

# AUGMENTED REALITY AND BEHAVIOURAL CHANGE: A TECHNOLOGY ACCEPTANCE STUDY

By

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# **Abstract**

Littering behaviour is a global issue affecting most countries, regardless of their development status. Augmented reality (AR) shows a promising contribution in different fields. However, despite the wider applications of AR in different areas such as cultural heritage and shopping, acceptance studies of augmented reality applications with environmental awareness are still rare.

This empirical study will contribute to the investigation of users' acceptance of AR within the environmental context. A number of behavioural theories have been utilised in this research, such as the Theory of Planned Behaviour (TPB) and the Technology Acceptance Model (TAM). A mixed methods research was applied to determine the correlations between personality traits, anti-littering behaviour, and the acceptance or non-acceptance of the environmental awareness augmented reality app (EVA), as measured by C-TAM-TPB. Additionally, a gamification method has been utilised by this research; therefore, perceived enjoyment factor has also been examined by this research.

We conducted three sets of experiments for each of the case studies in Australia and Saudi Arabia. The experiments were employed to investigate three different versions of the mobile app (EVA) to determine which version would be the best fit for the proposed model. EVA 1, a standard mobile application (control variable), was examined and compared with two other treatment variables, EVA 2 (AR mobile app) and EVA 3 (AR mobile app plus AR game).

This study states that AR, with or without gaming, was more effective than a standard mobile application in effecting a behavioural change towards anti-littering behaviour. Gamification elements were found slightly more effective than AR only in the app we tested, however this require further testing with more enjoyable game elements. A moderate to great deal of change in littering behavioural intention have been observed most in the case of the AR Game compared to the other two. Based on their experiences, the participants nominated AR Games, AR Videos, and AR images as the top three approaches to use for behaviour change, with respect to their effectiveness.

## **Keywords**

Augmented Reality; Littering Behaviour; Environmental Awareness

## **Declaration**

I hereby declare that the work in this thesis entitled “Augmented Reality and Behavioural Change: A Technology Acceptance Study” is my own work and that, to the best of my knowledge and belief it has not previously been submitted for a degree, nor has it been submitted as part of requirements for a degree, to any other university or institution other than Macquarie University. Any assistance that I received in my research work and the preparation of the thesis itself has been appropriately acknowledged. Ethics Committee approval has been obtained (5201500904). To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

**Majed Abdullah Alrowaily**



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Also, I would like to thank the fruit of my life (my wife and my three beautiful kids) for their support and encouragement during my study in Australia.

Finally, I would also like to thank all my friends in Australia whom helped me to overcome some difficult times; I will really miss them when I leave Australia for good.

# List of Publications

In the following a list of all publications related to this thesis:

- Alrowaily, M. A., & Kavakli, M. (2018, February). Mobile Augmented Reality for Environmental Awareness: A Technology Acceptance Study. In *Proceedings of the 2018 10th International Conference on Computer and Automation Engineering* (pp. 36-43). ACM.
- Alrowaily, M. A., & Kavakli, M. (2017, February). The Use of Augmented Reality for Encouraging Pro-Environmental Behaviors: The Case of Australia. In *Proceedings of the 9th International Conference on Computer and Automation Engineering* (pp. 21-25). ACM.

Other unrelated publication:

- Alrowaily, M. A., & Kavakli, M. (2015, November). The Use of Smart Meters and Social Media in Promoting Conservation Behaviour. In *2015 8th International Conference on u- and e-Service, Science and Technology (UNESST)* (pp. 50-56). IEEE.

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# **CHAPTER 1: Introduction**

Chapter 1 of this thesis has been removed due to copyright reasons

# **CHAPTER 2: Review of Theoretical Frameworks**

## 2.1 Introduction

There have been a number of works on the Theory of Reasoned Action (TRA) and the Theory of Planned Behaviour (TPB) since they were first proposed by Fishbein (1967) and Ajzen (1985). Some works describe TRA only. A few of them are: Fishbein (1979), Oliver and Bearden (1985), Sheppard, Hartwick, and Warshaw (1988), Vallerand, Deshaies, Cuerrier, Pelletier, and Mongeau (1992), Bagozzi, Wong, Abe, and Bergami (2000), Hale, Householder, and Greene (2002), Ryu and Jang (2006), Lada, Harvey Tanakinjal, and Amin (2009), Mishra, Akman, and Mishra (2014), S. Kim, Lee, and Yoon (2015), Doane, Kelley, and Pearson (2016), Oni, Oni, Mbarika, and Ayo (2017) and Muralidharan, La Ferle, and Pookulangara (2018). However, in this review, only the basic principles and applicability of these theories to littering behaviour will be discussed.

Based on a scoping review, (R. Davis, Campbell, Hildon, Hobbs, & Michie, 2015) identified 82 theories and used nine criteria for assessing the quality of theories. Their tabulated list of theories is reproduced in Figure 2.1. Out of these, 174 (63%) of the articles reviewed dealt with only four theories. These theories are: Trans-theoretical Model of Change (TTM; N = 91; 33%), the Theory of Planned Behaviour (TPB; N = 36; 13%), Social Cognitive Theory (SCT; N = 29; 11%) and the Information-Motivation-Behavioural-Skills Model (IMB; N = 18; 7%). An additional set of four theories accounted for about 32 (12%) of the articles. These theories are: the Health Belief Model (HBM) (N = 9; 3%), Self-determination Theory (SDT; N = 9; 3%), Health Action Process Approach (HAPA; N = 8; 3%), and Social Learning Theory (SLT; N = 6; 2%; SLT is a precursor of SCT). There were 10 studies related to environmental conservation. Most of the studies were related to behaviour and behaviour change of patients in different healthcare settings. It is practically impossible to discuss all the 82 theories listed. Hence, based on the finding that only eight theories identified as more commonly used in various studies, these eight theories: TTM, TPB, SCT, IMB, SDT, HBM and SLT are selected for further discussions in this chapter. Additionally, TRA, TAM, SoC, Big 5 and BCW have been included.



Table 1. Theories identified, along with first author and date of the primary theory source and the number of articles reporting the theory.

	Theory	First author theorist (date)	Number of articles reporting theory that were included in the review
1	An Action Model of Consumption	Bagozzi (2000)	1 <sup>a</sup>
2	Affective Events Theory	Weiss (1996)	1 <sup>a</sup>
3	AIDS Risk Reduction Model	Catania (1990)	5 <sup>a</sup>
4	Attitude-Social Influence – Efficacy Model and its successor I – Change	DeVries (1998)	2
5	Behavioural Ecological Model of AIDS Prevention	Hovell (1994)	1 <sup>a</sup>
6	Change Theory	Lewin (1943)	0
7	Classical Conditioning	Pavlov (1927)	0
8	COMB Model	Michie (2011)	0
9	Consumption of Social Practices	Spaargaren (2000)	0
10	Containment Theory	Reckless (1961)	0
11	Control Theory	Carver (1981/1982)	1
12	Diffusion of Innovations	Rogers (1983)	4
13	Differential Association Theory	Sutherland (1947)	0
14	Ecological Model of Diabetes Prevention	Burnet (2002)	1 <sup>a</sup>
15	Extended Information Processing Model	Flay (1980)	1 <sup>a</sup>
16	Extended Parallel Process Model	Witte (1992)	2
17	Feedback Intervention Theory	Kluger (1996)	1
18	General Theory of Crime	Goffredson (1990)	0
19	General Theory of Deviant Behaviour	Kaplan (1972)	1
20	Goal Directed Theory	Bagozzi (1992)	2 <sup>a</sup>
21	Goal Framing Theory	Lindenberg (2007)	1
22	Goal Setting Theory	Locke (1968)	1
23	Health Action Process Approach	Schwarzer (1992)	8
24	Health Behaviour Goal Model	Gerbhardt (2001)	1 <sup>a</sup>
25	Health Behaviour Internalisation Model	Bellg (2003)	1 <sup>a</sup>
26	Health Belief Model	Rosenstock (1966)	9
27	Health Promotion Model	Pender (1982)	1
28	Information-Motivation-Behavioural (IMB) Skills Model	Fisher (1992)	18 (17) <sup>b</sup>
29	IMB Model of ART Adherence (extension of IMB)	Fisher (2008)	1 <sup>a</sup>
30	Integrative factors influencing smoking behaviour model	Flay (1983)	1 <sup>a</sup>
31	Integrative model of health and attitude behaviour change	Flay (1983)	1 <sup>a</sup>
32	Integrating the factors influencing smoking behaviour and the model of attitude and behaviour change	Flay (1983)	1 <sup>a</sup>
33	Integrative Model of Behavioural Prediction	Fishbein (2000)	2 <sup>a</sup>
34	Integrated Theory of Drinking and Behaviour	Wagennar (1994)	1
35	Integrated Theoretical Model for Alcohol and Drug Prevention	Gonzalez (1989)	1 <sup>a</sup>

Table 1 (Continued)

Theory	First author theorist (date)	Number of articles reporting theory that were included in the review
36 Integrative Theory of Health Behaviour Change	Ryan (2009)	1 <sup>a</sup>
37 Model of Pro-environmental Behaviour	Kolmuss (2002)	0
38 Motivation Opportunity Abilities Model	Olander (1995)	0
39 Needs Opportunities Abilities (NOA) Model	Gatersleben (1998)	0
40 Norm Activation Theory	Schwartz (1977)	0
41 Operant Learning Theory	Skinner (1954)	0
42 Precaution Adoption Process Model	Weinstein (1988)	1
43 Pressure System Model	Katz (2001)	1 <sup>a</sup>
44 PRIME Theory	West (2006)	0
45 Problem Behaviour Theory	Jessor (1977)	0
46 Prospect Theory	Kahneman (1979)	3
47 Protection Motivation Theory	Rogers (1975)	2
48 Prototype Willingness Model	Gibbons (1995)	1 <sup>a</sup>
49 Rational Addiction Model	Becker (1988)	3 <sup>a</sup>
50 Reflective Impulsive Model/Dual Process Theory	Strack (2004)	1 <sup>a</sup>
51 Regulatory Fit Theory	Higgins (2000)	2
52 Relapse Prevention Theory	Marlatt (1980)	1 <sup>a</sup>
53 Risks as Feelings Model	Lowenstein (2001)	0
54 Self-determination Theory	Deci (2000)	9 (8) <sup>b</sup>
55 Self-efficacy Theory	Bandura (1977)	2 <sup>a</sup>
56 Self-regulation Theory	Kanfer (1970)	1
57 Six Staged Model of Communication Effects	Vaughan (2000)	1 <sup>a</sup>
58 Social Action Theory	Ewart (1991)	1 <sup>a</sup>
59 Social Action Theory	Weber (1991)	0
60 Social Change Theory	Thompson (1990)	0
61 Social Cognitive Theory	Bandura (1986)	29 (27) <sup>b</sup>
62 Social Consensus Model of Health Education	Romer (1992)	1 <sup>a</sup>
63 Social Development Model	Hawkins (1985)	3 <sup>a</sup>
64 Social Identity Theory	Tajfel (1979)	0
65 Social Influence Model of Virtual Community Participation	Dholakia (2004)	1 <sup>a</sup>
66 Social Ecological Model of Walking	Alfonzo (2005)	1 <sup>a</sup>
67 Social Ecological Model of Behaviour Change	Panther-Brick (2006)	1 <sup>a</sup>
68 Social Learning Theory	Miller (1941)	6
69 Social Norms Theory	Perkins (1986)	0
70 Systems Model of Health Behaviour Change	Kershell (1985)	1 <sup>a</sup>
71 Technology Acceptance Models 1, 2 and 3	Venkatesh (1989, 2000, 2008)	1 <sup>a</sup>
72 Temporal Self-regulation Theory	Hall (2007)	1 <sup>a</sup>
73 Terror Management Health Model	Goldenberg (2008)	0
74 Terror Management Theory	Greenberg (1986)	1
75 Theory of Normative Conduct	Cialdini (1991)	2
76 Theory of Interpersonal Behaviour	Triandis (1977)	0

Table 1 (Continued)

	Theory	First author theorist (date)	Number of articles reporting theory that were included in the review
77	Theory of Normative Social Behaviour	Rimal (2005)	1 <sup>a</sup>
78	Theory of Planned Behaviour/Reasoned Action	Ajzen (1985)	36 (34) <sup>b</sup>
79	Theory of Triadic Influence	Flay (1994)	0
80	Transcontextual Model of Motivation	Hagger (2003)	0
81	Transtheoretical/Stages of Change Model	Prochaska (1983)	91 (87) <sup>b</sup>
82	Value Belief Norm Theory	Stern (1999)	1

Note: Theories 30–32 were all reported in one paper.

<sup>a</sup>Theories for which the primary theory source was identified in our review.

<sup>b</sup>Numbers in brackets represent adjusted frequencies for articles in which the same first author has published more than one article applying the same theory to the same data-set or intervention.

Figure 2.1. Theories of behaviour and behaviour change (R. Davis et al., 2015)

## 2.2 Theories of Behavioural Change and Technology Acceptance

This section covers twelve different theories of behaviour change in more detail.

### 2.2.1 Theory of Reasoned Action (TRA)

Recognising TRA, as an expectancy value model, a schematic presentation of TRA was given by Blue (1995) in her comparison studies, and have been reproduced in Figure 2.2.

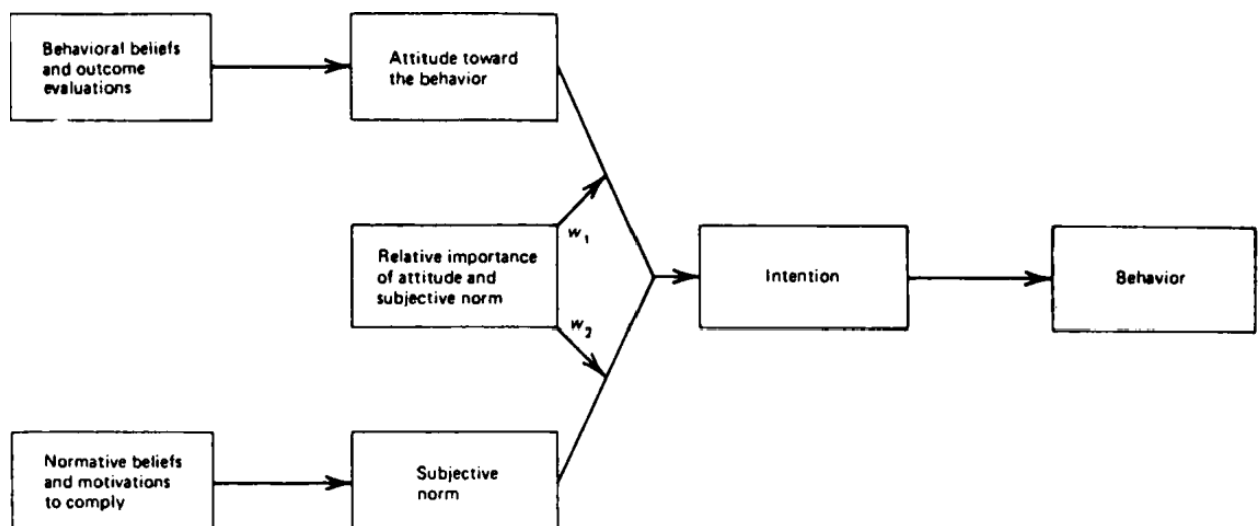


Figure 2.2 Schematic presentation of Theory of Reasoned Action (Blue, 1995)

Expectancy value models provide a framework for the relationship between attitudes and beliefs. Such an expectancy may, or may not, lead to an expected outcome. The value of the outcome is

derived from the subjective value placed on the outcome. Based on this principle, it is possible to motivate a person to perform a behaviour that will lead to a highly valued outcome. This principle can be directly applied to reducing littering. The highly valued outcome here is the clean environment. The behaviour that will lead to this valued outcome is non-littering behaviour and persuading others not to litter. The only factor remaining is how to motivate people to do so. The work of Gusmerotti, Corsini, Testa, Borghini, and Iraldo (2016), showed that the pro-environmental behaviour of junior high school students in Italy towards marine protection was predicted by awareness of the consequences, attitudes towards marine environment preservation, environmental knowledge, and social norms. Social norms were found to be the highest predictor of pro-environmental behaviour related to marine litter, whereas personal attitudes had a limited influence. In the case of marine littering prevention, the behaviour of individuals and groups may be influenced by knowledge, attitudes, and concerns about the environment. These factors may lead to motivation to act on solutions. Social norms, self-awareness, benefit-cost for the individual, and incentives are some factors associated with marine littering, or not littering, behaviour.

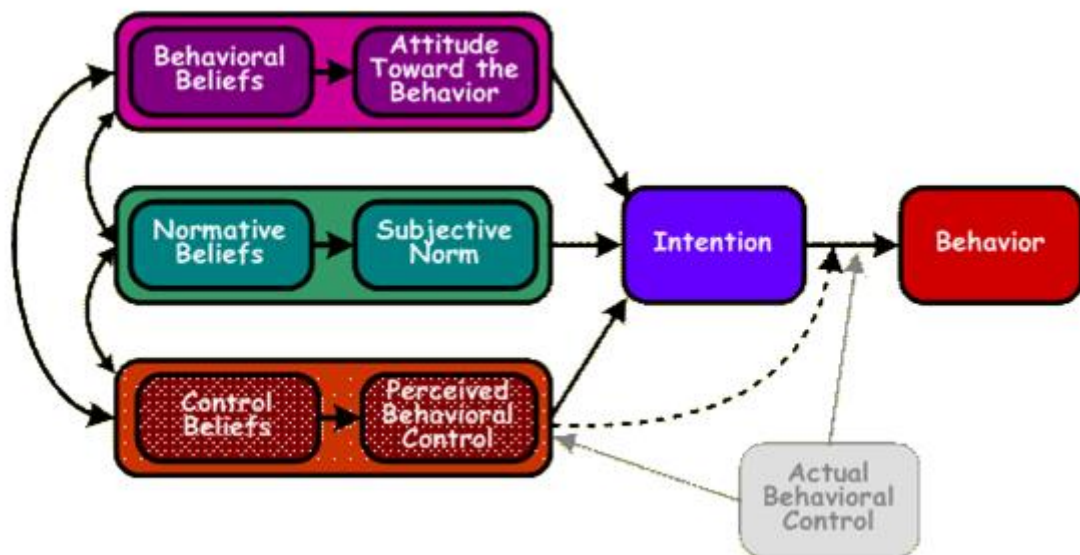
Hartley, Thompson, and Pahl (2015) examined the effect of educational interventions on a change in attitude and behaviour to non-littering outcomes among school children in UK. Even before intervention, children were aware of marine litter problems, causes, and impacts and were taking actions at their level. After the intervention, all these factors showed a marked increase. The changes in their perceptions and behaviours due to the intervention were also measured. These changes may have had social influences on their friends, parents, and the community.

