$$\eta = B\eta + \Gamma\xi + \xi \qquad (1)$$

$$\begin{bmatrix} \eta_1 \\ \eta_2 \\ \eta_3 \\ \eta_4 \\ \eta_5 \\ \eta_6 \\ \eta_7 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \beta_{61} & \beta_{62} & \beta_{63} & 0 & 0 & 0 & 0 \\ 0 & 0 & \beta_{73} & \beta_{74} & \beta_{75} & 0 & 0 \end{bmatrix} \cdot \begin{bmatrix} \eta_1 \\ \eta_2 \\ \eta_3 \\ \eta_4 \\ \eta_5 \\ \eta_6 \\ \eta_7 \end{bmatrix} + \begin{bmatrix} \gamma_{11} & 0 & 0 \\ 0 & \gamma_{22} & 0 \\ 0 & 0 & \gamma_{33} \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \cdot \begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \end{bmatrix} + \begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \\ \xi_4 \\ \xi_5 \\ \xi_6 \\ \xi_7 \end{bmatrix} \qquad (2)$$

Where B and Γ are β_{ij} and γ_{ij}'s matrices regression weights, respectively, and ξ is a vector of disturbance variables.

3.3 ANN Water Use Model

Feeding back the predictive amount of water use for every user could promote the intervention project, also, makes visualisation of behaviour intervention outcome. Psychological notion for behaviour in behavioural intervention theories means the outcome of the behavioural intervention. However, for water conservation project, a calculated behaviour value cannot represent all the meaning of users' behavioural intervention outcome, moreover, there is dimension difference between psychological behaviour value and physical water saving amount. Fu and Wu [46] proposed a water use modelling method to generate water consumption amount by using ETPB model. The dynamic modelling algorithm is applied in this IoT based behavioural information system. Figure 4 illustrates the ANN water use model structure. In the ANN model, the psychological data is firstly being processed in ETPB model to simulate behavioural change result. Combined with other residential variables, calculated in ANN water consumption model to predict future water use amount. All the variables definition can be found in the literature [46].

The study used multiple-layer ANN networks. This multi-layer networks consist of an input layer of value consisting of House Size (HS), Number of Resident (NOR), Month (M), Education Level (EL), Income Level (IL) and Behaviour Value (BV) from ETPB Questionnaire, two hidden layers of perceptron and an output lay for outputting the Water Consumption Data (WCD with a unit of Ton/month). Numbers of nodes in hidden layer is set as two. BV (Questionnaire Calculated Behaviour Value) is calculated according to empirical ETPB model regression weight. The artificial neural network for household water consumption is expressed as Equation (3).

$$WCD = F(W_2 F(W_1 R + \Psi_H I) + \Psi_0 I) \quad (3)$$

Where WCD is the standardized water consumption data as output vector, R is the standardized input vector which consisting house size (HS), number of resident (NOR), month (M), education level (EL), income level (IL) and questionnaire calculated behaviour value (BV); F(x) is the sigmoid function; W_1 is the weight vector between input and hidden layer; W_2 is the weight vector between hidden and input layer; Ψ_H and Ψ_0 are the threshold vectors of hidden layer and output layer; I is an unit matrix. The mean prediction error (%) of water consumption model based on ANN between the original data and predication data is less than 0.8% presented in previous publication [46].

3.4 Data Feedback

Interactive information technology designed for individual behaviour change is known as persuasive technology [47]. The persuasive technology contains three phases for promoting the intervention information, which are understanding the key issue of the system, analysing the persuasion context (intent, event, strategy) and system quality design. Previous researches applied persuasive technology in healthcare domain won success in the past decade [48]. By introducing the game mechanism in persuasive design step two, the IoT system could feedback water use prediction result via social media and wearable device competition game mechanism and sharing function. Gaming function design includes the awarding system, water conservation riddle, Facebook/Twitter sharing, 3D visualisation for water saving outcomes. The game mechanism applied in this IoT system has been proved efficient in many previous projects such as FitBit, Ubifit, HealthMath and Nike Pulse etc.

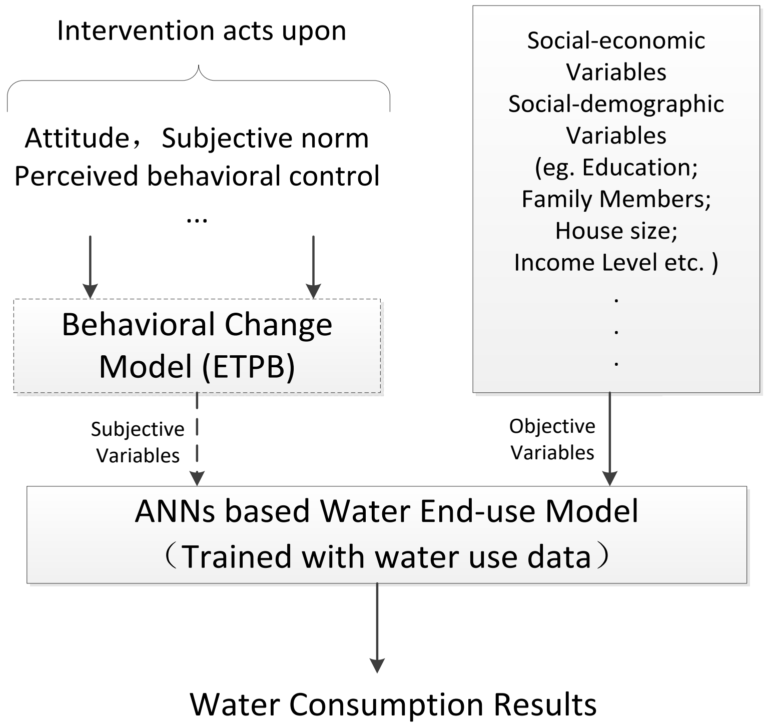


Figure 4. ANN water use model[46]

