Mobile Augmented Reality for Environmental Awareness: A Technology Acceptance Study

Majed Abdullah Alrowaily
University of Tabuk
Community College, Department of Computer Science,
Tabuk City, P.O.Box 741
71491 Saudi Arabia
Phone: +966 14 427 3022
malrowaily@ut.edu.sa

Manolya Kavakli
Macquarie University
Faculty of Science and Engineering Department
of Computing, Sydney NSW 2109, Australia
Phone: +61 (2) 9850 9514
manolya.kavakli@mq.edu.au

ABSTRACT
Littering behaviour is a global issue affecting most countries regardless of their development status. Mobile augmented reality (MAR) shows a promising contribution in different fields. However, despite the wider applications of MAR in different area such as cultural heritage [1, 2] and shopping [3], acceptance studies of mobile augmented reality applications with environmental awareness are still rare. This empirical study will contribute to the investigation of the users' acceptance of MAR for environmental context. Perceived Enjoyment (PE) was founded to be strongly positively correlated with the users' attitude (ATU) towards using EVA v2 app ($r = 0.833$, $p = < 0.01$). The correlation between Perceived Ease of Use (PEOU) and Subjective Norms (SN) was the weakest positive correlation ($r = 0.36$, $p = <0 .05$).

CCS Concepts
Human centered computing → Human computer interaction (HCI) → Empirical studies in HCI.

Keywords
Mobile Augmented Reality; Littering Behaviour; Environmental Awareness

1. INTRODUCTION
Mobile augmented reality (MAR) is a technology, which enhances the perception of the real world through the smartphone camera by overlaying virtual objects or information. MAR has been used in many disciplines such as education, health and marketing. MAR can be used to raise awareness of users' surrounding more than what they would gain by traditional methods such as radios, maps, and handheld displays [4]. Despite the wider applications of MAR in different area such as cultural heritage [1, 2] and shopping [3], acceptance studies of mobile augmented reality applications with environmental awareness are still rare.

The aim of this study is to examine the user acceptance of an environmental awareness MAR system. The research question of this study is framed to examine the pertinent dependent and independent variables, which may affect the people behaviour intention. The independent variables those were tested in this research are attitude, subject norm, perceived behaviour control, perceived usefulness, perceived ease of use and perceived enjoyment. The main dependent variable is the intention to use the MAR system for environmental context. The research question requires quantitative measurement and analysis methods to clarify the relationships between the dependent and independent variables.

The main research question of this research is:

What are the correlations between the independent factors of (TPB, TAM and Perceived Enjoyment) and the use of MAR system for promoting Anti-littering behaviour?

ICCAE 2018, February 24–26, 2018, Brisbane, Australia

ACM ISBN 978-1-4503-6410-2/18/02…$15.00

DOI: https://doi.org/10.1145/3192975.3193002

2. LITERATURE REVIEW

2.1 Littering Behaviour
Regardless the development state of all countries, they all encounter littering behaviour to some extent. The littering behaviour affects our water, soil and other living things in our plant. Littering behaviour has been defined to be one of two forms: active and passive [5]. Sibley and Liu [5] describe the active littering as the state of throwing waste on the ground while walking. Whereas, passive littering is the disposal failure for the litter left behind while sitting or waiting. They claim the rise of likelihood occurrence of the littering behaviour when littering is the norm [5].

Both social and personal norms have obtained the attention of recent research as means for behaviour change [6]. In 1990, two forms of norms, descriptive and injunctive were examined by (Cialdini et al. ,1990, as cited in [6]) each of these targeting a specific human incentive. The descriptive norm is described as how the population behave in a certain situation; therefore, the motivation comes from watching others behaviour (Cialdini, and Kallgren ,1993, as cited in [6]). An injunctive norm refers to what a certain culture accepts or rejects and can be described as a duty norm. The warning of receiving social sanction can be utilised for an injunctive norm incentive [6].

The personal norm is another type of norms, which seems to have an effect on the littering behaviour. "Personal norms are feelings of personal obligation tied to the self- concept such that conformity to a personal norm or self-expectation results in enhanced self-esteem or security (Schwartz, 1977, as citied in [7])". Several studies examined the use of values to trigger norm activation and has been validated across different cultures in European countries, Northern America, Latin America and Asia [8].

A comparative analysis by (Cialdini et al., 1990, as cited in [6]) examined the use of both descriptive and injunctive littering norms. They found that the littering reduction was only achieved when descriptive norm was activated in a clean environment. However, activating descriptive norm in a littered environment may result in raising littering behaviour. Additionally, they found that utilising the injunctive norms in a littered environment might motivate prosocial behaviour by moving the people's attention from the antisocial littering behaviour to the social cost of their actions (Cialdini et al., 1990, as cited in [6]). Both social norms and personal norms have shown strong effects on littering behaviour. Moreover, age and gender have been found to have an obvious consequence on personal norm against littering. However, young people are not affected by the norm activation (Cialdini et al., 1990, as cited in [6]).