One Chinese study stressed the importance of creating a pro-environment social norm and community among tourists through user-generated content in social media for environmentally responsible behaviour (ERB), such as not littering (Han, McCabe, Wang, & Chong, 2018). Another Chinese study, of an urban park (Zhao et al., 2018), found that individual traits were more important when affecting the ERB of tourists. The effect of satisfaction with interpretative services on ERB was mediated by place attachment. In a cross-cultural study, Minton, Spielmann, Kahle, and Kim (2018) correlated sustainable consumption with the level of pragmatism of the country (Hofstede, 2017) and used TRA to explain sustainable attitudes as being mediated by an individual's home country culture of pragmatism and sustainability perceptions and behaviour.

### **2.2.2 Theory of Planned Behaviour (TPB)**

TPB was proposed by Ajzen (1985) as an extension of TRA; a schematic diagram of the theory, provided by Ajzen (2006), is reproduced in Figure 2.3. The theory considers three types of factors

governing human behaviour. The first is belief about the possible outcomes of the behaviour and their evaluation, termed as behavioural beliefs. The second is, belief about the normative expectations others would have and motivation to go along these expectations, termed as, normative beliefs. The third is the belief about the factors and their relative powers, which may help or obstruct the performance of the behaviour, termed as control beliefs. These, in turn, lead to attitudes towards behaviour, subjective norms, and perceived behavioural control, all leading to the behavioural intention. A more positive attitude, subjective norms, and the greater the control, the stronger is the intention to perform the behaviour. When there is an adequate degree of control over the behaviour, the intentions are carried out at the earliest opportunity. This converts mere intention to actual behaviour. Some other workers have added more predictors to the model, such as descriptive norms (Rivis & Sheeran, 2003) and anticipated regret (Sheeran & Orbell, 1999). However, they did not show how and where exactly these additional predictors would fit in the schematic diagram.



**Figure 2.3. A schematic diagram of the Theory of Planned Behaviour (Ajzen, 2006)**

Nigbur, Lyons, and Uzzell (2010) studied kerbside collection of litter and recycling behaviour (as an environmental behaviour variable), and found that behaviour was predicted by intentions. Intention to recycle was predicted by attitudes, perceived control, and personal norms. Personal norms were created through an interaction between neighbourhood identification and injunctive social norms. Self-identity and descriptive social norms also contributed significantly as predictors. Mannetti, Pierro, and Livi (2004) found that for repeated behaviours such as recycling, the addition of self-identity variables to TPB predictors was useful. The authors called their model, 'Self-expressive Behaviour' and added an additional predictor, 'Identity similarity', below

‘Perceived behavioural control’ in Azjen’s (2006) schematic diagram to account for their findings.

Using a persuasive message as a motivator to pick up litter in Mt Field National Park, Tasmania was found to increase litter pick up by tourists by 15-20% compared to the control (no persuasive messages) (Brown, Ham, & Hughes, 2010). It also influenced the targeted beliefs and attitudes towards this environmentally valuable behaviour. Added benefits included cost savings on litter collection and reductions in adverse effects on animals and plants and aesthetic degradation of the tourist spot. TPB was used to explain the results.

In their review of theories on conservation behaviour, Vining and Ebreo (2002) noted that less work has been done on the application of the TRA in conservation studies. On the other hand, TPB has been used more in studying pro-environmental behaviour and, according to Ballantyne and Packer (2005, p. 4), “environmental interpretation that aims to influence specific attitudes and behaviour is often designed to challenge the salient behavioural, normative or control beliefs upon which the attitudes and behaviours are based, and/or promote behavioural, normative or control beliefs that will achieve the desired outcomes.”

In a study comparing three methods of measuring responsible environmental behaviour, Chao and Lam (2011) observed that TPB was best suitable to predict self-reported environmentally responsible behaviour. In a report on a series of studies, Cialdini et al. (1990) contended that social norms, projected by researchers like Fishbein and Azjen to be essential to understand human behaviour, may not be appropriate for normative explanations. All studies were on littering behaviour. Although social norms were found to be valid, there was also the need to distinguish between descriptive and injunctive norms. Otherwise, alternate explanations may also be possible for observed littering and non-littering behaviour. Therefore, conceptual refinements are required for these theories. In a study on tourists’ responsible environmental behaviour (REB) in a Huangshan Mountain scenic spot in China, Wang, Zhang, Yu, and Hu (2018a) obtained support for TPB in explaining the observed behaviour. However, environmental interpretations played a moderating role on the relationship between tourists’ intentions and actual responsible environmental behaviour. Howell, Shaw, and Alvarez (2015) also obtained evidence to support TPB in their study on the usefulness of bait shop workers’ social influence on boaters and anglers to reduce the spread of aquatic invasive species. Intentions to engage in outreach activities were strongly predicted by perceptions about normative social pressures. However, actual engagement with their customers was more strongly predicted by perceived behavioural control. In a study of non-compliance in national parks by Goh, Ritchie, and Wang (2017), the extended TPB model

was partially verified. Subjective norms strongly predicted visitors' compliance, however perceived behavioural control and pro-environment norms were not significant predictors. TPB was more suitable to predict specific behavioural intentions only.

In a study to reduce the use of plastic bags, Muralidharan and Sheehan (2016) used framing and TPB. Social marketing strategies, such as advertisements with messages of “avoiding a fee” as a gain and “paying tax” as a loss, increased shoppers' use of reusable plastic bags. In the case of framing it as a fee, the attitude towards compliance with the instruction and perceived control played significant roles in formulating intentions. Subjective norms were more important in the case of framing it as a tax to determine bringing reusable bags. Behaviour intention was a good predictor for both frames. The penalty framed as a tax may be a more effective way of reducing littering through use of reusable plastic bags. Corsini, Gusmerotti, Testa, and Iraldo (2018) also found that waste prevention attitudes were completely mediated by perceived behavioural control and that social norms strongly impacted waste prevention behaviour of individuals.

Many authors have compared the two theories in various contexts and applications (Blue, 1995) (Madden, Ellen, & Ajzen, 1992; Montaña & Kasprzyk, 2015). In their work, Kollmuss and Agyeman (2002) discussed many models of environmental behaviour mainly to answer why people's words and actions differ, with respect to environmental behaviour. Several studies, reviews, and meta-analyses have supported these theories and suggested additional variables and predictors have been published, some of which have been discussed.

This section has presented available evidence of how TRA and TPB are directly applicable to littering problems. Works on related issues like pro- or responsible environmental behaviour and waste prevention, reduction, and recycling to reduce litter at the source are also important and some works on these have also been discussed. Thus, the applicability of these theories to the littering problem, the topic of this study, is clear.

### **2.2.3 The Health Belief Model (HBM)**

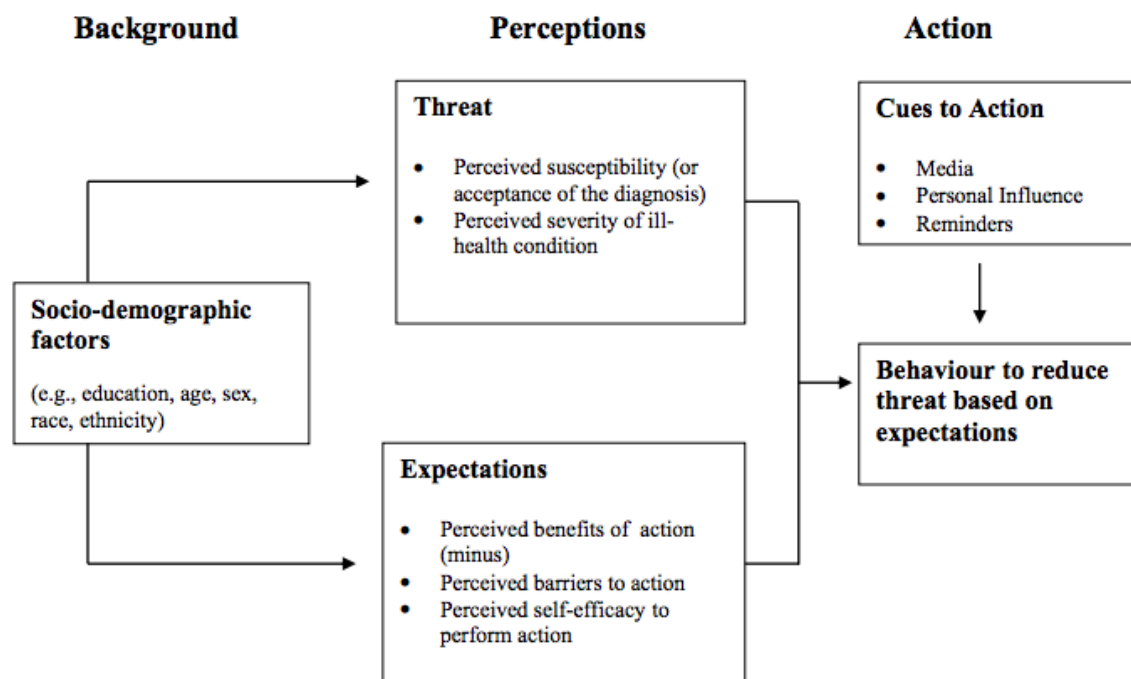
In the 1950s, HBM was developed to illustrate and anticipate preventive health behaviours (Humaidi, Balakrishnan, & Shahrom, 2014). HBM is a cognitive model assuming that the targeted behaviour can be defined by beliefs regarding risks to a person's well-being and the effectiveness and results of certain activities or behaviours (Morris, Marzano, Dandy, & O'Brien, 2012). Nisbet and Gick (2008, p. 297) described the model as follows:

“in order for behaviour to change, people must feel personally vulnerable to a health threat, view the possible consequences as severe, and see that taking action is likely to either



prevent or reduce the risk at an acceptable cost with few barriers. In addition, a person must feel competent (have self-efficacy) to execute and maintain the new behaviour. Some trigger, either internal ... or external ... is required to ensure actual behaviour ensues.”

HBM proposes four constructs: perceived susceptibility, perceived severity, perceived benefits, and perceived barriers, which contribute to determining the possibility, profits, and cost related to behaviour change (Humaidi et al., 2014). According to Nisbet and Gick (2008), there is a potential usage of HBM for environmental behaviour; especially, with its focus on perceived susceptibility and vulnerability. Particularly, it is more likely people will act when personally feeling danger and are able to undertake suitable and low-cost (i.e., low barrier) substitutional behaviours. Additionally, people are keen to know that their movements are going to make a difference and contribute to the overall effort to solve the issue (Nisbet & Gick, 2008). See the model in Figure 2.4 for more detail.



*Figure 2.4: Components of the Health Belief Model (Reproduced from (Rosenstock, Strecher, & Becker, 1994))*

#### 2.2.4 Stages of Change (Transtheoretical Model)

The transtheoretical model (TTM), also known as the Stages of Change (SoC), is widely applied in health research (Nisbet & Gick, 2008). At the beginning of the 1980s, Prochaska and DiClemente developed TTM (Taylor et al., 2006), a cognitive model, which categorises individuals into five groups that illustrate different milestones, or stages of motivational readiness



(Heimlich & Ardoin, 2008). These phases are pre-contemplation, contemplation, preparation, action, and maintenance (see Table 2.1 for a synopsis). The logic behind TTM is that similar issues and obstacles can be encountered by individuals who are at the same stage; therefore, the same form of intervention can be applied to help overcome those barriers. Additionally, TTM involves processes, which provide an explanation for how these shifts might happen (Nisbet & Gick, 2008).

Nisbet and Gick (2008) believed TTM was suitable to apply to environmental behaviour as it differentiates between individuals who are, or are not, willing to change and the length of their change process. This kind of information is important for establishing effective interventions by offering a framework for planning behavioural change programs based on individual variances in environmental beliefs and readiness to embrace new behaviours (Nisbet & Gick, 2008).

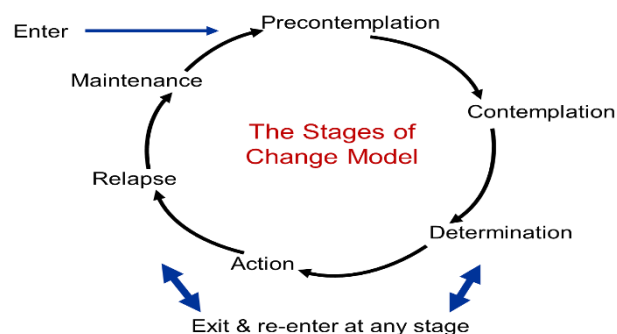
**Table 2.1 The Stages of Change Model (Reproduced from (Morris et al., 2012))**

Stage	Stage Definition	Process	Process Definition
Pre-contemplation	Individual is unaware of problem; No intention to change behaviour in foreseeable future	Consciousness raising	Increasing information about self and problem
		Dramatic relief	Experiencing and expressing feelings about one's problems and solutions:
		Environmental re-evaluation	Assessing how one's problem affects physical environment
Contemplation	Individual is aware of problem; Serious consideration of change in behaviour	Self-re-evaluation	Assessing how one feels and thinks about oneself with respect to a problem
Preparation	Individual is intending to take action	Self-liberation	Choosing and commitment to act or believe in ability to change
Action	Individuals modify their behaviour, experiences, and/or environment in order to overcome problem	Counter-conditioning	Substituting alternatives for problem behaviours
		Stimulus control	Avoiding or countering stimuli that elicit problem behaviours
		Helping	Being open and trusting about

		relationships	problems with someone who cares
		Reinforcement management	Rewarding one's self or being rewarded by others for making changes
Maintenance	Individual works to prevent relapse and consolidate gains.	Social liberation	Increasing alternatives for non-problem behaviours available in society

### 2.2.5 Trans-Theoretical Model (TTM)

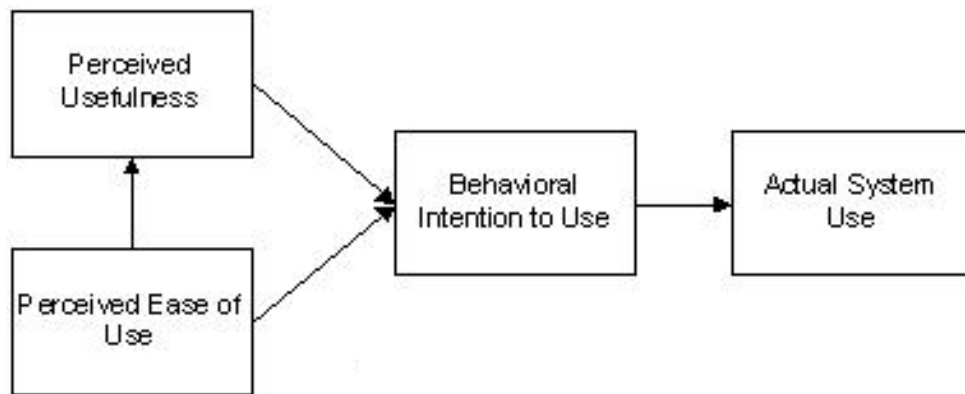
The trans-theoretical model (TTM) was proposed by Prochaska and DiClemente in the late 1970's. It is a decision-making model of intentional change. The various stages of change have been diagrammatically depicted in Figure 2.5. After a behaviour is changed, the chances of re-entry to the earlier behaviour are not precluded in the model. On the other hand, if the change cycle is terminated, the individual has no desire to relapse. However, the theory ignores socio-economic contexts. There is no set criteria to determine the stages; hence their separation is arbitrary. There is poor validation of the methods of measurement of the stages. Duration at each stage is not clearly known. The model assumes coherent and logical decision making by individuals; but this may not be true always (LaMorte, 2016). As the model was proposed for health care, most research works have also been done on this aspect. For example, Reed, Pritschet, and Cutton (2013) found that Big Five Inventory (BFI) Conscientiousness did not predict high intensity and moderate intensity exercise at TTM stage. In the case of health promoting, cancer preventing behaviour, the later stages of TTM (well-balanced diet and exercise) were correlated with personality traits (introversion, neuroticism, psychosocial stress), as reported by Choi, Chung, and Park (2013).



*Figure 2.5 Trans-theoretical model - Stages of change (LaMorte, 2016)*

### 2.2.6 Technology Acceptance Model (TAM)

Fred D. Davis, Bagozzi, and Warshaw (1989) proposed the TAM model to clarify users' acceptance levels of information systems or new technology. TAM suggests that the users' intention towards a technology is influenced by its perceived usefulness and perceived ease of use (Figure 2.6). Perceived usefulness is when the user believes task performance can be improved by utilising certain new technologies or information systems. Perceived ease of use refers to how easy it is for an individual to learn or operate new technology or information systems.