4. Case Study and ETPB Calibration

To test the ETPB model and the empirical model calibration ability of the IoT system, a case study in China is conducted. The data collected from this case is applied for the test of ETPB model configuration and hypothesis testing. To exam ETPB questionnaire and guarantee the reliability of the data collection method, a pilot study is conducted in the research area. Following by a national wide survey, 3000 residents from four different areas are invited to join our research. Sampling result and questionnaire content are given in Section 4.1 and 4.2. ETPB model calibration is presented in section 4.3. Section 4.4 and 4.5 presented the role of self-efficacy and past behaviour.

4.1 Sampling

Prior to the data collection, a pilot study based on face-to-face interview, was carried out on a sample of 23 subjects to ensure the validity of the ETPB questionnaire setting. This pilot study was refined through water conservation experts and residents' reviews in order to guarantee the validity and readability. SZ, a southern city of China facing critical water problem and has high population mobility, was finally chosen as a representative location for conducting pilot study. SZ is a new developed mega size city and most of its populations are from other provinces. SZ is also acting as the pioneer of water conservation project in China and has its own water conservation association for handling all the water conservation promotion. There are 84 face-to-face interviews with equal male and female quotas, carried out with respondents who were voluntarily be chosen to complete questionnaire in the town centre. 13 questionnaires had to be removed due to the inconsistencies and incomplete data. On average, respondents took 8-17 minutes to complete the questionnaire with fully understanding of the content.

The follow-up national wide data collection for this research was conducted from September 2014 to July 2015. The behaviour data collection system was set with a submission decline when indicates uncompleted questions, thus, missing values will not occur in the dataset. Also, in order to increase honest responses, the internet survey was designed to offer an anonymous feeling with a preamble advising [44]. Before the respondents start to complete questionnaire, introduction of preamble advising which is mentioned the importance of this research and faithful reply, was given in the study. Two criteria were set before the questionnaire being processed: the respondents should be over 18 years old and know very well about daily water use activity in their property.

By concerned the precipitation and water distribution condition, evenly, 3,000 participants from four different regions list of China (East coast (wet zone with abundant water resources from Yangtze and Zhu rivers), Central China (multi-water zone and humid areas in the middle stream of Yangtze and Xiang rivers), Northeast China (sub-humid and transition zone), Western China (semi-arid and drought area), excluding Hong Kong and Taiwan) represent, somewhat, to the Chinese population with quotas set for age, gender and education, being invited to fulfil questionnaire thorough the link via social media and email, leading to a final sample size 417 respondents (13.9% recycle rate). 19 responses were disregarded by online system because the questionnaire completion time is extremely low (5 min) and be processed as untrusted. Additional, 17 extreme cases were eliminated through a test of multivariate outliers' identification with a use of criterion Mahalanobis' distance $P < .001$, retaining a final sample volume of 381 cases. The sample results have shown almost equivalent numbers of male and female participants: 47.2% male respondents and 50.6% female respondents. The mean age is 37 years (standard deviation 18) with 39.7% high school education background responses.

4.2 Questionnaire

The construction for the Expanded Theory of Planned Behaviour questionnaire was generally followed the procedures in Ajzen's discussion [34]. TPB 7-point Likert scales (1 = strongly disagree to 7 = strongly agree) have been applied previously in water conservation behaviour research with similar research purpose, and they have established an acceptable reliability [37,38]. All the constructs that related to residential water conservation behaviour, are shown sufficient reliability. Cronbach alpha reliability coefficient of the sampling shown in Table 1 were applied with a result of good-to-excellent reliability ranging from 0.6 to 0.9.

Table 1. Survey questions, reliability and validity test results

Scales	Mean (s.d.)	CR	AVE
Intention (α=0.886)	**2.450(1.313)**	**0.7765**	**0.7028**
I expect I will engage in everyday actions to save water around my property	2.261(1.095)		
I intend to engage in water conservation activities in the near future	2.793(1.102)		
I plan to conserve water around my property in the near future	2.367(1.461)		
Attitude (α=0.867)	**2.352(1.029)**	**0.7678**	**0.7913**
I think engage in water conservation activities is beneficial	2.297(1.632)		
I think engage in water conservation activities is valuable	2.794(1.184)		
I think engage in water conservation activities is pleasant	2.435(1.093)		

I think engage in water conservation activities is good	2.103(1.615)		
I think engage in water conservation activities is intelligent	2.333(1.567)		
I think engage in water conservation activities is necessary	2.349(1.494)		
Perceived behaviour control (α=0.951)	**2.458(2.928)**	**0.9451**	**0.7423**
To what extent do you feel capable of conserving water when the water price is low	4.326(1.939)		
To what extent do you feel capable of conserving water when it is inconvenient	4.164(1.834)		
To what extent do you feel capable of conserving water when you are in a rush	3.653(2.305)		
Subjective norms (α=0.915)	**4.190(1.802)**	**0.9861**	**0.9220**
People who are important to me think that I should conserve water	4.354(1.681)		
People who are important to me expect that I will conserve water	3.836(1.933)		
I feel like there is social pressure to conserve water	3.964(1.238)		
The people whose opinions I value would conserve water	4.262(1.768)		
Self-efficacy (α=0.984)	**3.909(1.927)**	**0.9455**	**0.8526**
For me to conserve water around my living place is easy	2.635(2.387)		
I am confident that I could save water around the house and garden if I want	2.244(2.108)		
The decision to save water around the house and garden is under my control	2.302(1.164)		
I have the time and skills needed for water conservation activities	2.713(3.152)		
Past behaviour (α=0.909)	**2.889(1.407)**	**0.9640**	**0.8173**
check and fix leaking tap in the last six months	2.876(1.884)		