2.2 Mobile Augmented Reality (MAR)

Smartphones already have required technologies for hosting MAR applications, such as mobile processing, image recognition, object tracking, display technology and GPS location. They provide a suitable environment for hosting MAR application without paying any extra cost for special hardware. Many MAR applications were developed for the users of popular mobile operating systems: Android and IOS [2]. The available MAR applications in both Play store and App store are developed based on two main approaches: MAR browsers based on geo referenced positioning and image-recognition-based MAR [2].

Mobile augmented reality technology can raise environmental awareness and help learning about the surrounding context. Chou and ChanLin [4] state that AR can raise awareness of users' surroundings more than what they would gain by traditional methods such as radios, maps, and handheld displays. Additionally, the users learning interest can be improved by AR to reinforce learning [4]. Augmented reality and interactive storytelling were utilised by Li [9] from New Mexico University's ARIS to support users to uncover a fabricated murder mystery in fictional crime scene in their actual environment.

2.3 Theories and Models of Behaviour and Behaviour Change

Social sciences have many theories and models of human behaviour adopted from different disciplines. Therefore, a comprehensive review of theories of behaviour and behaviour change would not be possible. However, attempts have been made to cover here the most applied and validated behavioural change theories and models.

2.3.1 Theory of planned behaviour (TPB)

Ajzen [10] proposes TPB as an extension of theory of reasoned action (TRA) model. According to TPB model the main factors influencing the behaviour intention are attitude, subject norm and perceived behaviour control (Figure 1). Attitudes represent the positive or negative feelings towards implementing certain behaviours. The perceived social pressure towards behavioural engagement is the subjective norm. Perceived behavioural control is the individual's perception of their capability to accomplish a given behaviour [11]. Several studies utilised TPB in the field of information systems (Mathieson, 1991; Taylor and Todd, 1995a, b; Harrison et al., 1997, as cited in [11]).

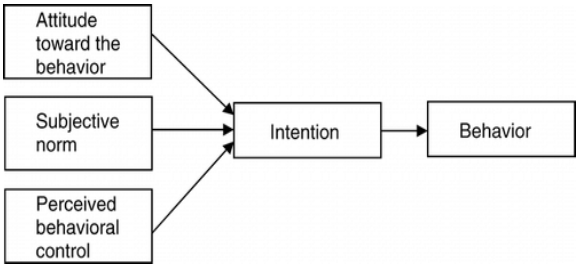

Figure 1. The Theory of Planned Behaviour (Reproduced from Ajzen [10].

Twenty to thirty per cent of the difference in behaviour caused by interventions that can be anticipated by utilising TPB and a better ratio of intention [12]. Previous studies have found solid correlations between behaviour and both the attitudes towards the behaviour and perceived behavioural control factors of the theory. However, the correlations between subjective norms component of the theory and the behaviour are weak [12]. TPB does not provide proper or effective way for planning and designing the nature of the intervention that will cause the behaviour change. Employing the TPB theory for clarifying and predicting possible behaviour may, however, be a useful way for isolating certain factors which have influence on behaviour that could be aimed for alteration (Hardeman et al 2002; Taylor et al. 2007; Webb et al. 2010, as cited in [12]).

It has been recommended by TPB research that whoever has positive attitudes towards pro-environmental behaviour, they are likely to change their behaviour as long as they feel capable and that the new habit is socially acceptable [13]. Although some of the conflicts between people's environmental concerns, their actual behaviour and attitudes can be a decent indicator for predicting behaviour, especially when behavioural obstacles are considered (Kaiser, Wo¨lfing, & Fuhrer, 1999, as cited in [13]). Social norms could foster particular behaviours if the environmentally friendly actions appear easy and the "right" thing to do (Bamberg, Hunecke, & Blo¨baum, 2007, as cited in [13]).

2.3.2 Technology acceptance model (TAM)

Davis, Bagozzi [14] [correct as Davis et al.] propose TAM model to clarify the users' acceptance level towards information system or new technology. TAM suggests that the users' intention towards a technology is influenced by perceived usefulness and perceived ease of use factors (Figure 2). Perceived usefulness is the user believes of improving the task performance by utilising certain new technology or information system. Perceived ease of use refers to how easy a new technology or information system to be learned and operated by individual.

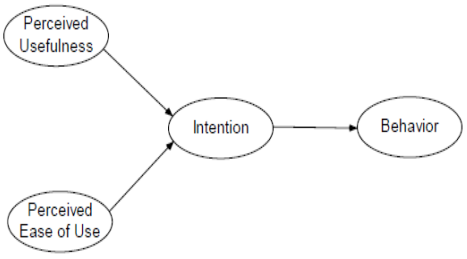

Figure 2. Technology acceptance model (Reproduced from Davis, Bagozzi [14].