*Figure 2.6 Technology acceptance model (Reproduced from Fred D. Davis et al. (1989))*

### 2.2.7 Social Learning Theory (SLT)

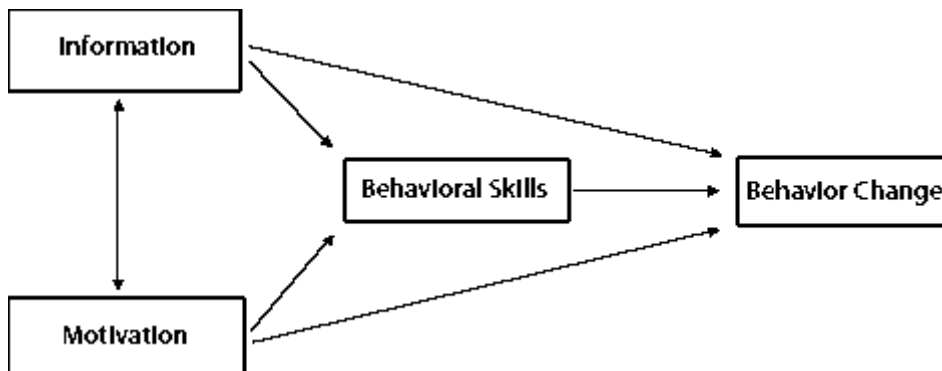
Social learning theory was proposed by (Bandura, 1971) as an improvement over the theories of Skinner and Rotter from the stimulus-response and the interaction of the individual with the environment angles. According to SLT, new behaviour can be acquired by observing and imitating others. Thus, learning is not only behavioural, but is also a cognitive process occurring in a social context. Only observation or direct instruction is required for learning to take place. The need for motor reproduction or direct reinforcement is only partial, which the limitation to its applicability in all contexts. Stimulus modelling by live models (direct demonstration of a behaviour by a person), verbal instruction, or symbolic via media displays are listed. Apart from the type of model, many cognitive and behavioural processes determine the outcome of observation. These processes include: attention, retention, reproduction and motivation. This theory has been applied in criminology, management, education, healthcare, developmental science, psychotherapy, social psychology, media violence etc. Entertainment education via soap operas and advertisement videos are being practised to effect desired social changes.

### **2.2.8 Social Cognitive Theory (SCT)**

This theory was first proposed by (Bandura, 1986) and is based on the understanding that learning is directly associated with observing others within the contexts of social interactions, experiences, and external influences such as media etc. A person first observes the behaviour of another and then uses the sequences and consequences of that behaviour when confronted with a similar situation. The observer may also perform the behaviour while the other person is still in the process of the behaviour. Thus, replication of actions by others helps with learning new behaviours, instead of always trying and succeeding or failing through self-attempts. The outcome the observed person achieves may often determine how the observer chooses to behave. Media is a rich source of examples of behaviour by various types of people in a variety of contexts. SCT is an expansion of SLT, in which the cognitive element has an important place. There is a direct correlation between a person's perceived self-efficacy and behavioural change. Self-efficacy arises from four sources: performance accomplishments, vicarious experience, verbal persuasion, and physiological states. SCT was brought into mass communication contexts in 2001. The significant ways in which symbolic communication can influence human thoughts and actions was stressed by (Bandura, 2001) and extended its application further to healthcare and global issues. A schematic triadic reciprocal causation at personal, behavioural and environmental levels. However, learning can also occur without a change in behaviour. The agentic perspective of SCT comes from individual (own), proxy (others), and collective (social) agencies. The core properties involved in human agencies are: intentionality, forethought, self-reactiveness, and self-reflectiveness. SCT has been applied in mass communication, psychology, healthcare, education, and management. The argument that the mass communication effects of SCT will produce beneficial outcomes is not proved by studies.

### **2.2.9 Information-Motivation-Behavioural-Skills Model (IMB)**

This model was developed by J. D. Fisher and Fisher (1992); (W. A. Fisher, Fisher, & Harman, 2003), especially for healthcare field, but could be used in other contexts also. Information relates to the basic knowledge about a phenomenon. Motivation consists of elements, such as personal attitudes towards the adherence behaviour, perceived social support for such behaviour, and subjective norms or perceptions of how others might behave. Behavioural skills encompasses ensuring possession of the specific behavioural tools or strategies necessary to perform the adherence behaviour, such as enlisting social support and other self-regulatory strategies. Information, motivation, and behavioural skills must directly pertain to a specifically desired behavioural outcome. A model of this theory, given by the (WHO, 2003) is reproduced in Figure 2.7.



*Figure 2.7 Information-Motivation-Behavioural Skills Model (IMB) (WHO, 2003)*

As per the model, information is an absolute necessity for the behaviour change to occur. However, information alone cannot achieve the desired change. Motivation is needed to initiate the action required for the change. In effect, the combination of information and motivation leads to the behavioural skills required for the change. No published examples outside of the medical field are available.

#### **2.2.10 Self-Determination Theory (SDT)**

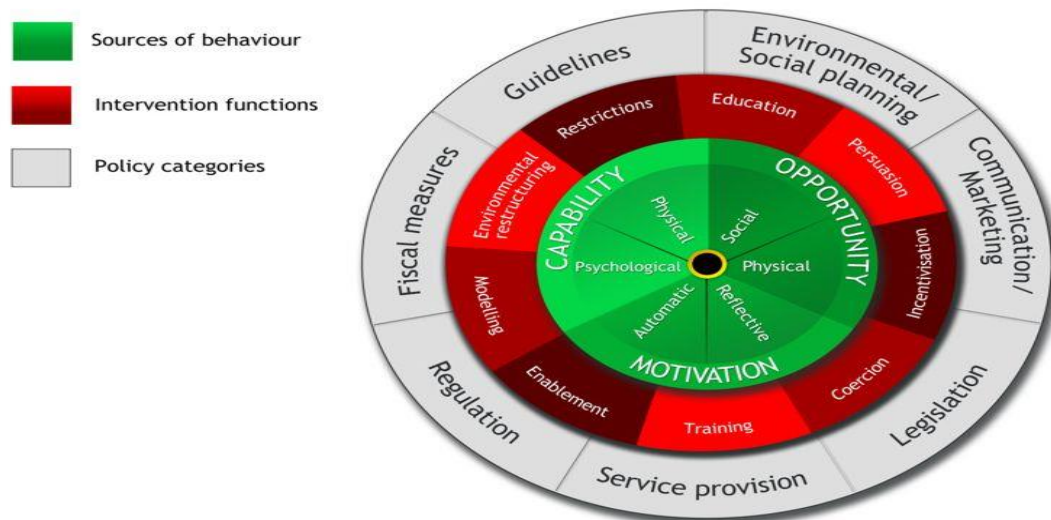
SDT is a macro theory. It deals with the motivation behind the choices individuals make without any external influence; so it becomes self-determination. SDT indicates the degree of an individual's self-determination and self-motivation. The role of intrinsic motivation in individual behaviour was first recognised during the 1980's. The theory of SDT was proposed by (Ryan & Deci, 2000), largely based on intrinsic motivation. The need for competence, autonomy, and relatedness drive intrinsic motivation for appropriate behaviour for psychological health and well-being. SDT has three elements related to human nature: first, inherent proactive nature has the potential to harness inner forces like drive and emotions; second, an inherent tendency towards growth and development and integrated functioning and; third, inherent optimal development and actions do not develop automatically. SDT has been applied in education, alcohol use, and motivational interviewing for initiating behaviour change. There have been many studies on the application of SDT in environmental behaviour. A motivation for environmental scale has been developed to assess the prospect of motivation of any individual towards the environment. The effect of intervention strategies on motivation using SDT has also been studied. Self-determination and perceived autonomy have been found to encourage positive environmental behaviour which is important to understand in relation to littering.

### 2.2.11 The Big Five Personalities

Lewis Goldberg's Big Five personality traits model (also known as the Five Factor model) is known by its acronym, OCEAN, which represents the five traits associated with the personality types to varying degrees. OCEAN stands for Openness (intellect, imagination, or creativity); Conscientiousness (level of care in work and life); Extraversion/Introversion (extraverts are more sociable, drawing energy from the crowd, and find it easier to communicate and work with people); Agreeableness (getting on with people); and Natural reactions (emotional stability, neuroticism, how well stress is managed); Some facets and sub-facets have been identified for each component of OCEAN by DeYoung, Quilty, and Peterson (2007) and Judge, Rodell, Klinger, Simon, and Crawford (2013) (as cited in Manktelow et al. (n.d.)). Individuals with more openness, conscientiousness, extraversion, agreeableness, and emotional stability are likely to be receptive to behaviour change to anti-littering.

### 2.2.12 Behaviour Change Wheel

A behaviour change wheel was proposed by (Michie, Van Stralen, & West, 2011) and is reproduced in Figure 2.8. The model consists of 19 frameworks covering nine categories of intervention functions and seven categories of policies to enable the interventions. The model has, at its centre, the three essential conditions of behaviour change: capability, opportunity, and motivation (COM-B system). From this centre outward are the circles of: the nine intervention functions (aimed at addressing deficits in one or more of these conditions), then the seven categories of policy, which could allow these interventions to occur.



*Figure 2.8 Behaviour change wheel (Michie et al., 2011)*

The theories and models discussed above fall into two categories: theories explaining behaviour patterns and theories indicating methods of behaviour change. The latter type is more relevant and useful in this work. However, if the reason for a specific behaviour is known, methods to change it to the desired behaviour can be devised. Thus, theories of behaviour are also useful.

### **2.3 Research Frameworks.**

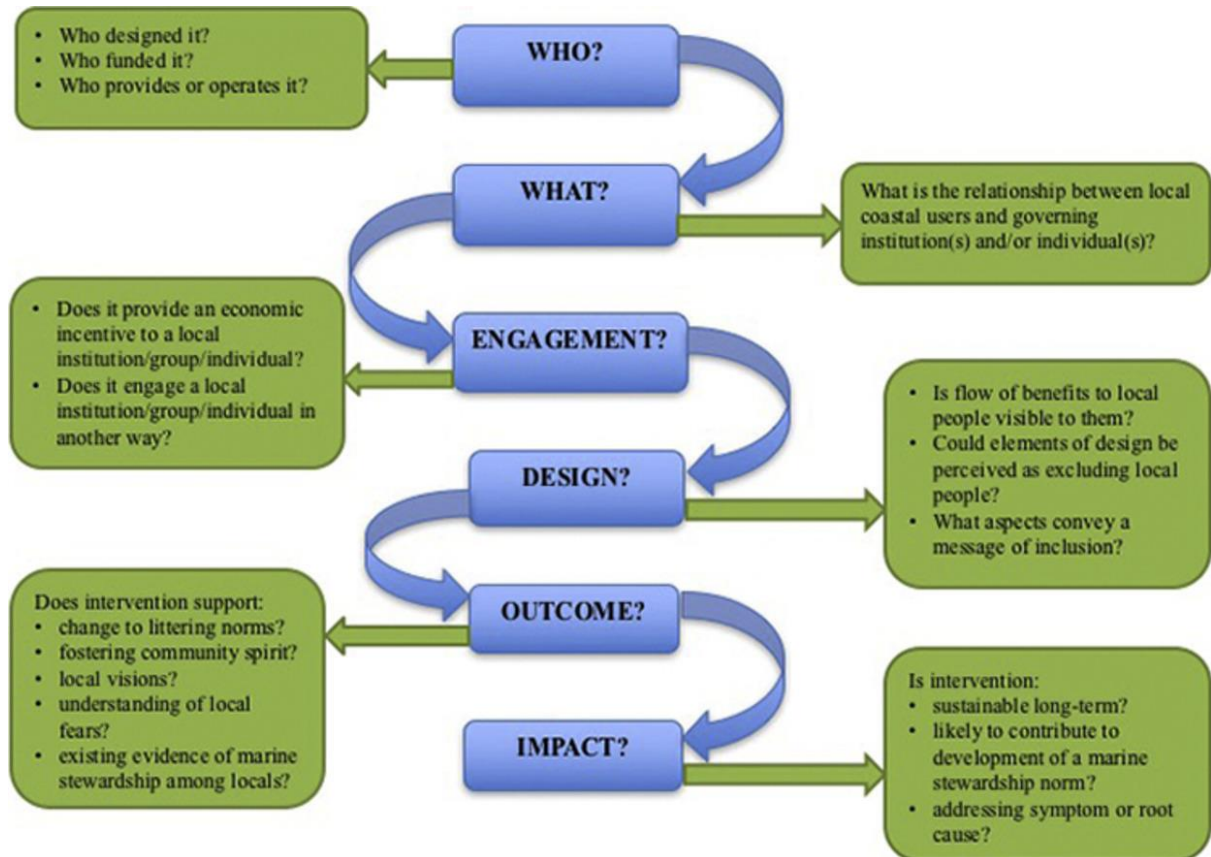
Practice theory has been suggested for conceptualisation and to prevent littering. Practice theory has been successfully applied to sustainable consumption. Practice theory proposes that littering is a by-product of a range of different bundled practices and not as much the result of particular attitudes and behaviours. So, unbundling these practices and changing them can prevent littering behaviour. For example, littering is very common at festivals attended by large public groups and Spotswood and Whitaker (2017) described littering during the Glastonbury Festival as an expensive, pervasive, and environmentally dangerous practice.

Unit pricing systems can contribute to socio-environmental problems like dumping, littering, backyard dumping, and residuals in recycling bins. From a case study of nine unit-pricing cities, Miranda and Bynum (2002) showed that community characteristics of demographic and socio-economic factors are important factors determining the littering and dumping behaviour of people.

Steg and Vlek (2009) have highlighted the importance of a framework to identify a behaviour to be changed, evaluate the factors of this behaviour, design and implement the interventions to change the behaviour, and evaluate their effects. An integrated framework for encouraging pro-environmental behaviour was proposed by Steg et al. (2014). The basic assumption was that pro-environmental behaviours had an element of conflict between hedonic/gain goals and normative goals. There are costs to people to achieve benefits to the environment. In the framework, two methods to encourage pro-environmental behaviour were considered. One was to reduce hedonic and gain costs to decrease conflict between goals. This method is applicable when choices of pro-environment behaviour are costly and may not sustain the actions over a long time. In the second option, normative goals are strengthened. In this case, pro-environmental actions are encouraged, even if they are costly. Here, values and situational factors (that influence the accessibility of these values) will determine the strength of normative goals.

A qualitative study was undertaken by Brennan and Portman (2017) on the perceptions of a small group of Arab-Israeli artisanal fishermen about marine litter and its impact (which is the system to be governed) in the socio-institutional structures context (the system which governs) aimed at managing and protecting the surrounding environment. The authors used interactive governance

theory. The results showed that long term success in reducing marine litter was dependent upon changing the relationship between local people and the government institutions involved in it. People's cooperation was possible only when this was done. The framework in the form of a checklist of effective marine interventions, given by the authors, is reproduced in Figure 2.9.



**Figure 2.9** *The intervention checklist for marine litter control (Brennan & Portman, 2017)*

The value-belief-norm model was applied by Landon, Woosnam, and Boley (2018) to study pro-environmental behaviour of US tourists. According to the hypothesis tested, three dimensions of the theory were: intent related to behaviours that reduce environmental impacts; the consumption of local goods and services; and a willingness to sacrifice time and money to choose sustainable options. Behaviour was assumed to be a function of altruistic values, beliefs, and personal norms. The results verified the hypothesised model. Personal norms explained a large portion of the variance in the pro-sustainable behavioural intentions of the tourists.

Most of these theories and frameworks were applied to pro-environmental or responsible environmental behaviour, waste prevention, reduction etc. rather than directly addressing littering problem. It can be assumed the higher the pro-environmental/responsible attitude, the lower the



tendency to litter. Littering involves throwing unwanted things out in public places. Unwanted things are wastes. So, if the individual is interested in minimising waste by reducing, preventing, or recycling, then less waste is available for littering. Therefore, all research discussed above are applicable to littering behaviour and to this study.

### **2.3.1 Behavioural Change and Enjoyment**

This section will focus on whether individuals who change their behaviour to be anti-littering enjoy the outcomes of this change. Research has shown that the perceived cost of changing a behaviour is greater than any individual benefit however it is very beneficial for the community.

Various aspects of the Tangalooma Dolphin Feeding Programme for tourists were evaluated (Orams, 1997) and it was found that participating in an environment friendly dolphin feeding increased enjoyment for the majority of the tourists. Results obtained by McCarty and Shrum (1994) have suggested that if an individual values excitement, fun, and enjoyment, that individual will consider that recycling solid wastes is important. However, this relationship did not lead to actual behavioural change.

The works discussed here are not directly related to the topic. From them it can be very generally assumed that a voluntary change in behaviour may lead to enjoyment and an enforced change in behaviour will not lead to enjoyment in any matter, including littering behaviour.

### **2.3.2 User Profiles in an AR System for Determining Behavioural Change**

Some user profiles can be derived from research that shows the types of people who are more likely to litter. It is necessary that social marketing with an AR-enhanced message should reach the majority of individuals who engage in littering behaviour, voluntarily or willingly.

### **2.3.3 Big Five Personalities (OCEAN) and Theory of Planned Behaviour (TPB).**

In Picazo-Vela, Chou, Melcher, and Pearson (2010) study, out of the Big Five factors, attitude, perceived pressure, neuroticism, and conscientiousness were found to be predictors of a customer's intention to provide an online review for online trade. The authors used an extended version of TPB and the Big Five personality traits. The possible effect of the Big Five traits on TPB have been discussed by Ajzen (2011) with respect to the generally observed tendency of a person to compare himself/herself with a few others, the predictive validity of intentions compared to the perceived prototype similarity and individual differences, which are stable and capable of influencing the different predictors in the TPB in different ways. From the results of the first study on the effect of personality traits (OCEAN) on intentions and behaviour (TPB), Conner and Abraham (2001) noted that there was partial mediation by cognition of the effect of

conscientiousness on intention. This study was aimed at intentions to engage in the goal-directed activity of health protection. In the second study, predictions of intentions and a more specific self-reported behaviour related to both health protection and exercise, were examined. Conscientiousness fully mediated its effect on intentions in both cases. These results showed that a more sufficient account of the determinants of intentions and behaviour is provided when personality traits are combined with cognitions. According to Hoyt, Rhodes, Hausenblas, and Giacobbi (2009), extraversion and conscientiousness of the five factor model and self-discipline were independent predictors of exercise behaviour. Activity and self-discipline and the TPB constructs of affective attitude, instrumental attitude, and subjective norms had indirect effects on exercise behaviour, which was mediated through intention and perceived behavioural control. Neuroticism (anxiety), from the five factor model, moderated the relationship between the intention and behaviour. Most other works have also been done on health-related behaviour, mainly exercise. In their study on the relationship of the five factor model to knowledge sharing behaviour, Teh, Yong, Chong, and Yew (2011) observed a positive relationship to extraversion, neuroticism, and subjective norms and a negative relationship to openness to experience with the attitude towards knowledge sharing. Both attitude towards knowledge sharing and subjective norms were independently related with the intention to share knowledge, which significantly influenced the actual knowledge sharing behaviour.