use minimal water in kitchen in the last six months	2.941(1.801)		
collect rainwater to use in the last six months	2.352(1.364)		
turn off taps when brushing teeth in the last six months	2.319(1.298)		
have shorter showers (4 min or less) in the last six months	2.166(1.033)		
only run washing machine if it is full in the last six months	3.136(1.641)		
Water conservation behaviour (α=0.973)	**3.721(2.359)**	**0.9683**	**0.8595**
I reuse water	2.530(2.174)		
I apply numerous water conservation technology	2.237(2.091)		
I participate water conservation activities	3.983(1.882)		
I check and repair leakage	2.148(2.014)		
I follow the government water conservation policy	3.155(2.263)		

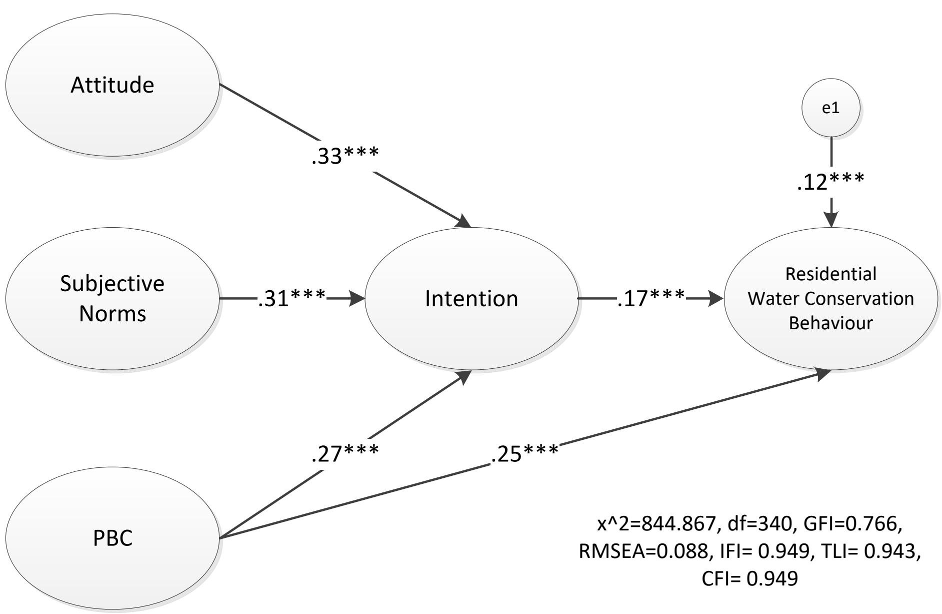
Note. C.R.: Composite reliability; AVE: The average variance extracted.

4.3 ETPB Calibration

A Confirmatory Factor Analysis (CFA) using maximum likelihood method was conducted to test construct validity for proposed latent variables. Model goodness-to-fit was assessed with various measures as below: x^2 (chi-square), Goodness of Fit Index (GFI), Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), Incremental Fit Index (IFI, also known as DELTA2), and Tucker-Lewis Index (TLI, also known as NNFI). The good-of-fit x^2 is very sensitive to sample size and the large chi-square value of CFA reveals a high degree of freedom.

A CFA test for the original TPB model (model 1) with attitude, PBC and subjective norms was initially conducted. The first CFA shown a good fit of the structural equation modelling (x^2= 837.347, df=335, GFI=0.768, RMSEA=0.089, IFI= 0.950, TLI= 0.943, CFI= 0.949). Another CFA test for TPB model with external construct – self-efficacy (model 2) also exhibited good psychometric properties (x^2= 957.463, df=414, GFI=0.763, RMSEA=0.083, IFI= 0.951, TLI= 0.944, CFI= 0.951), following by a good CFA fit test result from the proposed expanded TPB (model 3) which contains past behaviour and self-efficacy as external constructs (x^2= 1310.423, df=603, GFI=0.735, RMSEA=0.079, IFI= 0.945, TLI= 0.939, CFI= 0.945).