3. METHODOLOGY

This research pursues to investigate the users' acceptance of MAR system in environmental context. The full study of this research examined different versions of EVA system in the purpose of larger questions of the full study. The three different versions of EVA app are:

- EVA Standard Mobile App (without AR) (V1)
- EVA with marker-based AR Feature (V2)
- EVA with marker-based AR & AR Game Features (V3)

The first version of EVA app is considered as the control case. In order to confirm that the user's acceptance of MAR system was not only related to use of a mobile app but rather it was related to the use of the MAR technology; therefore, EVA standard mobile app version was developed. EVA v2 is used to examine the user acceptance of MAR technology. Lastly, the gamification element is investigated in EVA v3.

However, this paper highlights the results of EVA v2 experiment. This research has employed a number of behavioural change theories at the implementation of the EVA app and the evaluation phases of the research. Additionally, TPB and TAM theories were used at the development and the evaluation stages of EVA app. Some anti-littering learning materials in image and video forms were employed to positively affect the attitude of users towards anti-littering behaviour. Furthermore, another video was utilised to express the feelings of other people towards littering behaviour, which is assumed to have an influence on people subjective norm. Lastly, the perceived behavioural control was also promoted through EVA app by showing the users an image explaining to them how they could help preventing littering by following couple of techniques provided by EVA app.

Different questionnaires were adopted by this research. The predictors of Perceived Ease Of Use (PEOU) and Perceived Usefulness (PU) were adopted from [15]. The predictors of Perceived Enjoyment (PE) were adopted from [16]. The predictors of Attitude Towards Using EVA app (ATU), App Usage Intention (UI), App Usage Behaviour (UB), Subjective Norms (SN) and Perceived Behavioral Control (PBC) were adopted from [17].

4. THE EXPERIMENTAL STUDY: THE USE OF MOBILE AUGMENTED REALITY FOR PROMOTING ANTI-LITTERING BEHAVIOUR

4.1 Introduction

The aim of this study is to evaluate the effect of mobile augmented reality on promoting anti-littering behaviour among university students and staff. An AR mobile application is developed and used by this study. This research seeks quantitative (The App DB and questionnaires) results to examine the study variables and their influence on the university students and staff's acceptance of anti-littering MAR system called EVA 2. The ethical approval has been obtained.

4.2 Subjects

A verbal invitation were given to a total of 35 participants. They were invited by the study organiser and separated into three different groups randomly. Each of the three group used EVA versions in different order. However, only 22 participants were successfully completed the experimental study. The criteria and characteristics chosen for the participants of the Australian case study to be qualified to participate in this study were:

- Over the age of 18.
- Obtaining an Android device.
- An adequate knowledge on using smartphone.
- An available Internet access.
- Being a student or staff member at Macquarie University.

4.3 Physical Setup

Copies of an anti-littering poster were placed in three different locations at Macquarie University Campus known to have high proportion of litter behaviour. These posters were used as markers for EVA v2 and EVA v3. The participants' mobile devices were required to have an Internet connection and a functioning rear camera. Additionally, they were required to install the proposed applications.

4.4 Design

This experimental study seeks quantitative results. The quantitative results will be collected using questionnaires (littering survey, TPB and TAM questionnaires) and the proposed system DB. The independent variables those were tested in this research are attitude, subject norm, perceived behaviour control, perceived usefulness, perceived ease of use and perceived enjoyment. The main dependent variable is the intention to use the MAR system for environmental context. Initially, all of the participants will be given the following pre questionnaires:

- OCEAN questionnaire.
- Littering survey.
- TPB questionnaire.

All groups were involved in three tasks requiring them to visit different geo-locations at Macquarie University campus and perform anti-litter behaviour at those locations. Each of these tasks were required during the usage of each of EVA versions. The tasks were required them to find and look at the anti-litter poster placed at those locations, used EVA app and perform anti-littering behaviour at those locations. Randomly, the participants were assigned to one of three groups. All the groups used each of EVA versions in a different order as follows:

- Group A: (V1,V2,V3)
- Group B: (V2,V3,V1)
- Group C: (V3,V1,V2)

At the end of the each task the participants were required to complete post questionnaires (TPB and TAM questionnaires) related to the EVA version of that task. Finally, at the end of the experiment the participants will be given a post questionnaire.

4.5 Procedure

The participants were asked to perform three tasks. All the tasks will require them to be in specific locations of their case study. Firstly, they were required to sign the Consent Form and fill the pre questionnaire (OCEAN, littering survey (seeking personality details, demographics details, litter awareness, littering behaviour and attitude), and TPB questionnaires) which both can be accessed either by using the provided URL link or QR code through information sheet for A, B and C groups. The QR code can be scanned by using any QR scanner app from Play store.