#### **2.3.4 Five Factor Model and Technology Acceptance Model**

The Technology Acceptance Model (TAM) is based on TRA. Perceived usefulness and ease of use are the two determining factors of attitudes towards technology and its acceptance. This theory is also linked with the Information System (IS) theory. Fred D. Davis et al. (1989), who proposed the original theory, added behavioural intentions and cultural orientation later on, as well as beliefs about the system, social influence, and others' normative behaviour. Attitude and behavioural intention are also part of TRA (IGIGlobal, 2018).

In a study on the usefulness of the five factor model for technology acceptance and use related to information systems (IS), Devaraj, Easley, and Crant (2008) found that personality dimensions may be useful predictors of attitudes and beliefs of IS users. The relationship between intention to use and system use was also strongly supported by the findings. Ehrenberg, Juckes, White, and Walsh (2008) studied the effect of university students' personalities and self-esteem on use of communication technologies and found that disagreeable individuals spent more time on calls compared with extraverted and neurotic individuals who spent more time text messaging. Disagreeable individuals and those with lower self-esteem also spent more time instant messaging.

Neurotic individuals were found to have more addictive tendencies to mobile phones and stronger IM addictive tendencies were noted among disagreeable and low self-esteem individuals.

## **2.4 Chapter Summary**

TRA, TPB, OCEAN, and TTM were some theories which have been explained and research done on the application of these theories to littering was reviewed. Very few works were found to directly address the topic. Most works dealt with pro/sustainable environmental behaviour, especially of tourists. Marine littering also attracted some research. Considering that littering in urban areas is most problematic, the lack of research in this field is surprising.

TRA can be used to explain sustainable attitudes as being mediated by an individual's home country culture of pragmatism and sustainability perceptions and behaviour (Hofstede, 2017). Social norms were found to be the highest predictor of pro-environmental behaviour related to marine litter, whereas personal attitudes had a limited influence. In the case of marine littering prevention, the behaviour of individuals and groups may be influenced by knowledge, attitudes, and concerns about the environment. These factors may lead to motivation to act on solutions (Gusmerotti et al., 2016). Expectancy value models provide a framework for the relationship between attitudes and beliefs. The value of the outcome is derived from the subjective value placed on the outcome. Based on this principle, it is possible to motivate a person to perform a behaviour that will lead to a highly valued outcome (Blue, 1995). TPB has been used more in studying pro-environmental behaviour. Intention to recycle was predicted by attitudes, perceived control, and personal norms (Nigbur et al., 2010). TPB was best suitable to predict self-reported environmentally responsible behaviour (Chao & Lam, 2011). TPB was more suitable to predict specific behavioural intentions only (Goh et al., 2017). TAM suggests that the users' intention towards technology is influenced by its perceived usefulness and perceived ease of use.

Many of the works reviewed did not use the correct methodology of direct observation. Rather, they relied on self-reported survey responses and interviews, which have inherent subjective bias, as the issue uncovered is negative social behaviour.

The inter-relationship between theories in the littering context has also been very poorly researched. Although the littering problem has been highlighted well in a few Australian publications from different states, there has been very little research work on this topic and its connection with various theories.

The gaps in the research literature are obvious. Australia needs more serious research work on

littering, especially in terrestrial public places. Data collected through observational studies, supported with surveys or interviews, need to be examined for their theoretical underpinnings with TRA, TRB, the five factor model, TTM and other theories and their inter-relationships in the matter of littering. From these findings a coherent picture of littering in Australian public places needs to be derived. This is what was envisaged and achieved in this research. The integration of TAM and TPB were used by many technology acceptance studies (Kamariah, Mat, & Ilham, 2008; Lu, Huang, & Lo, 2010; Sentosa & Mat, 2012; Singh, 2015). Additionally, the big five personality traits model also was integrated with TAM model (Sullivan, 2012). Therefore, these three models (TPB, TAM and personality traits) are the most suitable for this research.

The next chapter will describe the methodology used in this research considering the gaps identified in this chapter.

# **CHAPTER 3: Research Methodology**

### **3.1 Introduction**

This chapter illustrates the research framework and the methodology of the thesis. Mixed methods research was applied to determine the correlations between the personality traits, anti-littering behaviour, and the acceptance, or non-acceptance, of the environmental awareness augmented reality app (EVA), as measured by C-TAM-TPB. Additionally, a gamification method has been utilised by this research; therefore, perceived enjoyment factor is also examined in this study.

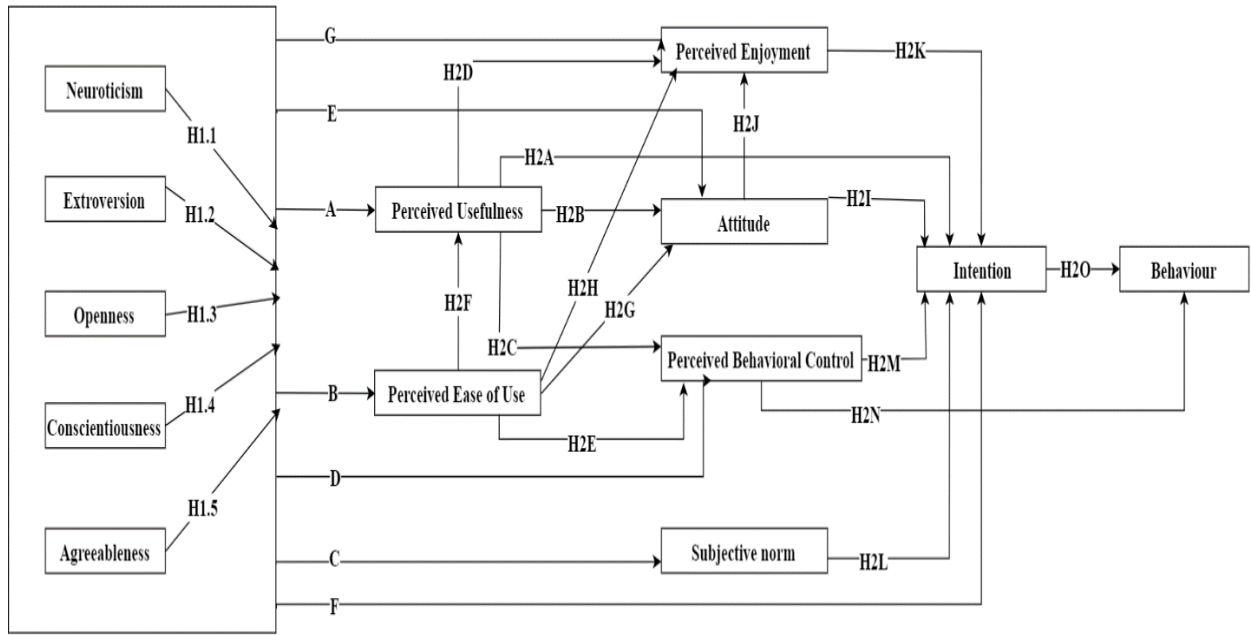
This research broadens several studies on the integration of TAM and TPB (Lu et al., 2010) (Sentosa & Mat, 2012) along with studies where the personality model and TAM were integrated (Lin & Ong, 2010) (Devaraj et al., 2008), by hypothesising that the Big Five personality types are positively correlated to the behaviour intention to utilise and accept an environmental awareness augmented reality app (EVA), as measured by C-TAM-TPB and the perceived enjoyment factor.

### **3.2 Theoretical Framework**

The TAM model has been well used as a measurement of technology acceptance. Additionally, it provides a sufficient prediction rate for individual technology acceptance. Our assumption is that through combining C-TAM-TPB and the Big Five personality traits we can predict individual technology acceptance and behaviour intention. We added perceived enjoyment to the study model because it has been shown that individual values such as, excitement, fun, and enjoyment, could promote that individual to consider pro-environmental behaviour (McCarty & Shrum, 1994). The gamification element has shown to increase the users' productivity (Hervas et al., 2017) and produce an enjoyable environment to foster engagement among users (Wee & Choong, 2019), (Lounis et al., 2014). Therefore, a number of gamification elements such as (competition, scoring leaderboard) were utilised in this research to examine the impacts of gamification. Bandura (1986) stated that replication of actions by others helps with learning new behaviours, therefore, a repetitive game approach was applied. The game requires the user to drag numbers of litter items repeatedly to the rubbish bin to get higher scores to win the game.

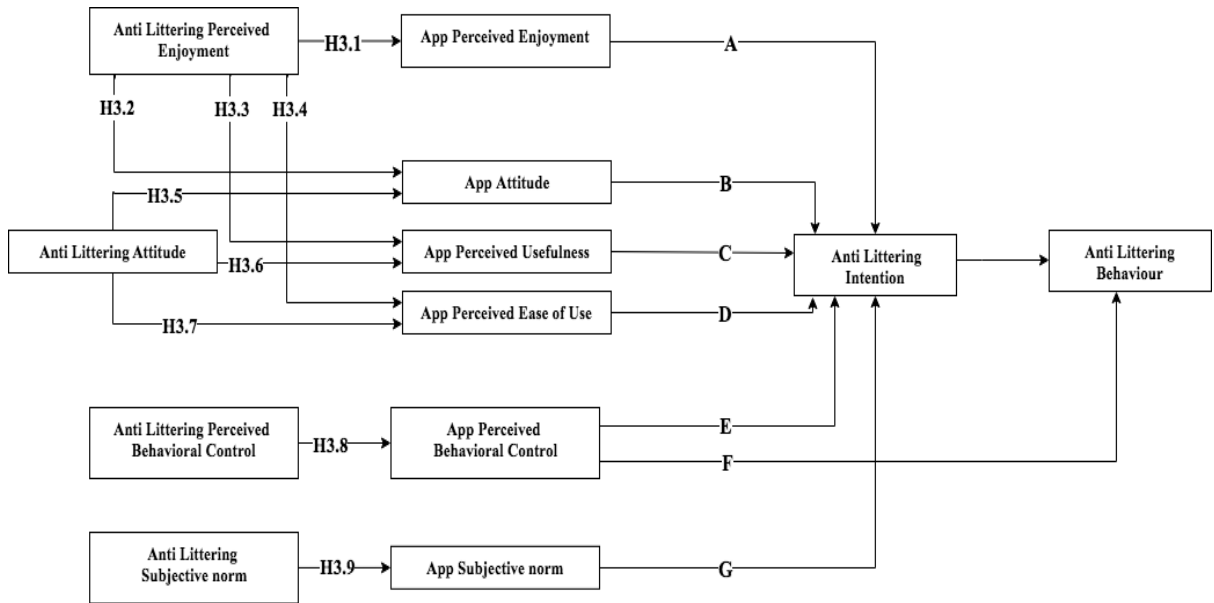
Experimental research techniques were employed to investigate existing phenomena. Therefore, three different versions of the mobile app (EVA) were utilised by this study to determine which version would be the best fit for the proposed model. EVA 1, a standard mobile application (control variable), was examined and compared with two other treatment variables, EVA 2 (AR mobile app) and EVA 3 (AR mobile app plus AR game). The study will be conducted in two different cultural environments Australia and Saudi Arabia.

Figure 3.1 illustrates the technology acceptance research model of this study and the hypotheses of the first and second research questions. The left side of the acceptance model includes the five personality traits (Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism), while the right side includes combined factors of TAM and TPB models (attitude, perceived behaviour control, subjective norm, perceived ease of use, perceived usefulness, intention) plus the perceived enjoyment factor. Finally, the dependent factor, the actual usage of an AR system, as included in the right side of the model. The study hypotheses are highlighted in the model.



**Figure 3.1 Research model for technology acceptance**

Another model was also utilised to examine the relationships between the acceptance of the EVA app and anti-littering behaviour, which is shown in Figure 3.2. The hypotheses of the third research question are highlighted in the same figure. The left side of the model includes four of the antilittering independent variables (anti-littering perceived enjoyment, anti-littering attitude, anti-littering perceived behaviour control, anti-littering subjective norm). The middle side of the models includes the mediator variables (App perceived enjoyment, App attitude, App perceived behaviour control, App subjective norm, App perceived ease of use, App perceived usefulness). The right side of the model includes another independent variable (Anti-littering behaviour intention) and the dependent variable (Anti-littering behaviour).



**Figure 3.2 Anti-Littering Research Model**

As demonstrated in the model (Figure 3.1), there are five personality dimensions namely: Extraversion, Agreeableness, Conscientiousness, Neuroticism and Openness as defined in Table 3.1.

**Table 3.1 Definition of the Big-5 Personality Dimensions**

Factors	Definitions
Extraversion	“Tendency to be outgoing, assertive, active, and excitement seeking.” (Barrick & Mount, 1991, p. 3)
Agreeableness	“Tendencies to be kind, gentle, trusting, and trustworthy.” (Barrick & Mount, 1991, p. 4)
Conscientiousness	“Tendency to be thorough, responsible, organized, hardworking, achievement oriented, and persevering.” (Barrick & Mount, 1991, p. 4)
Neuroticism	“Tendency to be anxious, fearful, depressed and moody.” (Barrick & Mount, 1991, p. 4)
Openness	“Tendency to be creative, imaginative, nonconforming, experimentative, perceptive, and thoughtful.” (Barrick & Mount, 1991, p. 5)



**Table 3.2 Definition of the independent constructs**

<b>Factors</b>	<b>Abbreviations</b>	<b>Definitions</b>
Perceived Usefulness	PE	“The degree to which a person believes that using a particular system would enhance his or her performance.” (Jen, Lu, & Liu, 2009)
Perceived Ease of Use	PEOU	“The degree to which a person believes that using a system would be free of effort.” (Jen et al., 2009)
Subjective Norm	SN	“The person’s perception that most people who are important to him think he should or should not perform the behaviour in question.” (Jen et al., 2009)
Perceived Behavioural Control	PBC	“Reflects perceptions of internal and external constraint on behaviour and encompasses self-efficacy, resource facilitating condition, and technology facilitating.” (Jen et al., 2009)
Attitude Toward Using	ATU	“An individual’s positive or negative feelings about performing the target behaviour.” (Jen et al., 2009)
Behavioural Intention	In littering (BI) In App (UI)	“A measurement of the strength of one’s intention to perform a specified behaviour.” (Jen et al., 2009)
Perceived enjoyment	PE	“The extent to which the activity of using the computer is perceived to be enjoyable in its own right, apart from any performance consequences that may be anticipated” (Davis & Wiedenbeck (2001), as cited (Zhou & Feng, 2017))

The main dependent variables are defined in Table 3.3.

**Table 3.3 Definition of the dependent constructs**

<b>Factors</b>	<b>Abbreviations</b>	<b>Definitions</b>
Actual system use	UB	“The actual use of each of EVA app versions”
Actual anti-littering behaviour	LB	“The actual anti-littering behaviour requested on the study tasks”

### 3.3 Research Questions and Hypotheses

The research questions focused on the analysis in order to gain the required information to achieve the research objective; that is, the acceptance of AR technology in the environmental awareness domain. Therefore, they provide a contextual framework for the thesis. The research questions were framed to examine the pertinent dependent and independent variables of the proposed model, which may affect acceptance of AR technology.

A number of significant independent variables have been tested in this research: These are

- The five main personality types: Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness (Barrick & Mount, 1991).
- The independent factors of the TAM and TPB models: Perceived Usefulness, Perceived Ease of Use, Subjective Norm, Perceived Behavioural Control, Attitude and Behavioural Intention (Jen et al., 2009).
- Perceived Enjoyment factor (Davis & Wiedenbeck (2001) as cited in (Zhou & Feng, 2017)).

The research questions are as follows:

#### 3.3.1 Research Question 1 and Associated Hypotheses

*Research Question 1:* What are the correlations between the Big Five personality traits (OCEAN) and the acceptance of the environmental awareness augmented reality app (EVA), as measured by C-TAM-TPB-PE?