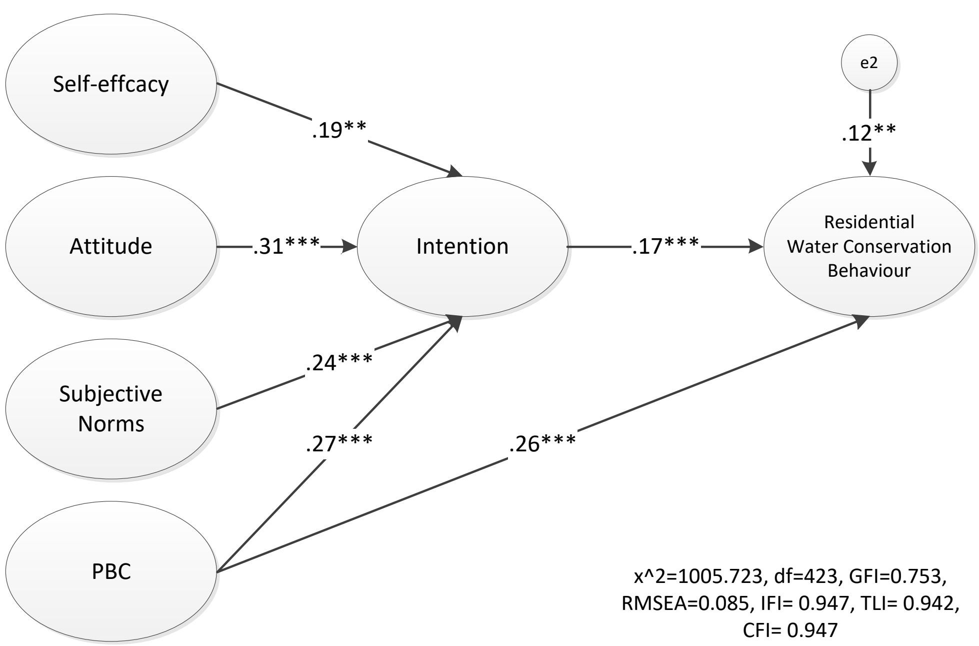
Additionally, variable composite reliability test for proposed model indicating high internal consistency, shown all reliability values were greater than suggested threshold of 0.60. As an assessment of the validity of the measures, factor loading within all the indicators, AVE (Average Variance Extracted), and construct correlation were calculated and depicted in Table 1. The result indicated an adequate convergent validity with all factor loading values, AVE, CR were above 0.5, 0.6 and 0.7 respectively. The hypotheses 1, 2 and 3 were initially tested by original TPB structural model (model 1, see Figure 2) which has a satisfactory model fit (x^2= 844.867, df=340, GFI=0.766, RMSEA=0.088, IFI= 0.949, TLI= 0.943, CFI= 0.949) and all standardized regression coefficients were significant at 0.01 level. Based on the coefficients in the equation, the three antecedent variables (see Figure 5) explained about 28% variance of intention and the four TPB variables (including intention) contributed 39% variance percentage for predicting water conservation behaviour. The regression paths from PBC (β=0.273, t=4.319, $p < 0.01$), subjective norms (β=0.235, t=3.710, $p < 0.01$) and attitude (β=0.293, t=4.600, $p < 0.01$) to intention were significant, therefore, H1, H2 and H3 are accepted.



***p < 0.01; **p < 0.05; $^{-}$p >0.05.

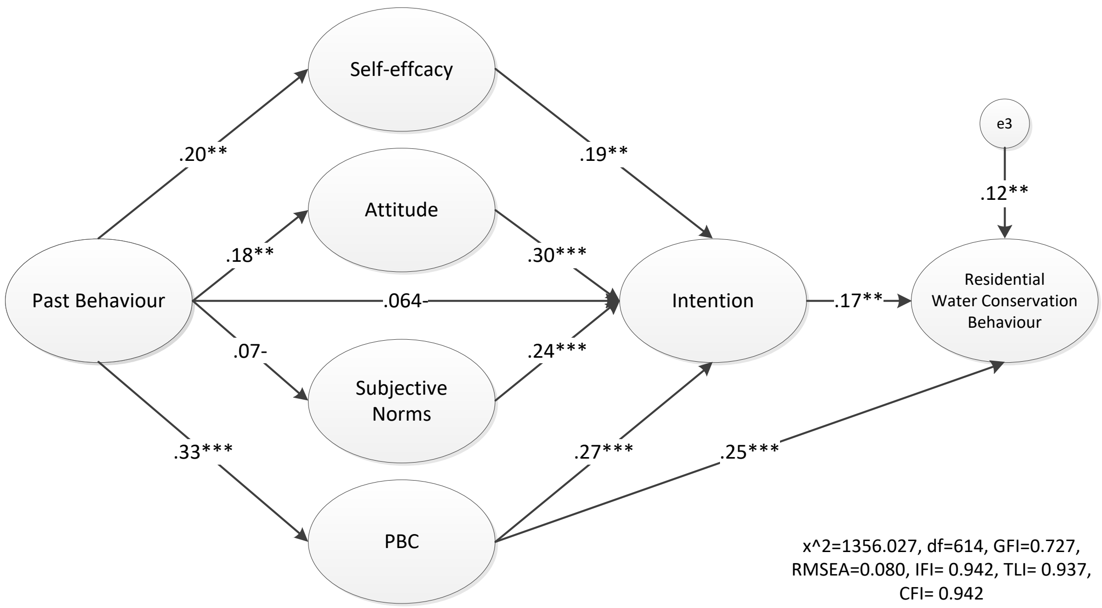
Figure 5. TPB (model 1) Structural Equality Model explaining water conservation behaviour (Standardized Solution Values)

An augmented version of the TPB was tested by model 2 to determine the influence of self-efficacy as a predictor of residential water conservation behaviour. The TPB model with external construct self-efficacy (model 2, see Figure 6) has a good model fit as well (x^2= 1005.723, df=423, GFI=0.753, RMSEA=0.085, IFI= 0.947, TLI= 0.942, CFI= 0.947). All the structural standardized coefficients are significant and self-efficacy appears to have an attenuation influences on relationship of model 1 where regression paths from PBC (β=0.223, t=2.443, $p< 0.01$), Subjective norms (β=0.212, t=3.157, $p< 0.01$) and attitude (β=0.264, t=4.129, $p< 0.01$) to intention decreased. Self-efficacy (β=0.168, t=2.443, $p< 0.01$) was found to be positively and significantly associated with intention which confirmed the H4, and self-efficacy explained 12% variance of intention with the water conservation behaviour explained by all five variables was 43%.