After completing the questionnaire, they were required to download either EVA (V1), EVA (V2) or EVA (V3) depend on their groups. Then they were asked to register a new account through the app. The download page can be accessed using the provided URL or QR code at the information sheet. The user account can be used to access all EVA versions. The participants were required visit the task location and use the downloaded EVA version to view the provided litter awareness materials and completed the required task by that version of EVA. The provided tasks by EVA versions as follow:

> *Task 1: In this task you are required to visit the specified location on the above picture which is located in front of the Campus Hub at Macquarie University Campus. You are required to watch the provided anti-litter promoting materials on EVA app. You are required to pick up or put your own trash in the nearest garbage bin.*
>
> *Task 2: In this task you are required to visit the specified location on the above picture which is located in the space behind E3A and E3B at Macquarie University Campus. You are required to watch the provided anti-litter promoting materials on EVA app. You are required to pick up or put your own trash in the nearest garbage bin.*
>
> *Task 3: In this task you are required to visit the specified location on the above picture which is located at level 1 of E1 parking at Macquarie University Campus. You are required to watch the provided anti-litter promoting materials on EVA app. Play the AR game and score at least 14 points. You are required to pick up or put your own trash in the nearest garbage bin.*

When they were done with the tasks, they were required to complete post questionnaires (TPB and TAM questionnaires) regarding EVA version of that task. Finally, when they used all EVA versions and completed all the required tasks by each EVA version, they were given a post questionnaire which consist question regarding the whole experiment.

4.6 Data Collection

The data will be gathered from two different sources: the questionnaires completed by the participants and stored information in the application database.

5. THE DEVELOPMENT OF AR MOBILE APPLICATION

This section describes the approach that was taken to develop the three versions of EVA APP. This section consists of the System Architecture, the Back-end component and the Front-end component and the User Interface.

5.1 System Architecture

This section explains the general concept of the proposed AR system. Figure 3 illustrates the general system architecture of EVA application. The system has two main components, which are the front-end and the back-end of components.

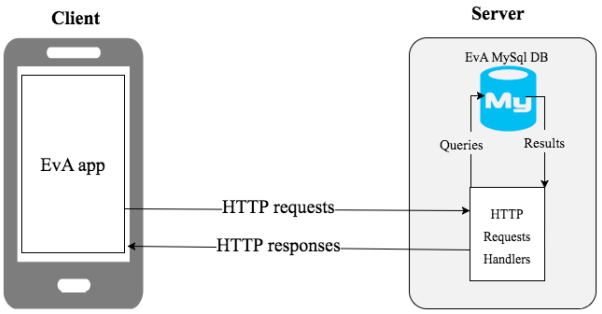

Figure 3. EVA system architecture.

5.2 Front-end Component (*Client: Smartphones*)

The front-end component is hosted on the client side. EVA mobile application makes different http requests to the back-end component to obtain different types of information such as: users' profile, tasks and store different data for instant user accounts, AR game scores and the users' usage activities.

EVA application is developed for Android devices. Android is an open source mobile operating system (OS) developed by Google [18]. It is one of the most widely spread operating systems. EVA application was built using Unity3d. The reason behind this choice is that Unity3d is a game engine which supports cross-platform development; therefore, different platforms could be targeted in further study. Additionally, Vuforia SDK was used for building the AR functionality. Table 1 shows the supported OS versions by Vuforia SDK.

Table 1. Vuforia Supported OS Versions

OS	Version
iOS	8+
Windows	10
Android	4.0.3+

5.2.1 User Interface

This section illustrates some of the system user interfaces.

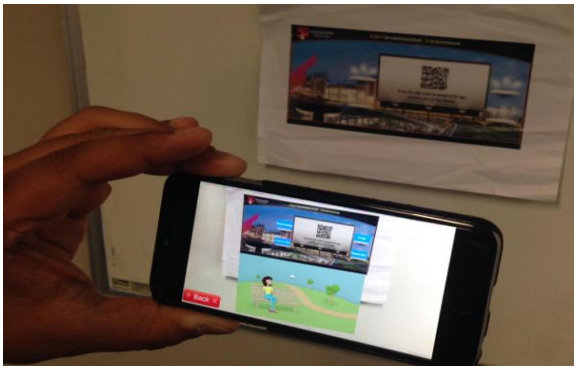

Figure 4. AR Anti-littering Interface.

Figure 4 presents the AR application. When users open this interface, the rear camera starts and the camera view tracks a specific target marker. When the camera recognises the marker, it

will show the augmented information on it. This interface provides some images and videos related to littering, which users can navigate through them using the provided buttons.