The associated positive hypotheses of the first research question are illustrated in Table 3.4

*Table 3.4 the associated hypotheses of the first research question*

Hyp	Correlation Relationship
H1.1A	<b>Neuroticism</b> and <b>Perceived Usefulness</b> of EVA app
H1.1B	<b>Neuroticism</b> and <b>Perceived Ease of Use</b> of EVA app
H1.1c	<b>Neuroticism</b> and <b>Subjective Norm</b> towards the use of EVA app
H1.1d	<b>Neuroticism</b> and <b>Perceived Behavioural Control</b> towards the use of EVA app
H1.1E	<b>Neuroticism</b> and <b>Attitude</b> towards the use of EVA app

H1.1F	<b>Neuroticism</b> and <b>Behavioural Intention</b> towards the use of EVA app
H1.1G	<b>Neuroticism</b> and <b>Perceived Enjoyment</b> of the use of EVA app.
H1.2A	<b>Extraversion</b> and <b>Perceived Usefulness</b> of EVA app
H1.2B	<b>Extraversion</b> and <b>Perceived Ease of Use</b> of EVA app
H1.2C	<b>Extraversion</b> and <b>Subjective Norm</b> towards the use of EVA app
H1.2D	<b>Extraversion</b> and <b>Perceived Behavioural Control</b> towards the use of EVA app
H1.2E	<b>Extraversion</b> and <b>Attitude</b> towards the use of EVA app
H1.2F	<b>Extraversion</b> and <b>Behavioural Intention</b> towards the use of EVA app
H1.2G	<b>Extraversion</b> and <b>Perceived Enjoyment</b> of the use of EVA app
H1.3A	<b>Openness</b> and <b>Perceived Usefulness</b> of EVA app
H1.3B	<b>Openness</b> and <b>Perceived Ease of Use</b> of EVA app
H1.3C	<b>Openness</b> and <b>Subjective Norm</b> towards the use of EVA app
H1.3D	<b>Openness</b> and <b>Perceived Behavioural Control</b> towards the use of EVA app
H1.3E	<b>Openness</b> and <b>Attitude</b> towards the use of EVA app
H1.3F	<b>Openness</b> and <b>Behavioural Intention</b> towards the use of EVA app
H1.3G	<b>Openness</b> and <b>Perceived Enjoyment</b> of the use of EVA app
H1.4A	<b>Conscientiousness</b> and <b>Perceived Usefulness</b> of EVA app
H1.4B	<b>Conscientiousness</b> and <b>Perceived Ease of Use</b> of EVA app
H1.4C	<b>Conscientiousness</b> and <b>Subjective Norm</b> towards the use of EVA app
H1.4D	<b>Conscientiousness</b> and <b>Perceived Behavioural Control</b> towards the use of EVA app
H1.4E	<b>Conscientiousness</b> and <b>Attitude</b> towards the use of EVA app
H1.4F	<b>Conscientiousness</b> and <b>Behavioural Intention</b> towards the use of EVA app

H1.4G	<b>Conscientiousness</b> and <b>Perceived Enjoyment</b> of the use of EVA app
H1.5A	<b>Agreeableness</b> and <b>Perceived Usefulness</b> of EVA app
H1.5B	<b>Agreeableness</b> and <b>Perceived Ease of Use</b> of EVA app
H1.5C	<b>Agreeableness</b> and <b>Subjective Norm</b> towards the use of EVA app
H1.5D	<b>Agreeableness</b> and <b>Perceived Behavioural Control</b> towards the use of EVA app
H1.5E	<b>Agreeableness</b> and <b>Attitude</b> towards the use of EVA app
H1.5F	<b>Agreeableness</b> and <b>Behavioural Intention</b> towards the use of EVA app
H1.5G	<b>Agreeableness</b> and <b>Perceived Enjoyment</b> of the use of EVA app

### 3.3.2 Research Question 2 and Associated Hypotheses

*Research Question 2:* What are the correlations between independent variables of C-TAM-TPB and perceived enjoyment and the study dependent variables?

The associated positive hypotheses of the second research question are illustrated in Table 3.5.

*Table 3.5 the associated hypotheses of the second research question*

<b>Hyp</b>	<b>Correlation Relationship</b>
H2A	<b>Perceived Usefulness</b> and <b>Intention</b> to adopt and use EVA system
H2B	<b>Perceived Usefulness</b> and <b>Attitude</b> towards the use of EVA system
H2C	<b>Perceived Usefulness</b> and <b>Perceived Behavioural Control</b> towards the use of EVA system
H2D	<b>Perceived Usefulness</b> and <b>Perceived Enjoyment</b> towards the use of EVA system
H2E	<b>Perceived Ease of Use</b> and <b>Perceived Behavioural Control</b> towards the use of EVA system
H2F	<b>Perceived Ease of Use</b> and <b>Perceived Usefulness</b> of EVA system
H2G	<b>Perceived Ease of Use</b> and <b>Attitude</b> towards the use of EVA system

H2H	<b>Perceived Ease of Use</b> and <b>Perceived Enjoyment</b> towards the use of EVA system
H2I	<b>Attitude</b> and <b>Intention</b> to adopt and use EVA system
H2J	<b>Attitude</b> and <b>Perceived Enjoyment</b> towards the use of EVA system
H2K	<b>Perceived Enjoyment</b> and <b>Intention</b> to adopt and use EVA system
H2L	<b>Subjective Norm</b> and <b>Intention</b> to adopt and use EVA system
H2M	<b>Perceived Behavioural Control</b> and <b>Intention</b> to adopt and use EVA system
H2N	<b>Perceived Behavioural Control</b> and <b>Behavioural Use</b> of EVA system
H2O	<b>Intention</b> and <b>Behavioural Use</b> of EVA system

### 3.3.3 Research Question 3 and Associated Hypotheses

*Research Question 3: To what extent does Technology Acceptance of EVA mediate the relationship between independent variables and dependent variables of anti-littering research model?*

The associated positive hypotheses of the third research question are illustrated in Table 3.6.

*Table 3.6 the associated hypotheses of the third research question*

Hyp	Mediation Relationship
H3.1A	EVA app <b>Perceived Enjoyment</b> between anti-littering ( <b>Perceived Enjoyment</b> and <b>Intention</b> )
H3.2B	EVA app <b>Attitude</b> between anti-littering ( <b>Perceived Enjoyment</b> and <b>Intention</b> )
H3.5B	EVA app <b>Attitude</b> between anti-littering ( <b>Attitude</b> and <b>Intention</b> )
H3.3C	EVA app <b>Perceived Usefulness</b> between anti-littering ( <b>Perceived Enjoyment</b> and <b>Intention</b> )
H3.6C	EVA app <b>Perceived Usefulness</b> between anti-littering ( <b>Attitude</b> and <b>Intention</b> )
H3.4D	EVA app <b>Perceived Ease of Use</b> between anti-littering ( <b>Perceived Enjoyment</b> and <b>Intention</b> )

H3.7D	EVA app <b>Perceived Ease of Use</b> between anti-littering ( <b>Attitude</b> and <b>Intention</b> )
H3.8E	EVA app <b>Perceived Behavioural Control</b> between anti-littering ( <b>Perceived Behavioural Control</b> and <b>Intention</b> )
H3.8F	EVA app <b>Perceived Behavioural Control</b> between anti-littering ( <b>Perceived Behavioural Control</b> and <b>Behaviour</b> )
H3.9G	EVA app <b>Subjective Norm</b> between anti-littering ( <b>Subjective Norm</b> and <b>Intention</b> )

### 3.3.4 Research Question 4 and Associated Hypotheses

*Research Question 4: Is there a significant difference between the mean littering scores of V1 (control) and V2, and V1 (control) and V3, and V2 and V3?*

H4A: The mean littering scores of EVA V2 is significantly better than the mean littering scores of V1.

H4B: The mean littering scores of EVA V3 is significantly better than the mean littering scores of V1.

H4C: The mean littering scores of EVA V3 is significantly better than the mean littering scores of V2.

### 3.4 Research Plan

This research is based on mixed research methods, whereby researchers adapt quantitative and qualitative research plan to examine the existence of relationships between the study's measured variables. Within-subjects design was utilised in this research to formulate the experiment of the three different conditions (versions) of the study environmental awareness app EVA, to determine the relationship, if any, between measured variables and compare the effect of these three conditions on that relationship. Gergle and Tan (2014) stated that the key benefit of within-subjects design is that the same participants can effectively serve as their own control where they are tested under various conditions. Additionally, a within-subjects design is more precise for identifying differences across conditions, when there is a large number of individual variance because the differences within an individual experiencing the conditions can be highlighted (Gergle & Tan, 2014). Another advantage of employing within-subjects design is that it can be very efficient, as the number of participants necessary to illustrate a significant difference among experimental conditions is decreased in comparison to other experimental design methods, such as between-

subjects design (Gergle & Tan, 2014).

However, the key drawback to the within-subjects design is that the learned experience of the study's previous conditions may impact the participants' behaviour in the current examined condition (Gergle & Tan, 2014). To overcome this particular issue, the participants were randomly assigned to three groups. All these groups used each of the EVA versions in a different order. Additionally, randomising the usage order of the EVA versions on the study tasks will help prevent participants from jumping to any conclusion.

### **3.5 Physical Setup**

The Australian case study had one physical setup as there is only one campus at Macquarie University. Therefore, copies of an anti-littering poster were placed in three different locations at Macquarie University Campus, which were identified as having a high proportion of littering behaviour. Likewise, three different locations at Aljouf University were chosen at each of the two university campuses (as female and male students study separately, there are two campuses at Aljouf University). 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.

### **3.6 Instrumentation**

Different questionnaires were adopted by this research. The littering survey was adapted using ("Don't Trash Arizona," 2015), developed by the Maricopa Association of Governments and Hughes (2010). The brief version of the Big Five Inventory (BFI-10) survey was adapted from Rammstedt and John (2007). The items of PEOU and PU were adapted from Masrom (2007); while UB, SN, and LPB were adapted from Lu et al. (2010). ATLBPB, LPI, and UI scale items were developed from Livesey (1992); whereas, PE and ATU were adapted from Liao, Tsou, and Shu (2015) and Huang (2015), respectively.

### **3.7 Data Collection**

This experimental study was designed to collect quantitative and qualitative results using surveys (littering survey, TPB, BFI-10, and TAM surveys) and the proposed system database. Initially, all of the participants were given the following pre questionnaires:

- BFI-10 questionnaire.
- Littering survey.
- TPB questionnaire regarding anti-littering behaviour.

All groups were involved in three tasks requiring them to visit different geo-locations at Macquarie University and Aljouf University campuses and perform anti-litter behaviour at those locations. Each of these tasks was required while using each of EVA versions. The tasks required them to find and look at the anti-litter posters placed at those locations, use the EVA app, and perform anti-littering behaviour at those locations. The participants were randomly assigned to one of three groups. All the groups used each of the 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 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 were given a post questionnaire consisting of some questions regarding the participants' general opinion of each of the EVA versions and their littering self-reporting at each task.

### **3.8 Sample**

This study follows the typical guidelines for sample sizes in case studies, which is 15 participants for each treatment group. As there are two cases studies (Australian and Saudi case studies) and three treatment groups (control treatment using standard EVA v1, AR treatment using EVA v2, and AR game treatment using EVA v3) for each, the targeted sample size is 90 participants.

A verbal invitation was given to a total of 50 participants at Macquarie University in Australia, of which 40 participants committed to participating. An additional 30 participants were invited by email; however, only 10 of these participated. For the Saudi case study, 35 participants were verbally invited, with 30 agreeing to participate. Another 40 invitations were delivered via email and half of these (20 participants) also agreed to participate in the Saudi case study. However, only 45 Australian participants and 46 Saudi participants successfully completed the experimental study. The qualifying criteria and characteristics for the participants of the Australian and Saudi case studies in this study were:

- Be over the age of 18.
- Have access to an Android device.
- Adequate knowledge on how to use a smartphone.
- Available Internet access.
- Be a visitor, student, or staff member at Macquarie University or Aljouf University.



### 3.9 Procedure

The participants were asked to perform three tasks. All the tasks required them to be at a specific location for their case study. Firstly, they were required to sign the Consent Form and fill out the pre-questionnaire (BFI-10, littering survey (seeking personality details, demographics details, litter awareness, littering behaviour, and attitude), and TPB questionnaires targeting the anti-littering behaviour), which can both be accessed through the provided URL link or QR code on the information sheets. The QR code can be scanned using any QR scanner app from Play store.

After completing the questionnaire, the participants were required to download EVA (V1), EVA (V2), or EVA (V3), dependent on their group, and register a new account through the app. The download page can be accessed using the provided URL or QR code on the information sheet. The same user account can be used to access all EVA versions. The participants were required to visit the task location and use the downloaded EVA version to view the provided litter awareness materials and complete the required task with that version of the EVA. The following tasks were provided by EVA version for the Australian case study. Similar tasks were provided for the Saudi case study.

***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 promotion materials on the 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 promotion materials on the 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 the 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.*

After completing the tasks, they were required to complete post questionnaires (TPB and TAM questionnaires) regarding the EVA version of that task and anti-littering behaviour. Finally, after using all EVA versions and completing all the required tasks, they were given a post questionnaire,

which consisted of questions about the whole experience.

### **3.10 Chapter Summary**

Several theories have been integrated in the theoretical framework of this research. These are TAM, TPB and Big Five personality traits models. Enjoyment factor has been included in the theoretical framework to examine the effect of the AR technology and the gamification element. The gamification element was combined with one of the AR versions of the application developed for this research. Therefore, experimental research techniques were employed to investigate existing phenomena.

This study was conducted in Australia and Saudi Arabia. The research has employed mixed research methods to investigate the existence of relationships between the study's measured variables. The physical setup, the instruments used in this research, the data collection process the sample size and the experimental procedure were included in this chapter. The following chapter is going to highlight the development of the mobile AR application (EVA) used in the experimental part of this research.

# **CHAPTER 4: The Development of an AR Mobile Application**

### 4.1 Introduction

This chapter describes the approach that was taken to develop the mobile AR application. In order to examine the study hypotheses, it was important to develop an anti-littering AR application. There are not currently any anti-littering AR applications available that could be used for this experimental study. The success of the AR mobile game, *Pokémon Go*, was the key motivation for considering AR technology as an approach for anti-littering awareness. Different components were utilised during the implementation stage, such as Unity (game engine), Vuforia (AR library), MySQL (Databased), and Apache (Web Server). A justification of these choices will be given in each of the components' sections.

Unity game engine and Vuforia SDK have been utilised in many mobile AR applications because together they provide a smooth integration. Utilising both components provides developers with the chance to deploy their applications cross-platform. Unity was used to develop three mobile applications versions for this research, while Vuforia SDK integrated in only two of these versions. The back-end components were hosted at VM on the Macquarie University development server to provide a more secure location for the participants' collected data.

In order to confirm that the user's acceptance of the AR system was not only related to the use of a mobile app but to the use of the AR technology, the EVA v1 standard mobile app version was developed and considered as the control case. EVA v2 was used to examine users' acceptance of AR technology and finally, the gamification element was investigated in EVA v3.

In the Saudi case study, EVA apps were translated and deployed in Arabic versions with similar Arabic content to the English versions. The selected treatment locations for both the Australian and the Saudi case studies were identified as having a high level of littering behaviour. The treatment locations of the Australian case study were: near the food court; between two buildings (the Language Institute building and the International Centre building); and the covered car park. The treatment locations for the Saudi case study are as follows: the food court; between the Science and Engineering buildings; and the main car park (See Appendix 9 for the case studies' maps).

This chapter covered the scenario use and system requirements, system architecture, and front-end and back-end components. The front-end components section covered Vuforia SDK, Unity, setting the development environment, and the user interfaces. The back-end components section covered EVA RESTful API, EVA MySQL DB, EVA admin portal, and the file resources directory.

## 4.2 Use Scenario and System Requirements

Let us explain the development of the app with a scenario. Saeed is a student at Macquarie University and he lives in the Student village. He is not concerned about the environment and is not cautious about littering. He frequently throws empty bottles on the ground while he is walking or leaves litter behind when he has lunch at the Campus Hub. He is aware of the importance of recycling, as promoted by different sources of media and environmental campaigns. However, he does not practice anti-littering behaviour. One day, as Saeed walks around the University campus, he finds a poster about an AR Game called EVA. He decides to download the mobile app because he is interested in playing mobile games.

After downloading the EVA app, he is directed to various locations at the campus. He goes to the first location and finds the EVA poster at that location. The location is heavily littered. He starts scanning the poster using the EVA app and AR content appears on the poster. He is amazed by the AR app because it is his first time experiencing interactive AR content. He responds to the anti-littering message for the first time in his life because he plays the AR anti-littering game frequently. The game shows him litter items around the poster and litter bin. He starts dragging the litter items to the litter bin and it is fun because different litter items need to be dragged and placed at a different angle to be correctly put inside in the litter bin during the game time. He gets different scores for different litter items. He has not yet achieved his best score to win the game so, he tries again and again to win the game. He finds that his score is not in the top five at that location, and he tries again to beat the other gamers. Finally, after a while, he reaches the highest score at that location. By that time, he realises that the AR anti-littering content and game he has been playing has positively changed his intention towards littering. Therefore, the EVA app helps him to develop and practice anti-littering habits.

The previous use scenario can be used to highlight the minimum system requirements for developing a mobile AR app for this project. The minimum system requirements were determined by the Vuforia SDK requirements and the IT department of Macquarie University, where the web server of this project was hosted. Table 4.1 consists of the minimum Hardware and software requirements of the web server and the development machine, such as 40 GB of HD and 2 MB of RAM running Linux OS with Apache 2, MySQL 5.5+ and PHP 5.5+ support for the web server and 120GB of HD and 2 MB of RAM running Windows 7 SP1+, 8, 10 or Mac OS X 10.11+ with Unity 5.3.6+ and Vuforia SDK 6.0.112+ for the development machine. Additionally, Table 4.2 illustrates the minimum hardware and software requirements for the supported Android device to run the study's AR mobile app, which are Android 4.0.3+, with an inbuilt 3Megapixel camera.