***p < 0.01; **p < 0.05; ¯p >0.05.

Figure 6. TPB with self-efficacy (model 2) Structural Equality Model explaining water conservation behaviour (Standardized Solution Values)



***p < 0.01; **p < 0.05; $^{-}$p >0.05.

Figure 7. Proposed ETPB (model 3) Structural Equality Model explaining water conservation behaviour (Standardized Solution Values)

The proposed model (model 3, shown in Figure 7) provided a satisfactory fit (x^2= 1356.027, df=614, GFI=0.727, RMSEA=0.080, IFI= 0.942, TLI= 0.937, CFI= 0.942). The majority of the structural regression coefficients are again significant (p<0.01), apart from the past behaviour to subjective norms (p>0.05). H5 was tested. Results shown that pas behaviour has a positive influence on water conservation intention (β=0.196, t=2.757, p< 0.01), attitude (β=0.179, t=2.502, p< 0.05), PBC (β=0.380, t=5.468, p< 0.01), self-efficacy (β=0.302, t=3.104, p< 0.01) and subjective norms (β=0.076, t=1.053, p> 0.05), thus, H5 was partially confirmed. In order to evaluate the H6, the 95% confidence intervals ($CI_{0.95}$) for standardized coefficients [29] was performed in model 2 and model 3. There is overlap occurred for the confidence intervals of the PBC-intention standard coefficient in model 2 ($CI_{0.95}$= 0.21≥0.27≥0.39) and model 3($CI_{0.95}$= 0.14≥0.27≥0.32), and no significant attenuation of model relationships is shown as a result of the past behaviour inclusion, therefore H7 is rejected. In the proposed model, all variables (past behaviour, subjective norm, PBC, intention and attitude) accounted for 49% of the variance in water conservation behaviour. Based on above finding, the Chinese residential behaviour intervention ETPB model transfer weight can be calibrated and applied for the future use and the model has been proved significant for behavioural intervention investigation.

4.4 The role of Self-efficacy and PBC

In previous research, studies (such as [27]) have already pointed out that using principal components factor analysis method could identify the distinction between PBC and Self-efficacy. In this research, the principal components analysis (KMO value = 0.845, Chi-square = 929.538, df=21, p<0.001) with factor matrix rotation produced PBC and self-efficacy are shown in table 2. PBC is significantly related to the external beliefs such as water price and in the inconvenient water use circumstance. Self-efficacy is not associated with these items, but with the belief related to confidence to save water and control of water conservation decision making. The result provided evidence for discriminate validity between the two conceptualizations of control. In Figure 6, it also shown that the inclusion of self-efficacy in the original TPB model did not attenuated the relationship between PBC and intention, which indicated the variance that PBC shares with intention is not accounted for by self-efficacy. This support the findings that have made the distinction between self-efficacy and PBC in water conservation application.

Table 2. Distinguishing self-efficacy in TPB: rotated factor matrix for principal components analysis

Items	Factor Loading	
	PBC	Self-efficacy
To what extent do you feel capable of conserving water when the water price is low	<u>0.862</u>	0.268
To what extent do you feel capable of conserving water when it is inconvenient	<u>0.881</u>	0.216
To what extent do you feel capable of conserving water when you are in a rush	<u>0.790</u>	0.304

For me to conserve water around my living place is easy	0.372	0.659
I am confident that I could save water around the house and garden if I want	0.397	0.861
The decision to save water around the house and garden is under my control	0.194	0.847
I have the time and skills needed for water conservation activities	0.235	0.763

4.5 The role of Past Behaviour

In this study, mediation analysis is performed to fully understand the inclusion of past behaviour to the original TPB model relationship. The Sobel test and bootstrapping method (with default N=1000 bootstrap resamples) were used to calculate the indirect effects from it. The Sobel test describes the mediator potency by creating the asymptotic standard error using multivariate delta method [50]. Analysis process is performed by a SPSS-micro which offers an estimation of indirect effect and 95% Monte Carlo confidence interval with effect size measures [51].

The finding in Table 3 revealed that past behaviour cannot significantly affect water conservation intention through Subjective norms. All the other indirect influencing relationship from past behaviour to intention were significant, thus, H7 was partially confirmed. The bootstrap results also reveal that all the significant indirect effects are trusted between zero for the predicted confidence intervals except from relationship of “Past Behaviour → Subjective Norms → Water Conservation Intention”. These findings indicated that residential past water conservation behaviour does not have significant mediating role in the relationship between Subjective norms and water conservation intention.

Table 3. Indirect effects

Independent variable	Mediator	Dependent variable	Effect size	se	Mediation confidence interval	
					Lower	Upper

Past Behaviour	Attitude	WCI	0.0554**	0.0303	0.0147	0.1404
Past Behaviour	PBC	WCI	0.0857***	0.0446	0.0194	0.1996
Past Behaviour	Subjective Norms	WCI	0.0230-	0.0238	-0.0260	0.0680
Past Behaviour	Self-efficacy	WCI	0.0620**	0.0253	0.0209	0.1253

***p < 0.01; **p < 0.05; $^{-}$p >0.05.

5. Discussion and conclusion

Little research has focused on residential water conservation decision-making process in IoT environment. This research proposed a behavioural information system for understanding the water conservation behaviour and lead to enhance water demand and water quality management, these will facilitate water hygiene practise to improve public health and prevent disease due to risky water hygiene practice. By incorporating two constructs in TPB: frequency of past water conservation behaviour and self-efficacy as significant predictors of residential water conservation behaviour, the proposed system explained 49% of the variance in the extended TPB model. Our findings are comparable to previous studies of water conservation behaviour in the USA [6], UK [7], Australia [8] and Greece [9] demonstrating the universality of the TPB to predict residential water conservation behaviour.