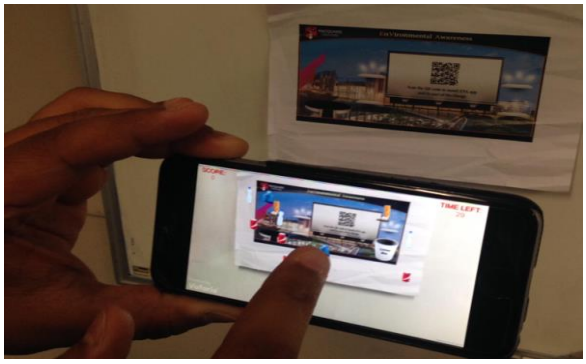

Figure 5. AR Anti-littering game.

The AR game is illustrated in figure 5. The users can touch and drag any litter item to the litter bin. They will score different points for different litter items.

5.3 Back-end Component

The back-end component is hosted on Linux virtual machine. It consists of HTTP handlers, which handle all, request from front-end component and MySQL DB, which contains (user profiles, tasks, play).

5.3.1 Entity-relationship diagram of EVA database

EVA database was designed and established for the purpose of this study; therefore, it had only the most required entities and attributes for simplicity. The ER diagram (Figure 6) represents the schema of EVA database.

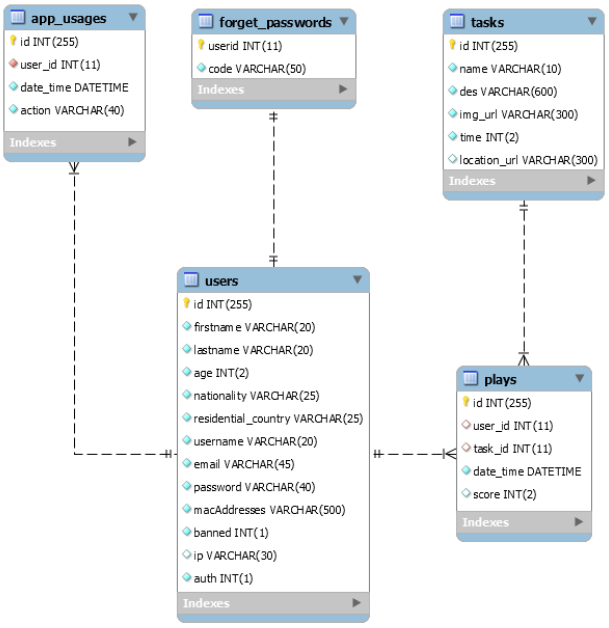

Figure 6: Entity-relationship diagram of EVA database.

There are five entities in the EVA database: *users*, *tasks*, *plays*, *app_usages and forget_passwords* tables. The *users* table has a number of attributes such as id, firstname, lastname, age, nationality, residential_country, username, email, password, banned, macAddresses, ip, auth.

The descriptions of these attributes are described below.

- **ID:** is the user ID. It is the primary key of this table. The data type of this attribute is INT(255).
- **Firstname**: is the first name of the user. The data type of this attribute VARCHAR(20).
- **Lastname**: is the last name of the user. The data type of this attribute VARCHAR(20).
- **Age**: is the age of the user. The data type of this attribute INT (2).
- Nationality: is the nationality of the user. The data type of this attribute VARCHAR (25).
- **Residential_country**: is the residential country of the user. The data type of this attribute VARCHAR (25).
- **Username**: is the username of the user. The data type of this attribute VARCHAR (20).
- **Email**: is the email address of the user. The data type of this attribute VARCHAR (45).
- **Password**: is the password of the user. The password stored as MD5 hash. The data type of this attribute VARCHAR (40).
- **Banned**: is the banned status of the user. It is utilised to ban a specific user from using EVA application. The data type of this attribute is INT(1).
- **MacAddresses**: is the Mac Address of the user device. It is used to ban the user device. The data type of this attribute VARCHAR (500).
- **IP**: is the IP address of the user. It is used to ban the user. The data type of this attribute VARCHAR (30).
- **Auth**: is the authority level of the user. It is used to make sure that only authorised users have access to certain sections of the EVA application. The data type of this attribute is INT(1).

The *Tasks* table has six attributes: id, name, des, img_url, time and location_url. These attributes are described below.

- **ID:** is the task ID. It is the primary key of this table. The data type of this attribute is INT (255).
- **Name**: is the name of the task. The data type of this attribute VARCHAR(10).
- **Des**: is the description of the task. The data type of this attribute VARCHAR(600).
- **Img_url**: is the URL link of the task image. The data type of this attribute VARCHAR(300).
- **Time**: is the time in second of the task. This attribute is used by the AR game for timing. The data type of this attribute INT (2).
- **Location_url**: is the URL link of the task location. It's a google map link for the task location. The data type of this attribute VARCHAR (300).

The *Plays* table has five attributes: id, user_id, task_id, date_time and score. These attributes are described below.