*Table 4.1 Minimum H-S/W System Requirements for Web Server and Development Machine*

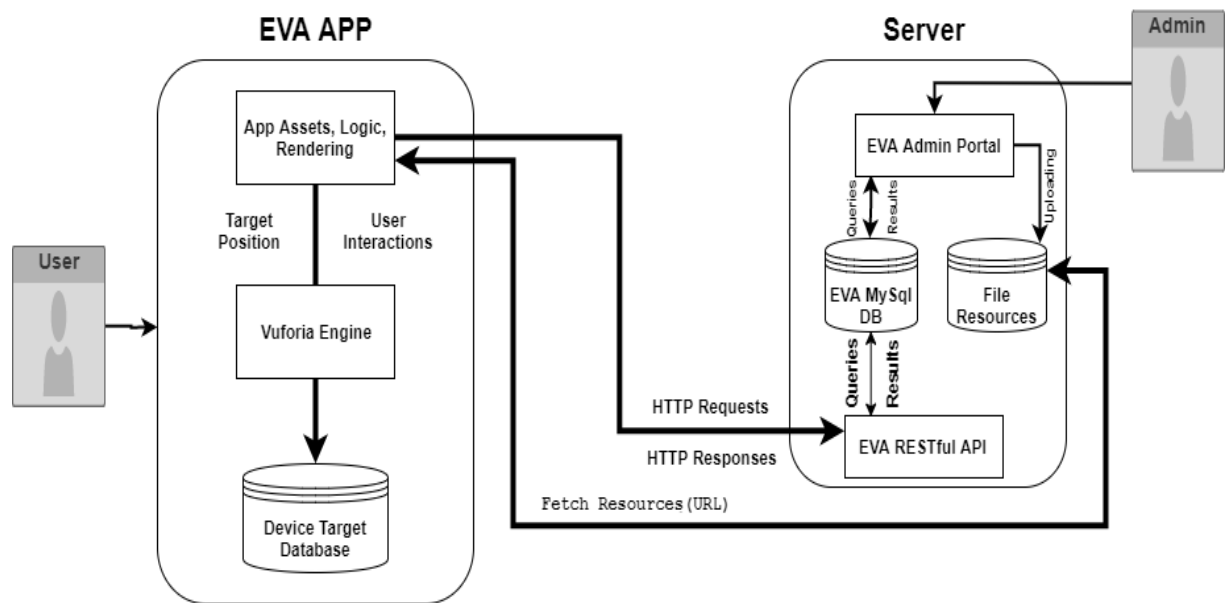
		Web Server	Development Machine
<b>H/W</b>	<b>Processor</b>	Intel(R) Xeon(R) CPU E5-2665 0	Pentium 4 class CPU
	<b>Speed</b>	2.4 GHz	2.4 GHz
	<b>RAM</b>	2 GB	2 GB
	<b>Hard Disk</b>	40 GB	120GB Serial-ATA or better with at least 20GB free
	<b>Graphics</b>	-	Graphics card with DX9 (shader model 3.0) or DX11 with feature level 9.3 capabilities
	<b>USB</b>	-	USB 2.0
<b>S/W</b>	<b>Operating System</b>	VM (Linux 4.4.0-57- generic)	Windows 7 SP1+, 8, 10; Mac OS X 10.11+.
	<b>Debugging Tools</b>	Apache error log	Visual Studio or MonoDevelop debugger
	<b>Programming Language</b>	PHP 5.5+	C#
	<b>Database</b>	MySQL 5.5+	-
	<b>SDKs and Packages</b>	Apache 2	Vuforia SDK 6.0.112+  Android SDK 4.0.3+
	<b>Tool sets</b>	-	Unity 5.3.6+  Android Debug Bridge (ADB)

**Table 4.2 Supporting Devices (Phone Specifications):**

<b>OS</b>	Android 4.0.3 and above
<b>Inbuilt Camera</b>	Yes
<b>Camera Specifications</b>	3Megapixel Camera

### 4.3 System Architecture

This section explains the general concept of the proposed AR system. Figure 4.1 illustrates the general system architecture of the EVA application. The system has two main sets of components, which are the front-end and back-end components. The front-end component is hosted on the client side while the back-end is hosted on the server side. Both of these components will be further discussed in the following section.

**Figure 4.1 EVA system architecture**

### 4.4 Front-end Component (Client: Smartphone)

The EVA application was developed for Android devices. Android is an open source mobile operating system (OS) developed by Google (Kaur & Sharma, 2014). It is one of the most widely used operating systems. The EVA application was built using Unity3d because 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.

The EVA mobile application consisted of three main components: App Assets, Logic and Rendering Engine component, Vuforia Engine, and Device Target Database. The App Assets, Logic and Rendering Engine component makes different http requests to the back-end component to obtain different types of information, such as user profile and tasks, and stores different data for instant user accounts, AR game scores, and users' usage activities. Vuforia Engine is responsible for the augmentation process while all the markers that have been used to show the AR experience were created using a web tool called Vuforia Target Manger, then stored locally in the device target database component.

#### **4.4.1 Vuforia Augmented Reality Framework**

Vuforia is a Software Development Kit (SDK) provided by PTC Inc. It is one of the most used platforms to develop Augmented Reality applications. According to ("Vuforia Developer Library," n.d.) over 60,000 AR applications powered by Vuforia engine technology currently available on the App Store and Google Play. Additionally, there are more than half a million registered developers and more than 45,000 projects in development. Vuforia SDK is available in various operating systems, such as Android, iOS and UWP. In 2017, Vuforia Engine was integrated by Unity, which makes it even easier to develop outstanding AR user experiences for both handheld and headworn devices.

Figure 4.2 demonstrates Vuforia SDK architecture. It supports the following features:

- Callbacks for events (example: on or off target detection)
- High-level access to hardware units (example: Camera start/stop, flashlight on/off)
- Multiple trackables (tracking types)
- Image targets
- Multi targets
- Cylinder targets
- Word targets
- Frame markers
- Real-world interactions
- Virtual buttons



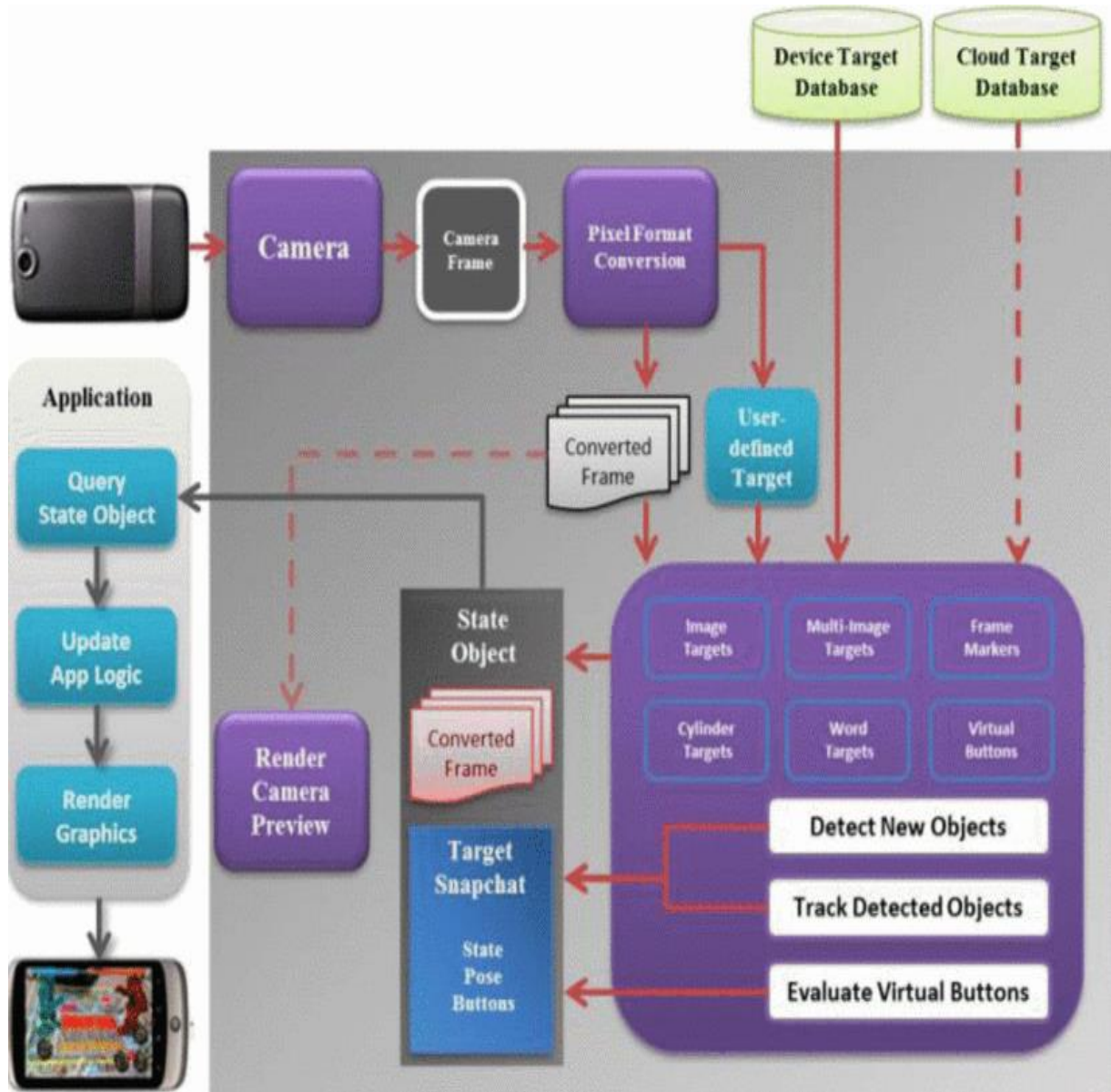


Figure 4.2 Vuforia augmented reality SDK ("Vuforia Developer Library," n.d.)

#### 4.4.2 Unity

Unity is one of most widely used game engine frameworks. It provides the best kit to develop rich, interactive 2D, 3D, VR, and AR experiences ("Unity Public Relations," 2018). Unity supports cross-platform development, where developers can adjust their content for more than 25 platforms. According to ("Unity Public Relations," 2018), three billion devices worldwide run unity apps with more than 24 billion app downloads and 750 downloads per second. Unity developers contribute more than 60% of the available AR/VR content and more than 50% of mobile games. JavaScript and/or C# are used on Unity for development. The GUI interface of Unity helps the new developers in their approach (Patil & Alvares, 2015).

#### **4.4.3 Setting Up The Development Environment**

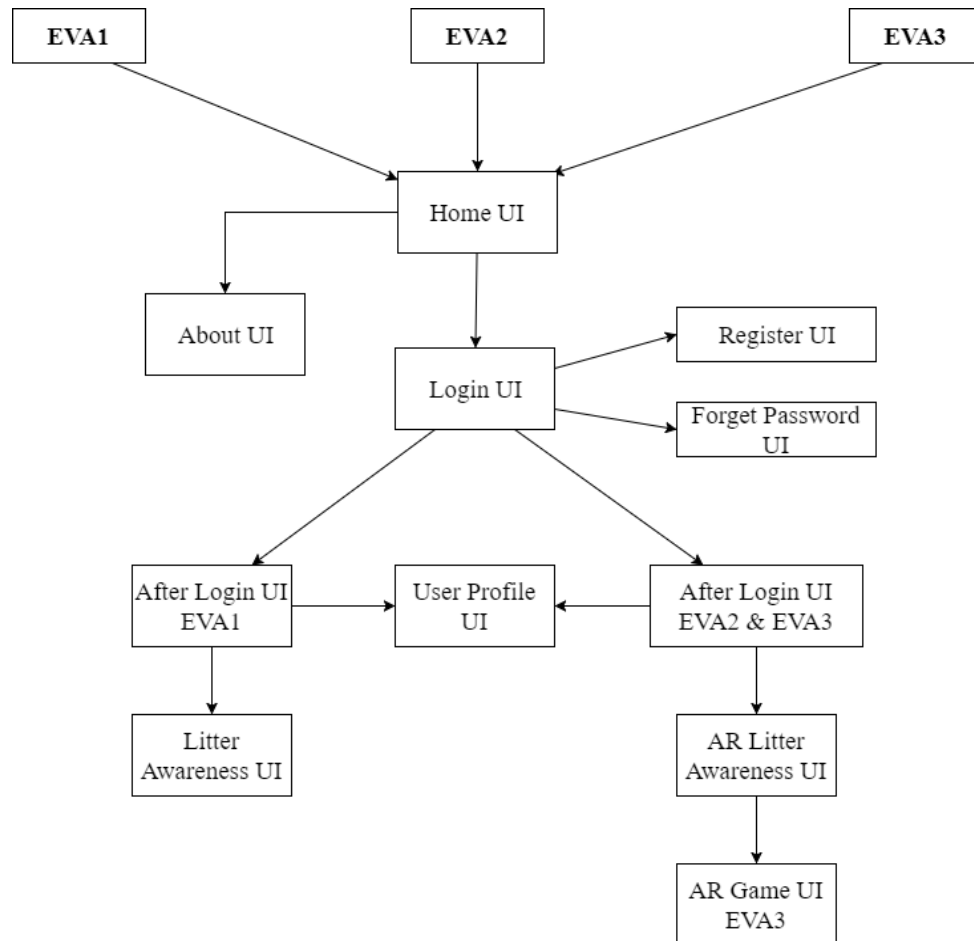
In order to develop the client AR mobile application, a number of packages needed to be installed on the development machine.

- Unity3D V6.2 was installed on the development machine, which was the latest version during the development stage of this research.
- Vuforia SDK 6.2.10 for Unity development was downloaded and imported in the EVA Unity project.
- Vuforia developer license key was created using License Manager at Vuforia developer portal and added in the App License Key field on the Vuforia Configuration panel of the EVA Unity project.
- The EVA Targets database, which includes the markers of this study was created using Target Manager at Vuforia developer portal and imported to the EVA Unity project.
- Android SDK was installed on the development machine and its path included in the Unity preferences option.

After setting up these packages, the development machine was ready for developing the EVA app.

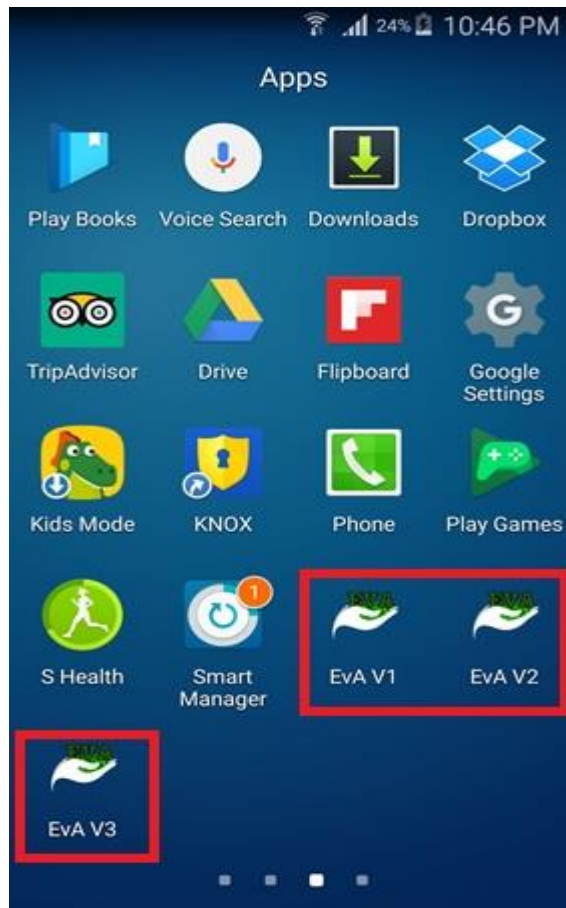
#### 4.4.4 User Interface (UI)

This section illustrates some of the system user interfaces for all of the three versions of the EVA app. Figure 4.3 shows the user interface flow diagram of all of the EVA app versions. Some of the user UIs and layouts were shared across the EVA versions for consistency, in order to only evaluate the targeted variables of this study.



**Figure 4.3 User Interface Flow Diagram**

After installing the EVA app versions, the applications' icons will appear on the user's mobile phone home screen, as can be seen in Figure 4.4. Figure 4.5 illustrates the EVA home UI, which is shared across all EVA versions. It has two main buttons *Login* and *About*. When users clicked on the *About* button, they were directed to the About UI, which can be seen in Figure 4.6 and included some static information about the application. Returning to the Home UI, in Figure 4.5, the *Login* button took the users to the Login UI, see Figure 4.7. The user account handling (Login, Register, and User Profile) was shared among all the EVA versions.

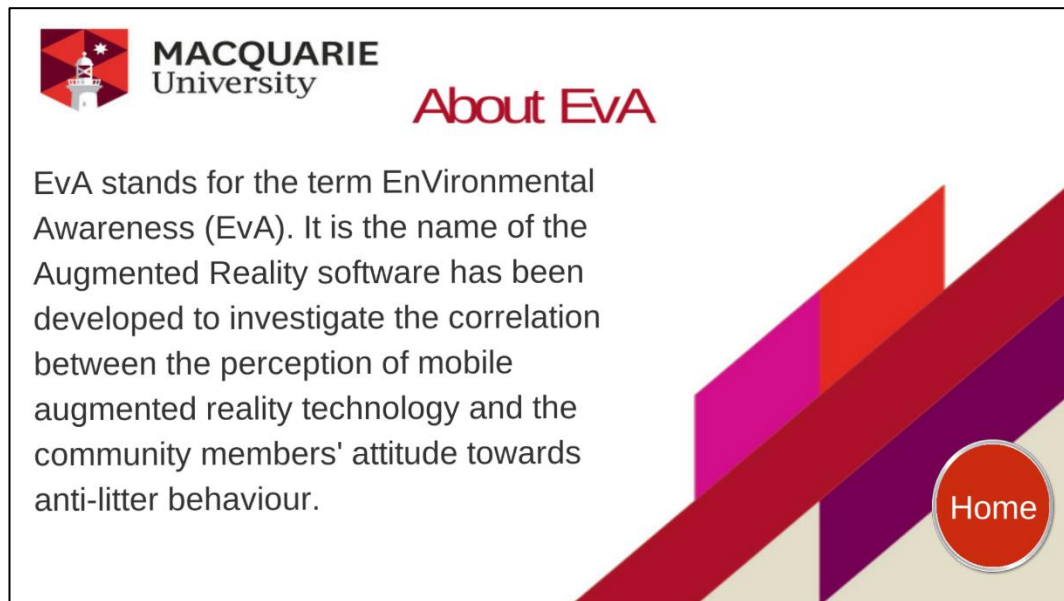


*Figure 4.4 The installed EVA versions*

The Login UI consisted of the login fields: Username and Password. New users could register a new account by clicking the *Register* button on the Login UI (Figure 4.7), which took them to the Register UI (Figure 4.8). All the input fields at the Register UI were required to complete the users' registration.