The IoT system has been proved to offer easy access to healthcare related behaviour. From our project, the system increased the delivery speed and offered all day access to the intervention guidance. This system somehow can improve the effect of the behaviour intervention project delivery. Moreover, through our communication with our users, there are a lot of users willing to try IoT technologies and agreed the 24/7 easy access method. Different from individualistic cultures (e.g. UK or US), people in our research area emphasize shared values and are relative loyal to the collective “we”, has its uniqueness cultural background, according to Hofstede’s individualism-collectivism dimension. High power distance, which refers to the high extent of individuals’ acceptance that government of organization is distributed equally, as another label for Chinese culture also makes Chinese residents perceive lower internal control locus with a belief that certain behaviour is more influenced through their own decision and evaluation. Louise et al. [49] argued that the effect of subjective norm on intention would be stronger in countries high in collectivism and power distance. Our findings support this argument, having a larger correlation (standard solution value 0.31 in model 1) for the relation subjective norms (SN) to intention. In the TPB theoretical application perspective, these findings about Chinese culture differences have important practical implications for water conservation project managers in understanding drivers of residential water conservation behaviour and when starting marketing promotions across nation. The impact of subjective norm on conservation intention is greater in China, thus, promotion messages should likely be more effective in persuading residents to participate the water conservation activities compared to individualistic and low power distance countries.

Attitude was the strongest predictor of residential water conservation intention in this study, having a larger coefficient than all other constructs in both TPB and ETPB models. This result is consistent with previous finding [53] in Bulgaria which attitude is the most effective TPB component on water conservation intention followed by PBC and subjective norm. Absolute scores of TPB questionnaire items measuring attitude and PBC were relatively low, while those for subjective norms and self-efficacy tended to be high. Overall, residents have received a positive social pressure to perform water conservation behaviour, attempts should be made to increase attitude and PBC among users. The low attitude score indicated that even Chinese government has intensively promoted its water conservation project, residents do not have enough awareness to its importance. Providing residential educational and positive persuasive information through TV, WeChat, Weibo or other media channels are likely to increase the acceptance of water conservation projects. Regarding to PBC, Blanke et al. [54] argued that policy supporting institutions should provide in some case financial assistance and coordination to help resident conquer external barriers. The ratio of investment in water conservancy project to capital construction investment for China was less than 2% during 2005-2009. Raising more investments from third parties or NGOs and proportion of government water conservation investment could, therefore, help to current Chinese water conservation projects. All the behaviour intervention modelling result will be written as guidance and published on behavioural intervention platform by using data feedback method in this study.

As shown in Table 3, this study indicated that among the four mediator variables in proposed ETPB model, only subjective norms cannot significantly mediate the impact of past behaviour on water conservation intention. This finding implied that past behaviour shapes attitude, self-efficacy and PBC towards a behaviour, and these will enhance residential water conservation decision. Accordingly, water conservation project managers should consider the residential water conservation background areas before starting to promote and install water conservation technologies. It is suggested that water conservation technologies should fit past residential water conservation background (behaviour). For example, if the residents in an area have a long-term habit to take short shower, the corresponding technologies in enhanced shorter shower time will be more easily to gain success in the case. And the development of more effective water conservation strategies is essential to improve their residential experiences while participate a project.

The present study in this paper contributes to examine the past behaviour influence on residential water conservation intention, attitude, PBC, subjective norms and self-efficacy, which are little addressed. The Control of past water conservation behaviour did not attenuate the influence of TPB relationship and self-efficacy which is consistent with Hagger's findings [29, 39], but in contrary to the previous studies (see examples [40, 43]). The lack of social cognitive attenuation influence by past behaviour suggests that past water conservation behavioural engagement does not has the similar cognitive-reducing influences on residential water conservation intentions that reported in literature. One of the possible reason may be that most residents do not have organized past behavioural patterns in study care.

Moreover, apart from research findings, several limitations of this study should be pointed out. Firstly, due to the complexity of the behavioural information format, this information system based on IoT environment did not address the translation method for other behavioural information such as image and video. Further research, therefore, will investigate more detailed solutions for translating behavioural information from other channels. Secondly, this system only shown capability to study individual’s behavioural intervention process, however, for a community and city level, the modelling method in the system cannot work very effectively due to the theory basis we applied in this research. We will apply a community based behavioural intervention model in the system to simulate large population’s behaviour in the future research. Adding the populated information in the consumption modelling process could ideally offer a solution for this limitation. Thirdly, some other analysis and machine learning technologies such as cluster analysis and decision tree are also suggested for digging more information of behaviour, should be considered to apply in the further research.

Acknowledgement

This research was supported by a Marie Curie International Research Staff Exchange Scheme within the 7th European Community Framework Programme-SmartWater (GA 318985) and FP7 WatERP project (GA 318603). The author would also like to appreciate the helps offered by anonymous reviewers.

Reference

[1] Davis, R., Campbell, R., Hildon, Z., et al., 2014.Theories of behaviour and behaviour change across the social and behavioural sciences: a scoping review’, Health Psychol. Rev., 8, pp. 1–22.

[2] Pagella, C., Galli, R., De Faveri, D.M., 2000. Water reuse in industrial food processing. J. Food Technol. Africa, 5 (1), pp. 25–29.