- **ID**: is the auto increment number of the record. It is the primary key of this table. The data type of this attribute is INT(255).
- **User_id:** is the foreign key. It is used to link the *Users* table with *plays* table. The data type of this attribute is INT(11).
- **Task_id:** is the foreign key. It is used to link the *Tasks* table with *plays* table. The data type of this attribute is INT(11).
- **Date_time:** is the actual date and time of the AR game completion. The data type of this attribute is DateTime.
- **Score:** is the game score. The data type of this attribute is INT(2).

The *App_Usages* table has four attributes: id, user_id, date_time and action. These attributes are described below.

- **ID**: is the auto increment number of the record. It is the primary key of this table. The data type of this attribute is INT(255).
- **User_id:** is the foreign key. It is used to link the *Users* table with *App_Usages* table. The data type of this attribute is INT(11).
- **Date_time:** is the actual date and time where the users access a particular interface. The data type of this attribute is DateTime.
- **Action:** is the name of EVA interface where it was accessed by EVA app. The data type of this attribute is VARCHAR (40).

The *Forgot_passwords* table has two attributes: user_id and code. These attributes are described below.

- **User_id:** is the user ID. It is the primary key of this table. The data type of this attribute is INT (11).
- **Code:** is a random code generated by EVA http handler to verify the users' accounts before resetting their passwords. The data type of this attribute is VARCHAR (50).

EVA HTTP Handler

EVA HTTP Handler deals with different requests for instant users' accounts, tasks info, and MAR game and app usages. It was developed using PHP language. EVA HTTP Handler retrieves, stores or updates data on EVA database using SQL statements. After executing the SQL statements the handlers send back the responses to EVA App. Commas are used to separate each of the responses fields to allow EVA app to read the responses correctly. A key called $SecureKey is requested with every HTTP calls and if the provided key does not match the stored $SecureKey at EVA HTTP Handler, the request will be denied. Additionally, all the SQL statements are run through a secure function called *make_safe* prior execution to avoid any SQL injection threats.

5.3.1.1 Users

There are four types of requests for users' component: register, login, profile and password resetting requests. When the user install any of EVA version, they will be required to have an account to start using the application. Therefore, it is essential for them to register using one of EVA version. After they enter the required information on register interface, EVA app will send an HTTP request to EVA HTTP Handlers with the provided information by the user. The users' accounts will be created once their provided data pass the validation procedures.

The login request requires the username and the password from the user. The provided username and password are used to query the users table to find the user record. If the handler finds a match record then the rest of the user information will be sent with the response.

Sometimes the users forget their passwords; therefore, it is necessary to have a password resetting functionality to any accounts system. When resetting request is received and the request source and the email address are verified successfully, a random code will be generated and email back to the user email address. In order for the users to change their passwords, they need to use the received code to reset their password.

The profile request is used to update the user password or the user profile information. After verifying the call source, the profile request handler will check the request type whether it is changePassword or changeInformation requests. If it is changePassword request, the provided user ID and the new password will be used to update the user's password. The provided new password will be transferred to MD5 hash before storing it in the users table. If the request type changeInformation, all of the allowed fields of the user information will be updated after validation. If the user profile information is updated successfully, the profile request handler will send back a successful response code.

5.3.1.2 Tasks

The task handler provides tasks details to EVA app. When the task interface is opened by the users, the task ID will be sent to the tasks handler. Then the handler will responded with the task details as follow:

> *1,3,Task 3,In this task you are required to visit the specified location on the above picture which is located at level 1 of E1 parking at Macquarie University Campus. You are required to watch the provided anti-litter promoting materials on EVA app. Play the AR game and score at least 14 points. You are required to pick up or put your own trash in the nearest garbage bin,IMG_3624.jpg,30,https://goo.gl/maps/QYLMcTunEgz*

The respond will start with the successful indicator (number 1). Following that the (Task ID, Task Name, Task Description, Task Image, Location URL).

5.3.1.3 AR game

The AR game handler stores the users' scores of the AR game. Therefore, every time the users play the game, their scores will be posted and stored to the EVA DB through AR game handler. The users IDs, scores and the current date and time will be stored to keep tracking the users' performance for the AR game.

5.3.1.4 App usages

The App usages handler is used to track the users' usage of EVA app versions. Therefore, whenever an interface of EVA app versions is lunched, the handler will call the App usages handler

to store the users' activities. The interface name and the date and time of the usage are sent with every call made to the handler.

6. EVALUATION AND DISCUSSION

This section presents the correlation analysis of the results from EVA v2. Table 3 shows the correlation and significant analysis of Perceived Ease of Use (PEOU), Perceived Usefulness (PU), Perceived Enjoyment (PE**)**, Attitude towards Using EVA app (ATU), App Usage Intention (UI), App Usage Behaviour (UB), Subjective Norms (SN) and Perceived Behavioral Control (PBC). A discussion including practical recommendations and limitations of the research follows.