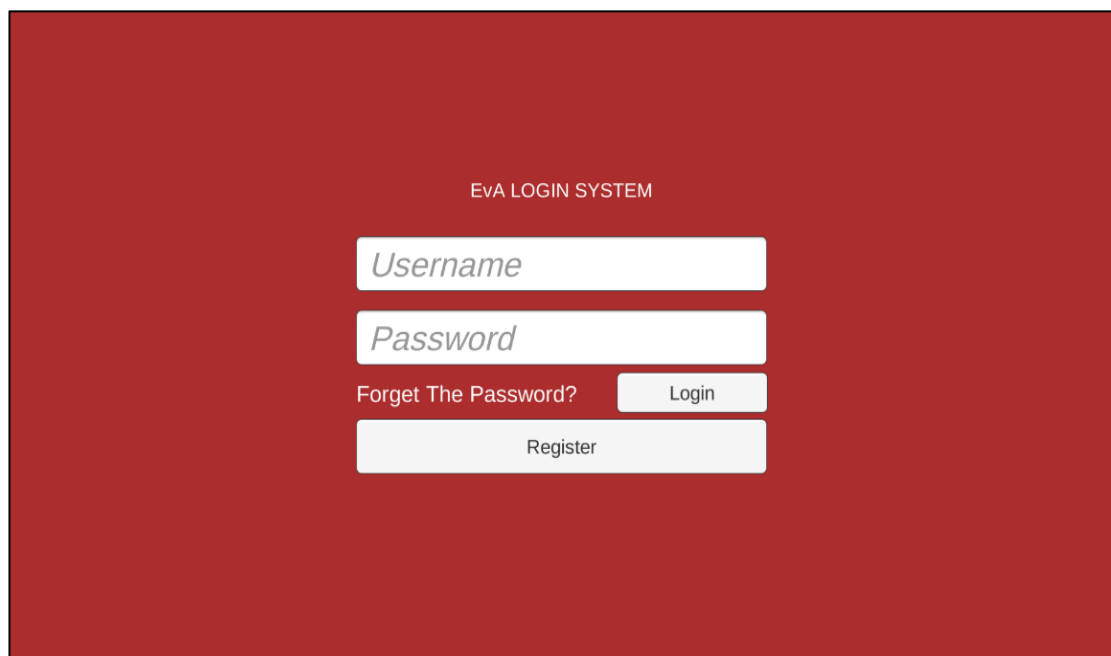


*Figure 4.5 EVA Home UI*



**Figure 4.6 About UI**

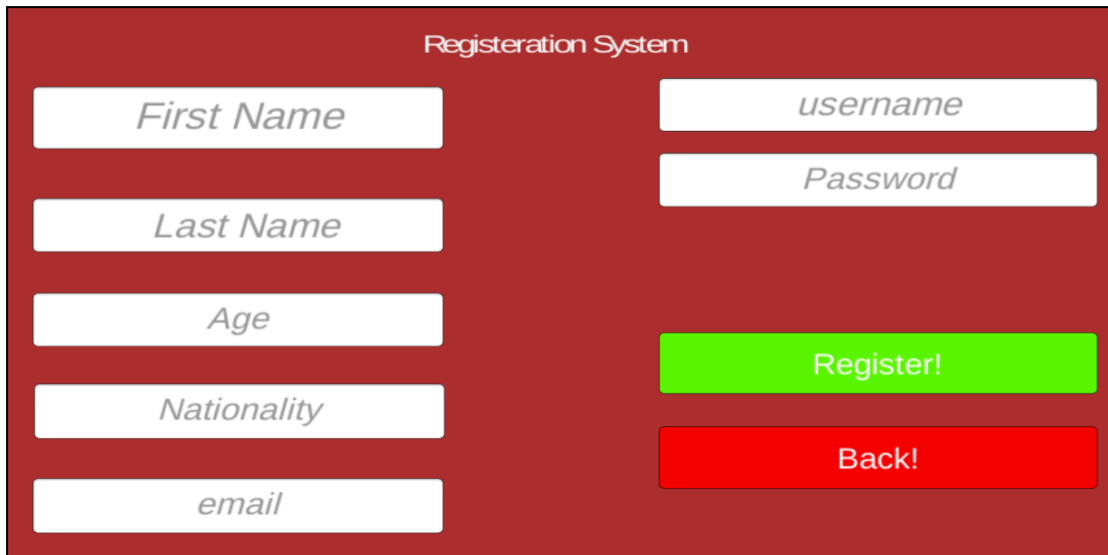
Once the users completed their registration, they were forwarded to the Login UI (Figure 4.7). In Figure 4.9 the registered users can reset their password, if they forget their login details. When logged in, they could update their profile information using the User Profile UI (Figure 4.10); the EVA V1 users saw the UI in Figure 4.11, while the users of EVA V2 and V3 saw the UI in Figure 4.12.



**Figure 4.7 Login UI**

Both UIs had a similar outline and buttons, such as *Task* and *User Profile* buttons. However, while

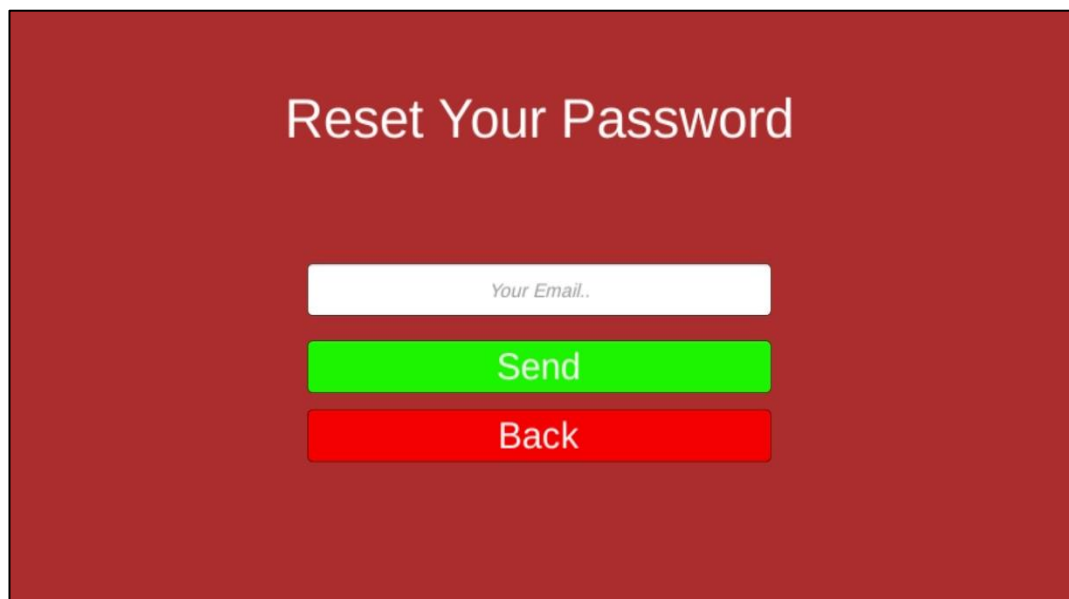
they both had a button leading to the anti-littering materials, the presentation differed between the three versions.



The image shows a user registration interface with a dark red background. At the top, the title "Registration System" is centered in white. Below the title, there are two columns of input fields. The left column contains five white rectangular boxes with the labels "First Name", "Last Name", "Age", "Nationality", and "email" in a light gray font. The right column contains two similar boxes labeled "username" and "Password". Below these input fields, there are two buttons: a bright green "Register!" button and a red "Back!" button, both with white text.

**Figure 4.8 User Registration UI**

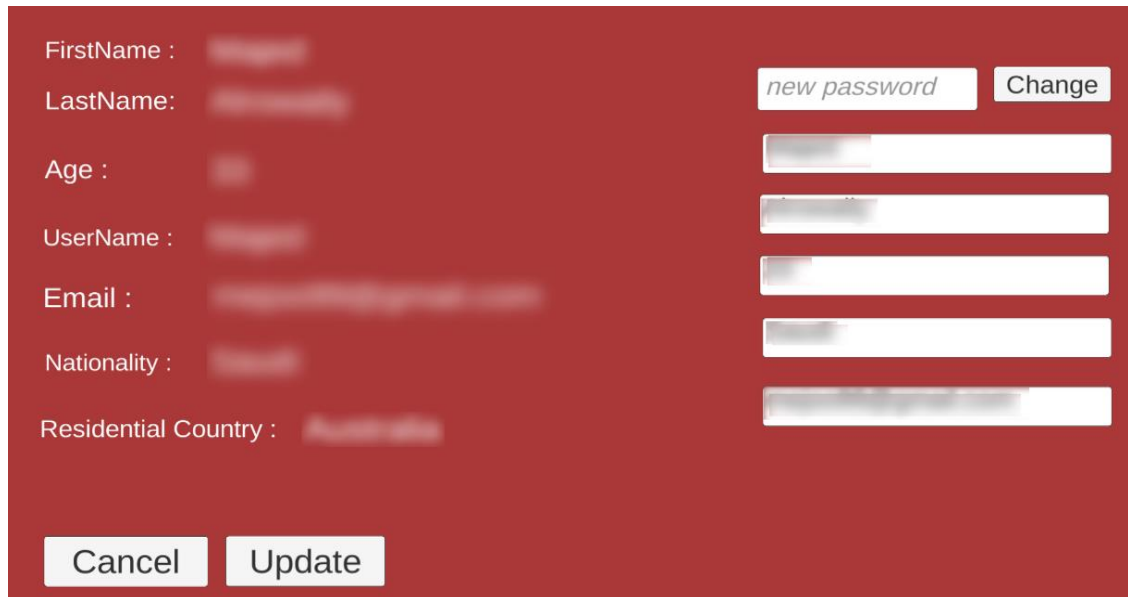
When the users of all EVA versions clicked on the *User profile* button, they were taken to Figure 4.10, as explained earlier. Additionally, the task information could be accessed in all of the EVA versions by clicking the *Task* button. Finally, EVA V1 users could access the anti-littering materials by clicking the *Litter Awareness* button in Figure 4.11, which lead them to the UI in Figure 4.13.



The image shows a "Reset Your Password" interface with a dark red background. The title "Reset Your Password" is centered at the top in white. Below the title, there is a single white rectangular input box with the placeholder text "Your Email..". Below the input box, there are two buttons: a bright green "Send" button and a red "Back" button, both with white text.

**Figure 4.9 Forget Password UI**

Users of the EVA V2 and V3 could access the anti-littering materials by clicking the *AR Litter Awareness* button in Figure 4.12, which took them to the UIs in Figure 4.14 for V2 users and Figure 4.17 for V3 users.

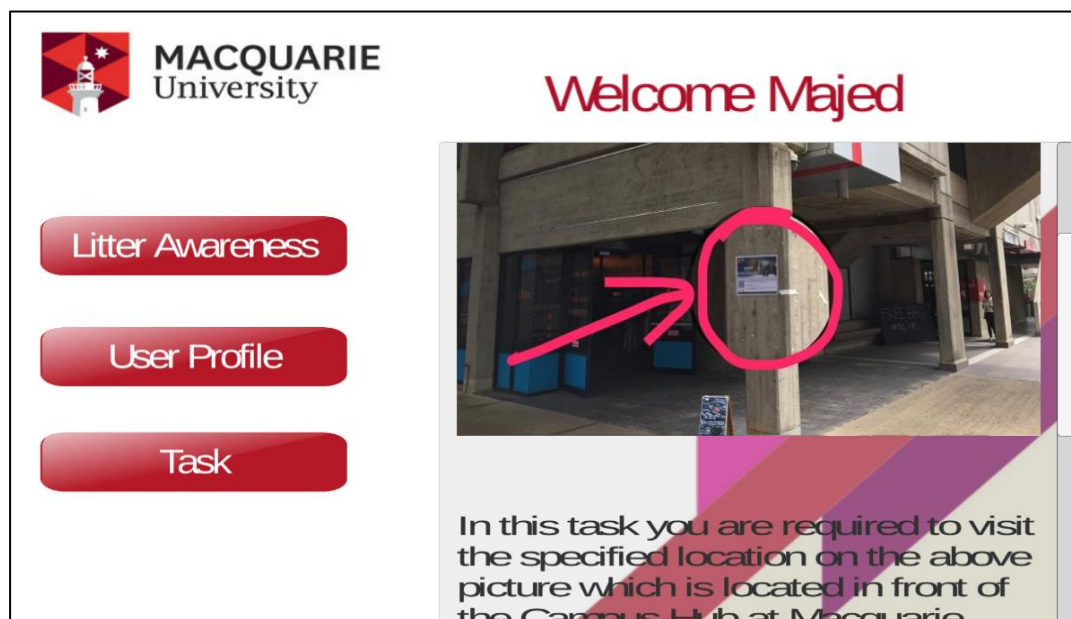


The image shows a user profile update form on a red background. It contains the following fields and controls:

- FirstName : [text input]
- LastName: [text input]
- Age : [text input]
- UserName : [text input]
- Email : [text input]
- Nationality : [text input]
- Residential Country : [text input]
- A password field with the placeholder text "new password" and a "Change" button next to it.
- At the bottom, there are "Cancel" and "Update" buttons.

**Figure 4.10 User Profile UI**

The litter awareness materials for EVA V1 (Figure 4.13) had different buttons to access some anti-littering videos and photos. In contrast, EVA V2 and V3's litter awareness materials could be accessed by moving the camera view of the device to track the study marker. When the camera recognised the marker, it displayed the augmented information on it. This interface provided some



**Figure 4.11 After Login UI of EVA V1**



images and videos related to anti-littering materials, which users could navigate using the provided buttons.

The difference between the AR Litter Awareness UI of V2 (Figure 4.14) and V3 (Figure 4.17) is the introduction of the AR game button in V3 on the bottom right corner. Figure 4.15 and Figure 4.16 are examples of the augmented anti-littering video and picture respectively, in both V2 and V3.

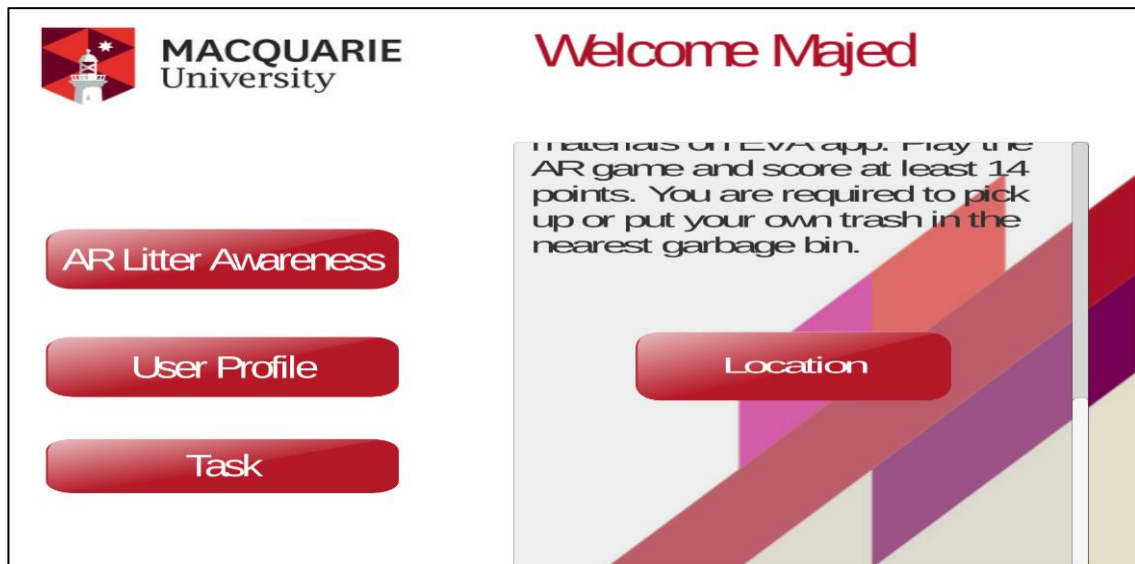


Figure 4.12 After Login UI of EVA V2 & V3

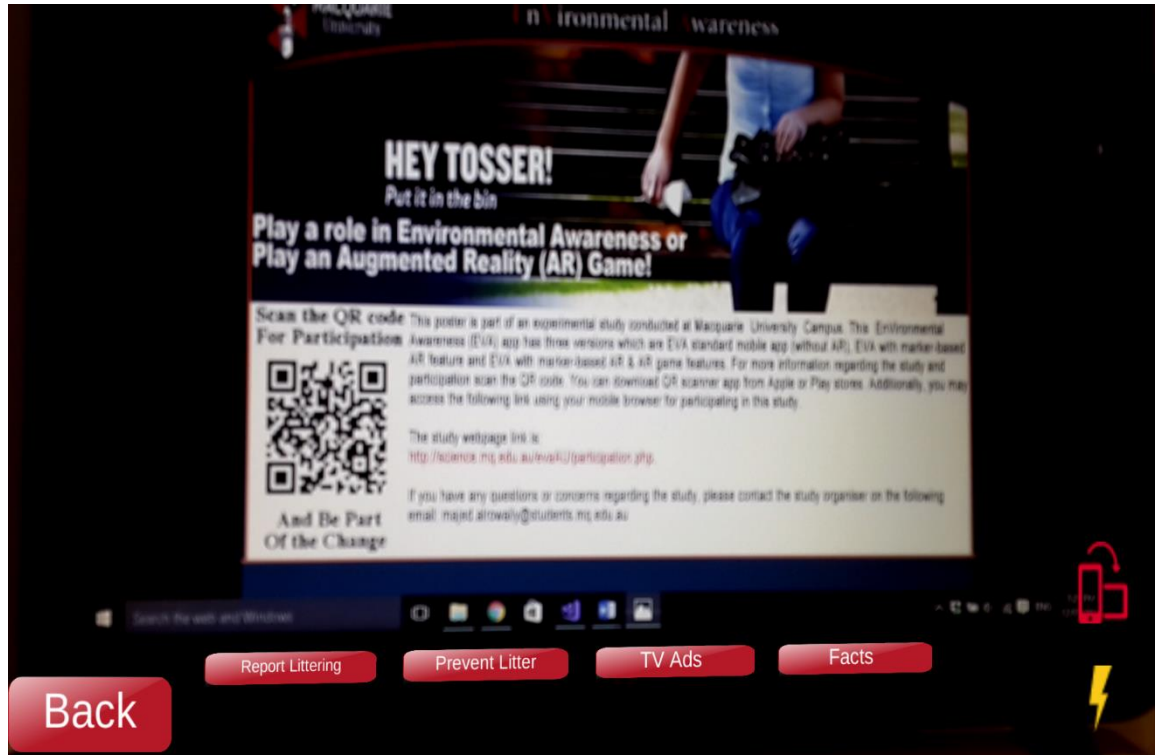
Lastly, the users of EVA V3 could access the anti-littering AR game by clicking the *AR game* button in Figure 4.17. Then they were taken to the AR game UI (Figure 4.18).