[3] Mark, J., Carl, M.: ‘Promoting professional behaviour change in healthcare – what interventions work, and why? Protocol for a theory-led overview of systematic reviews’, BMJ Open, 2015, 5, (9), pp. 1–10.

[4] Australia Psychological Society, Evidence-based Psychological Interventions in the Treatment of Mental Disorder: A Literature Review, Australia Psychological Society, https://www.psychology.org.au/Assets/Files/Evidence-Based-Psychological-Interventions.pdf, 2010 (accessed 02/01/2017).

[5] Ajzen, I., 1991. The Theory of Planned Behavior. Organizational Behavior and Human Decision Process, 50, pp. 179-211.

[6] Pirie, R.L., de Loë, R.C., Kreutzwiser, R., 2004. Drought planning and water allocation: an assessment of local capacity in Minnesota. J. Environ. Manag. 73 (1), pp. 25-38.

[7] Gilg, A., Barr, S., 2006. Behavioural attitudes towards water saving? Evidence from a study of environmental actions. Ecol. Econ. 57 (3), pp. 400-414.

[8] Hurlimann, A., Dolnicar S., Meyer, P., 2009. Understanding behaviour to inform water supply management in developed nations-a review of literature, conceptual model and research agenda. J. Environ. Manag. 91 (1), pp. 47-56.

[9] Jones, N., Evangelinos, K., Gaganis, P., Polyzou, E., 2011. Citizens' perceptions on water conservation policies and the role of social capital. Water Resour. Manag. 25 (2), pp. 509-522.

[10] Zhang, H.H., Brown, D.F., 2005. Understanding urban residential water use in Beijing and Tianjin, China. Habitat International. 29, pp. 469-491.

[11] Chen, H., Zhang, Y., Ma L., Liu, F., Zheng, W.,2012. Change of water consumption and its potential influential factors in Shanghai: a cross-sectional study. BMC Public Health. 12:450.

[12] Fu, Y,, Wu, W., 2016. Predicting Household Water Use Behaviour for Improved Hygiene Practices in Internet of Things Environment via Dynamic Behaviour Intervention Model. IET Networks, 5(5), pp. 143-151.

[13] Alok, K., Sampada, S., 2014.Healthcare applications of the internet of things: a review, Int. J. Comput. Sci. Inf. Technol., 5 (5), pp. 6229–6232.

[14] Yang, P., Stankevicius, D., Marozas, V. et al., 2016. Lifelogging data validation model for internet of things enabled personalized healthcare. IEEE Transactions on Systems, Man and Cybernetics: Systems, PP (99), pp. 1-15.

[15] Phillip, L., Mohamad, K., Nancy, L., et al., 2017. Building Caring Healthcare Systems in the Internet of Things. IEEE Systems Journal, PP (99), pp. 1–8.

[16] Azzawi, M, A,. Hassan, R, H,. and Bakar, K, A, A,. 2016. A review of Internet of Things (IoT) in Healthcare, International Journal of Applied Engineering Research, 11(20), pp. 10216-10221.

[17] Prochaska, J. J., & Prochaska, J. O. (2011). A Review of Multiple Health Behavior Change Interventions for Primary Prevention. American Journal of Lifestyle Medicine, 5(3), 10.1177/1559827610391883. http://doi.org/10.1177/1559827610391883

[18] Po, Y., Wu. W., M. Moniri and C. C. Chibelushi, 2013. Efficient Object Localisation Using Sparsely Distributed Passive RFID Tags, IEEE Transactions on Industry Electronics, 60(12), pp. 5914-5924.

[19] Po, Y., Wu, W., 2014. Efficient Particle Filter Localisation Algorithm in Dense Passive RFID Tags Environment, IEEE Transactions on Industry Electronics, 61(10), pp. 5641 - 5651.

[20] Po, Y., 2015. Experimental Evaluation and Analysis of Achieving High Accuracy and Precision in Passive HF RFID Location Systems, IEEE Internet of Things Journal. 2, pp.159-167.

[21] Jun, Q., Po, Y., Geyong, M. et al., 2017. Advanced internet of things for personalised healthcare systems: a survey. Pervasive and Mobile Computing, 2, pp. 132-149.

[22] Jun, Q., Po, Y., Martin, H. et al., 2016. Multiple density maps information fusion for effectively assessing intensity pattern of lifelogging physical activity, Neurocomputing. 220, pp. 199-299.

[23] Sultan H. Almotiri, Murtaza A. Khan, Mohammed A. Alghamdi, 2016.Mobile Health (m-Health) System in the Context of IoT, IEEE International Conference on Future Internet of Things and Cloud Workshops (FiCloudW), pp. 39-42. 10.1109/W-FiCloud.2016.24

[24] Thomas, W., Judith, J., Lucy, Y., et al., 2012. Using the internet to promote health behaviour change: a systematic review and meta-analysis of the impact of theoretical basis, use of behaviour change techniques, and mode of delivery on efficacy, J. Med. Internet Res., 12, (1), e4

[25] Ajzen, I., 1985. From Intentions to Actions: a Theory of Planned Behavior, in: Julius Kuhl, Jurgen Beckmann. (Eds.), Action Control. Springer, Berlin, pp. 12-39.

[26] Taylor, D., 2006. A Review of the use of the Health Belief Model (HBM), the Theory of Reasoned Action (TRA), the Theory of Planned Behaviour (TPB) and the Trans-Theoretical Model (TTM) to study and predict health related behaviour change. National Institute for Health and Clinical Excellence, Manchester.