6.1 Results from the Correlation Analysis of EVA 2

The rule of thumb in Table 2 was applied to interpret the size of a correlation coefficient of the investigated variables.

Table 2. Rule of Thumb for Interpreting the Size of a Correlation Coefficient [1]

Size of Correlation	*Interpretation*
.90 to 1.00 (-.90 to –1.00)	Very high positive (negative) correlation
.70 to .90 (-.70 to -.90)	High positive (negative) correlation
.50 to .70 (-.50 to -.70)	Moderate positive (negative) correlation
.30 to .50 (-.30 to -.50)	Low positive (negative) correlation
.00 to .30 (.00 to -.30)	Little if any correlation

The question of this research is:

What are the correlations between the independent factors of (TPB, TAM and Perceived Enjoyment) and the use of MAR system for promoting Anti-littering behaviour?

This paper highlights only the result of EVA v2 experiment. Therefore, the following figures only related to that version. The main independent factors of TPB are SN, PBC and ATU, while the independent factors of TAM model are PEOU and PU. The intention of a behaviour is addressed in both models TAM and TPB. The PE is also analysed in this research. The examined dependent variable is the use behaviour of EVA v2 system.

There were moderate positive correlations between PEOU and PU ($r = 0.527$, $p = < 0.01$), UB ($r = 0.537$, $p = < 0.01$) and PBC ($r = 0.643$, $p = < 0.01$). Additionally, There were low positive correlations between PEOU and PE ($r = 0.46$, $p = < 0.01$), ATU ($r = 0.49$, $p = < 0.01$), UI ($r = 0.426$, $p = < 0.01$) and SN ($r = 0.36$, $p = < 0.05$). PU was found to have a high positive correlation with ATU ($r = 0.78$, $p = < 0.01$) and moderate positive correlations with PE ($r = 0.689$, $p = < 0.01$), UI ($r = 0.692$, $p = < 0.01$), UB ($r = 0.579$, $p = < 0.01$) and SN ($r = 0.562$, $p = < 0.01$) and PBC ($r = 0.624$, $p = < 0.01$).

Furthermore, PE was shown high positive correlations with ATU ($r = 0.833$, $p = < 0.01$), UI ($r = 0.7$, $p = < 0.01$) and UB ($r = 0.721$, $p = < 0.01$) and moderate positive correlations with SN ($r = 0.697$, $p = < 0.01$) and PBC ($r = 0.641$, $p = < 0.01$). In addition, ATU was highly positively correlated with UI ($r = 0.724$, $p = < 0.01$), UB ($r = 0.761$, $p = < 0.01$) and SN ($r = 0.73$, $p = < 0.01$) and moderate positive correlation with PBC ($r = 0.688$, $p = < 0.01$). UI was highly positively correlated with SN ($r = 0.789$, $p = < 0.01$), while it was moderately positively correlated with UB ($r = 0.679$, $p = < 0.01$) and PBC ($r = 0.633$, $p = < 0.01$). Finally, UB was found highly positively correlated with SN ($r = 0.803$, $p = < 0.01$) and PBC ($r = 0.777$, $p = < 0.01$); while, a moderate positive correlation was found between SN and PBC ($r = 0.595$, $p = < 0.01$).

Table 3. Correlation for EVA 2

		PEOU	**PU**	**PE**	**ATU**	**UI**	**UB**	**SN**	**PBC**
PEOU	Correlation Coefficient	1							
	Sig. (2-tailed)								
PU	Correlation Coefficient	0.527	1						
	Sig. (2-tailed)	0.001							
PE	Correlation Coefficient	0.46	0.689	1					
	Sig. (2-tailed)	0.004	0.000						
ATU	Correlation Coefficient	0.49	0.78	0.833	1				
	Sig. (2-tailed)	0.002	0.000	0.000					
UI	Correlation Coefficient	0.426	0.692	0.7	0.724	1			
	Sig. (2-tailed)	0.010	0.000	0.000	0.000				
UB	Correlation Coefficient	0.537	0.579	0.721	0.761	0.679	1		
	Sig. (2-tailed)	0.001	0.000	0.000	0.000	0.000			
SN	Correlation Coefficient	0.36	0.562	0.697	0.73	0.789	0.803	1	

	Sig. (2-tailed)	0.027	0.000	0.000	0.000	0.000	0.000		
PBC	Correlation Coefficient	0.643	0.624	0.641	0.688	0.633	0.777	0.595	1
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	

6.2 Discussion

Perceived Enjoyment (PE) was the highest positive correlation with the user's attitude (ATU) towards using EVA v2 app ($r = 0.833$, $p = < 0.01$) among the other variables. This indicates the need of providing an enjoyable experience for the users in order to promote them to use a new MAR system. The main limitations of EVA app were the tracking condition and the users' willingness. As EVA is an outdoor marker-based app; therefore, it requires placing the markers at the targeted locations. The markers were exposed to different climatic conditions, which affected the condition of the markers themselves, and the application tracking functionality. Another issue was the 'step barrier' linked to the QR/app use. The QR code integrated with the marker to provide an easy access to EVA installation webpage. Users needed to get out their phone, to download EVA app. Getting users to download the application and keep their usage interest was a challenge.