[27] Conner, M., Armitage, C.J., 1999.Extending the Theory of Planned Behavior: A Review and Avenues for Further Research. Journal of Applied Social Psychology. 28, pp. 1429-1464.

[28] Hasbullah, D., Mahajar, A.J., Salleh, M.I., 2014. Extending the theory of planned behavior: Evidence of

the arguments of its sufficiency. International Journal of Humanities and Social Science. 4(14), pp. 101-105.

[29] Hagger M. S. Chatzisarantis, N., Biddle, S.J., Orbell, S., 2001. Antecedents of children's physical activity intentions and behaviour: Predictive validity and longitudinal effects. Psychology & Health. 16, pp. 391–407.

[30] Jorgensen, B., Graymore, M., O'Toole, K., 2009. Household water use behaviour: An integrated model. Journal of Environmental Management. 91, pp. 227-236.

[31] Leviston Z., 2005. Towards Sustainable Irrigation Practices: Understanding the Irrigator. A Case Study in the Riverland-South Australia. CSIRO, Dickson. http://catalogue.nla.gov.au/Record/3773200, 2005 (05/01/2017 access).

[32] Gregory, G.D., Leo, M.D, 2003. Repeated behaviour and environmental psychology: the role of personal involvement and habit formation in explaining water consumption1. Journal of Applied Social Psychology. 33, pp. 1261–1296.

[33] Lam, S.P., 2006. Predicting intention to save water: theory of planned behaver, response efficacy, vulnerability, and perceived efficiency of alternative solution1. J. Appl. Sco. Psychol. 36(11), pp. 2803-2824.

[34] Inauen,, J., 2012. Theory-based promotion of safe water consumption. Dissertation. University of Zurich, Department of Psychology.

[35] Inauen, J., Mosler, H.R., 2016. Mechanisms of behavioural maintenance: Long-term effects of theory-based interventions to promote safe water consumption. Psychol Health. 31(2), pp.166-183

[36] Fishbein, M., & Ajzen, I., 2010. Predicting and changing behavior: The reasoned action approach. New York: Psychology Press.

[37] Dolnicar, S., Hurlimann, A., Grun, B., 2012. Water conservation behaviour in Australia. Journal of Environmental Management. 105, pp. 44-52.

[38] Yazdanpanah, M., Hayati, D., Hochrainer-Stigler, S., Zamani, G.H., 2014. Understanding farmers' intention and behaviour regarding to water conservation in the Middle-East and North Africa: A case study in Iran. Journal of Environmental Management. 135, pp. 63-72.

[39] Hoekstra, A.Y., 2000. Appreciation of water: four perspectives. Water Policy. 1(6), 605-622.

[40] Sommer, L., 2011. The theory of planned behaviour and the impact of past behaviour. International

Business and Economic Research Journal, 10(1), pp. 91-110.

[41] Hagger M. S., Chatzisarantis, N., Biddle S.J., 2001. The influence of self-efficacy and past behaviour on the physical activity intentions of young people. Journal of Sports Sciences. 19(9), pp. 711-725.

[42] Ouellette, J.A., Wood, W., 1998. Habit and intention in everyday life: The multiple processes by which past behaviour predicts future behaviour. Psychological Bulletin. 124, pp. 54-74.

[43] Norman P., Conner, M., Bell, R., 2000. The Theory of Planned Behaviour and exercise: Evidence for the moderating role of past behaviour. British Journal of Health & Psychology. 5, pp. 249-261.

[44] Terry, D.J., O'Leary, J.E., 1995. The Theory of Planned Behaviour: The effects of perceived behavioral control and self-efficacy. British Journal of Social Psychology. 34, pp. 403-415.

[45] Yordy, G.A., Lent R.W., 1993. Predicting aerobic exercise participation: Social cognitive, reasoned action, and planned behaviour models. Journal of Sport and Exercise Psychology. 15, pp. 363-374.

[46] Fu, Y., Wu, W. 2015. Simulation and conservation of the end use water based on behaviour intervention modelling, Procedia Engineering, 119, pp. 761-770.

[47] Fogg, B.J, Persuasive Technology: Using Computers to Change What We Think and Do. San Francisco: Morgan Kaufmann Publishers, 2003.

[48] Intille, S. S. 2004. Ubiquitous Computing Technology for Just-in-Time Motivation of Behavior Change, Studies in Health Technology and Informatics, 107(2), pp. 1434-1437.

[49] Babbie, E., 2013. The Basics of Social Research, Sixth ed. Wadsworth Publishing, Belmont.

Bandura, A., 1997. Self-efficacy: The exercise of control, First ed. Freeman, New York.

[50] López-Mosquera, N., Garcia, T., Barrena, R., 2014. An extension of the Theory of Planned Behavior to predict willingness to pay for the conservation of an urban park. Journal of Environmental Management. 135, pp. 91-99.

[51] Hayes A. F., 2013. Introduction to Mediation, Moderation and Conditional Process Analysis, First ed. Guilford Press, New York.

[52] Louise, H., Edward, S., Sara, P., 2016. Addressing the cross-country applicability of the theory of planned behaviour (TPB): A structured review of multi-country TPB studies. J. Consumer Behav. 15(1), pp. 72-86.

[53] Clark, W.A., Finley, J.C., 2007. Determinants of Water Conservation Intention in Blagoevgrad, Bulgaria. Society and Natural Resources, 20(7), pp. 613–627.

[54] Blanke, A. et al., 2007. Water saving technology and saving water in China. Agr. Water Manage. 87, pp. 139-150.