7. CONCLUSION

The aim of this study is to help community members to minimise their ecological footprint by promoting pro-environment behaviours using mobile augmented reality to protect our environment. The lack of research regarding the use of mobile augmented reality to promoting anti-littering behaviour in Australia drove the attention of this research. TPB and TAM theories was utilised during the implementation and evaluation stages of EVA system. The tracking condition and the users' willingness were the main obstacles for applying EVA system. All the targeted variables were correlated with each other and the correlation between PE and ATU was the highest positive correlation while the correlation between PEOU and SN was the lowest positive correlation.

8. REFERENCES

[1] Haugstvedt, A.C. and J. Krogstie. *Mobile augmented reality for cultural heritage: A technology acceptance study*. in *2012 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*. 2012.

[2] de los R ós, S., et al., *Using Augmented Reality and Social Media in Mobile Applications to Engage People on Cultural Sites*, in *Universal Access in Human-Computer Interaction. Universal Access to Information and Knowledge*, C. Stephanidis and M. Antona, Editors. 2014, Springer International Publishing. p. 662-672.

[3] Olsson, T., et al., *Expected user experience of mobile augmented reality services: a user study in the context of shopping centres.* Personal and Ubiquitous Computing, 2013. **17**(2): p. 287-304.

[4] Chou, T.-L. and L.-J. ChanLin, *Augmented Reality Smartphone Environment Orientation Application: A Case Study of the Fu-Jen University Mobile Campus Touring System.* Procedia - Social and Behavioral Sciences, 2012. **46**: p. 410-416.

[5] Sibley, C.G. and J.H. Liu, *Differentiating Active and Passive Littering: A Two-Stage Process Model of Littering Behavior in Public Spaces.* Environment and Behavior, 2003. **35**(3): p. 415-433.

[6] de Kort, Y.A.W., L.T. McCalley, and C.J.H. Midden, *Persuasive Trash Cans: Activation of Littering Norms by Design.* Environment and Behavior, 2008. **40**(6): p. 870-891.

[7] Rice, G., *Pro-Environmental Behavior in Egypt: Is There a Role for Islamic Environmental Ethics?* Journal of Business Ethics, 2006. **65**(4): p. 373-390.

[8] Steg, L., et al., *An Integrated Framework for Encouraging Pro-environmental Behaviour: The role of values, situational factors and goals.* Journal of Environmental Psychology, 2014. **38**: p. 104-115.

[9] Li, S. *'Augmented Reality' on Smartphones Brings Teaching Down to Earth*. 2010 04/08/2015]; Available from: http://chronicle.com/article/Augmented-Reality-on/65991/.

[10] Ajzen, I., *The theory of planned behavior.* Organizational Behavior and Human Decision Processes, 1991. **50**(2): p. 179-211.

[11] Sentosa, I. and N. Mat, *Examining a theory of planned behavior (TPB) and Technology acceptance model (TAM) in Internet purchasing using structural equation Modeling.* Journal of Arts, Science & Commerce, 2012. **3**(2): p. 62-77.

[12] Morris, J., et al., *Theories and models of behaviour and behaviour change*. 2012, Forestry Commission UK.

[13] Nisbet, E.K. and M.L. Gick, *Can health psychology help the planet? Applying theory and models of health behaviour to environmental actions.* Canadian Psychology/Psychologie canadienne, 2008. **49**(4): p. 296-303.

[14] Davis, F.D., R.P. Bagozzi, and P.R. Warshaw, *User Acceptance of Computer Technology: A Comparison of Two Theoretical Models.* Management Science, 1989. **35**(8): p. 982-1003.

[15] Masrom, M., *Technology acceptance model and e-learning.* Technology, 2007. **21**(24): p. 81.

[16] Liao, C.-H., C.-W. Tsou, and Y.-C. Shu, *The Roles of Perceived Enjoyment and Price Perception in Determining Acceptance of Multimedia-on-Demand.* International Journal of Business and Information, 2015. **3**(1).

[17] Lu, C.-T., S.-Y. Huang, and P.-Y. Lo, *An empirical study of on-line tax filing acceptance model: Integrating TAM and TPB.* African Journal of Business Management, 2010. **4**(5): p. 800.

[18] Kaur, P. and S. Sharma. *Google Android a mobile platform: A review*. in *Engineering and Computational Sciences (RAECS), 2014 Recent Advances in*. 2014.