Figure 4.13 Litter Awareness UI



In Figure 4.18, the users could touch and drag any litter item to the litter bin. They scored different points for different litter items. Once the game was done, the users had two button options, either the *Restart* button, which restarted the game, or the *Leaderboard* button, which gave the top scores (Figure 4.19).



**Figure 4.14 AR Litter Awareness UI of EVA V2**



**Figure 4.15 AR Litter Awareness Video Material UI of EVA V2**

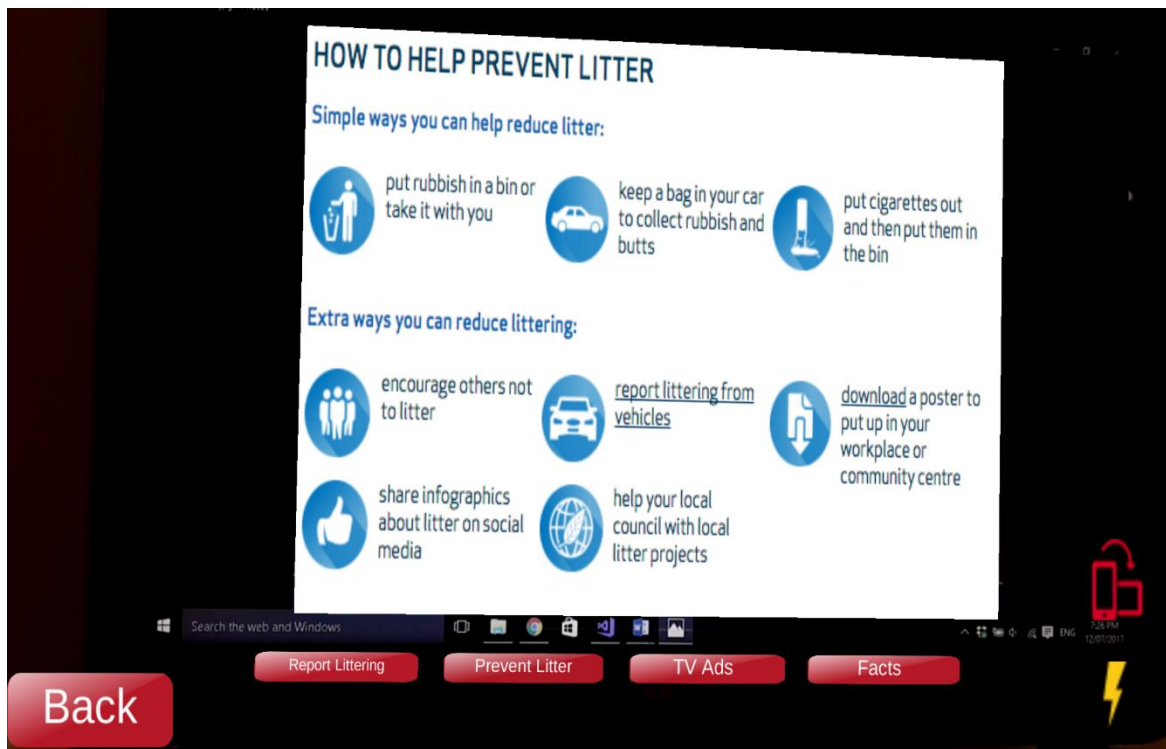


Figure 4.16 AR Litter Awareness Picture Material UI of EVA V2

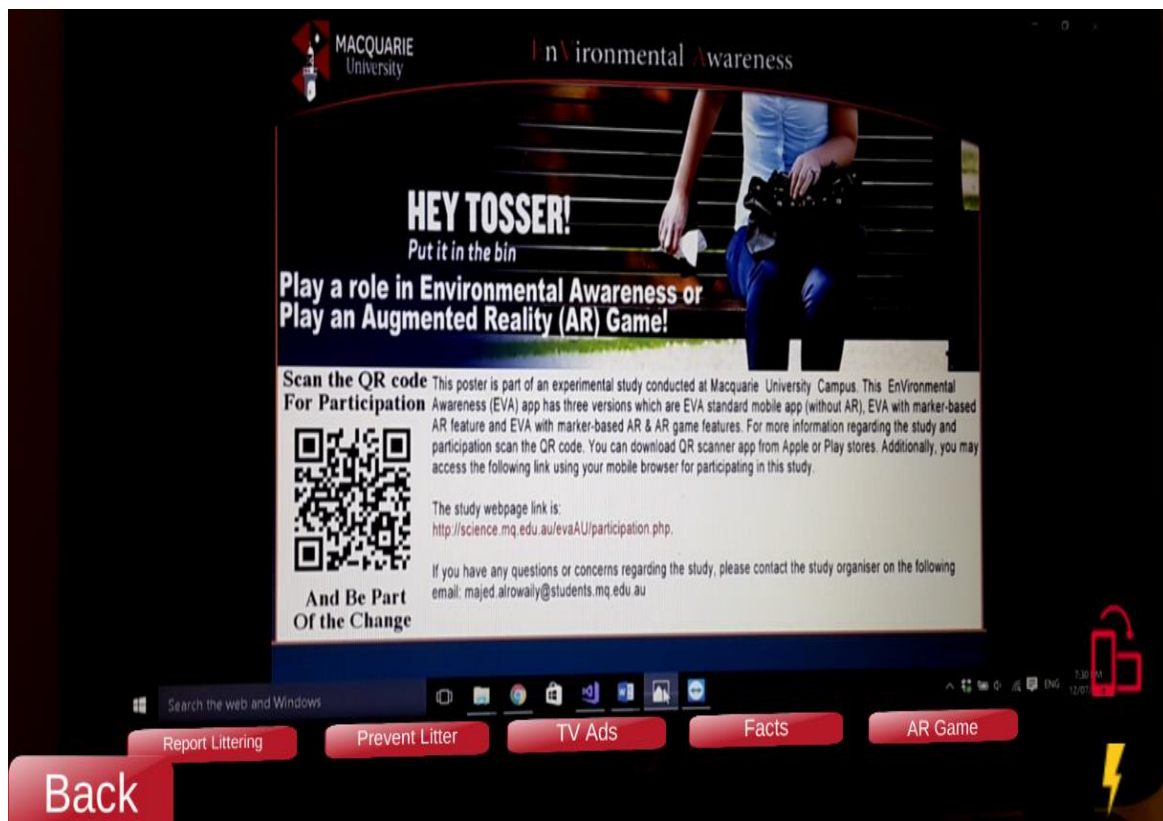


Figure 4.17 AR Litter Awareness UI of EVA V3



Figure 4.18 AR game UI

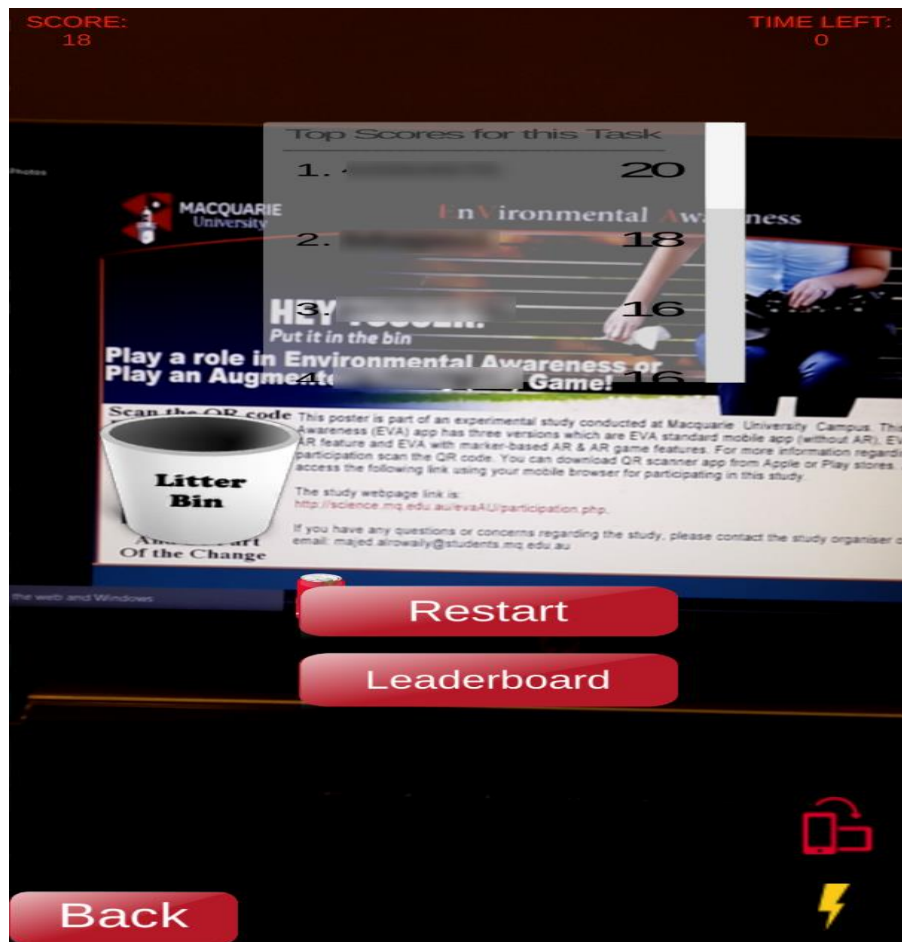


Figure 4.19 AR game Leaderboard UI

## 4.5 Back-end Component

The back-end component was hosted on a Linux virtual machine. It consisted of HTTP handlers, which handle all requests from the front-end components; EVA MySQL DB, which contained user profiles, tasks, and play data; EVA Admin Portal, where the administrator of the EVA app could update some of the app contents and see different information about the app and; the File Resources Directory, where all of the photos and videos used by the app were kept.

### 4.5.1 EVA RESTful API

EVA RESTful API handled different requests, for example user accounts, task info, AR game scores, and app usages. It was developed using PHP language. EVA RESTful API retrieved, stored, or updated data on the EVA database using SQL statements. After executing the SQL statements, the handlers sent back the responses to the EVA App. Commas were used to separate each of the responses' fields to allow the EVA app to read the responses correctly. A key, called \$SecureKey, was requested with every HTTP call and if the provided key did not match the stored \$SecureKey at the EVA RESTful API, the request was denied. Additionally, all the SQL statements were run through a secure function called *make\_safe* prior to execution to avoid any SQL injection threats. All the requests and responses will be explained in detail in this section.

#### 4.5.1.1 Users

There were four types of requests for the users' component: register, login, profile, and password resetting requests.

##### 4.5.1.1.1 Register Request

The register request used the GET method and verified the call source using secure key matching. The \$SecureKey was stored in a file called Key.php at the EVA server. Therefore, it is referenced as the register file to access the stored \$SecureKey.

```
if(@$_GET["secure"] == $SecureKey )
```

If the provided key matched the stored key, then it passed to the following verifications statements.

```
if(!empty($_GET['username']) and !empty($_GET['email']) and
!empty($_GET['password']))

{

if(strlen($_GET['password']) < 1){
```

```
die("The password must be bigger than 0 characters");

}if(strlen($_GET['username']) < 3){

die("The nickname must be bigger than 2 characters");

}if (!filter_var($_GET['email'], FILTER_VALIDATE_EMAIL)) {

    die( "This email not vaild!");
```

The previous code verified if the request provided the username, email, and password and validated them when provided. The following code shows the other validations required to ensure the uniqueness of the username and email entities and the allowed age range.

```
$checkmail      =      mysql_query("SELECT      *      FROM      users      WHERE
email='".$_make_safe($_GET['email'])."'");

$checkUsername  =      mysql_query("SELECT      *      FROM      users      WHERE
username='".$_make_safe($_GET['username'])."'");

$getNumEmail    =      mysql_fetch_array($checkmail);

$getNumUsername =      mysql_fetch_array($checkUsername);

if($getNumEmail > 0 ){

die("This Email Is Already used");

}if($getNumUsername > 0 ){

die("This Username Is Already used");

}if ctype_space($getNumUsername){

die("This Username has Whitespace");

}

if (!is_numeric($_GET["age"]) || $_GET["age"] > 65) {

    die("Wrong Age!!");

}
```

If all validation criteria passed, then the user account was stored at EVADB.USERS table using the insert statement.

#### 4.5.1.1.2 Login Request

The login request required the username and the password from the user and they were delivered via the GET method. Furthermore, the call source was verified using the secure key matching system.

```
if(!empty($_GET["username"]) and !empty($_GET["password"]) and
!empty($_GET["secure"])) {

if($_GET['secure'] != $SecureKey) {

die("Secured! File");

}
```

The provided username and password were used to query the users' table to find the user record. The provided password was transferred to MD5 hash because the users' passwords at the database were encrypted in MD5 hash for security reasons. The result of the query was fetched using the `mysql_fetch_array` function and the results row was returned as an array.

```
$checkUser = mysql_query("SELECT * FROM users WHERE
username='".$_make_safe($_GET['username'])."' AND
password='".$_md5(make_safe($_GET['password']))."'");

$getInfo = mysql_fetch_array($checkUser);
```

The number of return records was counted by the `mysql_num_rows` function and then the IF Statement was used to check if any records has been returned by the `$checkUser` query or not. If there was a record then the `echo` function was used to firstly print number 1, which was read by the EVA app as a successful call and then the rest of the user information was printed, with a comma in between them. If the provided username and password were not correct, then the handler returned number 2, which meant an unsuccessful request and returned a *Wrong username or password* message to the EVA app. Finally, if one or both of the required fields were missing, the



handler returned a *Please Fill All Field* message with number 2 for an unsuccessful request.

```
$getNumAccount = mysql_num_rows($checkUser);

if($getNumAccount > 0 ){

    echo
    "1, ".$getInfo['id'].', '.$getInfo['firstname'].', '.$getInfo['lastname'].
    ', '.$getInfo['nationality'].', '.$getInfo['residential_country'].', '.$ge
    tInfo['username'].', '.$getInfo['age'].', '.$getInfo['email'].', '.$getInf
    o['auth'];

} else{

    echo '2,Wrong username or password' ;

}

else{

    echo ("2,Please Fill All Field!");

}
```

#### 4.5.1.1.3 Reset Password Request

Sometimes users forget their passwords; therefore, it is necessary to have a password resetting functionality for any accounts system. When a resetting request was received, the *sendcode.php* handled this request. It started by verifying the request source and email address.

```
if(@$SecureKey == @$_GET['secure']) {

    if(@$_GET["email"]){

        if (!filter_var($_GET['email'], FILTER_VALIDATE_EMAIL)) {

            die( "This email not vaild!");

        }

    }

}
```

If the provided email address was in the correct form, then it was used to query the users' table to find the user with the provided email. If the provided email matched one of the users' emails, then

the user ID was used to query the *forget\_passwords* table. If a record was found in the *forget\_passwords* table, then the code field was updated by a new random code using *rand()* functionality. If there was no record for that user in the *forget\_passwords* table, a new record was inserted with a random code, generated using *rand()* functionality. Finally, an email was sent to the user's email address with the random code, which could be used in the EVA app to reset the user's password. If the request was successful, the handler returned number 1 to the EVA app. If sending the email was unsuccessful then the following message was sent back to the EVA app: *Error in Mail Server! Try Again Later*. If the provided email address was not found, then the following message was sent back to the EVA app: *This Email is not registered*.

```
$checkmail = mysql_query("SELECT * FROM users WHERE
email='".$$_GET['email']."'");

$checkRecord = mysql_num_rows($checkmail);

if($checkRecord > 0){

    $getUserInformation = mysql_fetch_array($checkmail);

    $checkForgetRecordForUser = mysql_query("SELECT * FROM
forget_passwords where
userid='".$make_safe($getUserInformation["id"])."'");

    $getInformation = mysql_fetch_array($checkForgetRecordForUser);

    $checkRecordForUser = mysql_num_rows($checkForgetRecordForUser);

    $code = rand(0000000000000000,9999999999999999);

    if($checkRecordForUser > 0){

        $updateCode = mysql_query("UPDATE forget_passwords SET
code='".$code."' WHERE
userid='".$make_safe($getInformation["userid"])."'");

    }else{

        $insertRecord = mysql_query("INSERT INTO forget_passwords
VALUES('".$make_safe($getUserInformation["id"])."', '".$make_safe($code)."'
')");

    }

}
```



```
$sendMail = mail($_GET["email"], 'Reset the Password', $code);

if($sendMail){

echo "1";

}else{

echo "Error in Mail Server! Try Again Later";

}

}else{

echo "This Email is not registered!!";

}
```

The first procedure was completed by inserting a record which had a random code at the *forget\_passwords* table and sending that code to the user's email address. After that the user was required to provide this code to the *resetPassword.php* handler with the new password, to update his or her password. Firstly, the *resetPassword.php* handler verified the request source. The provided code was used to query the *forget\_passwords* table. If a record was found, then the new password to be provided was utilised to generate the MD5 hash code and update the user password at *users* table. After updating the user password, the random code of that user in *forget\_passwords* table was deleted. Different errors were caught by the *resetPassword.php* handler.

```
if($SecureKey == @$_GET['secure']){

if(@$_GET["code"] && @$_GET["password"]){

$CheckCode = mysql_query("SELECT userid FROM forget_passwords WHERE
code='".make_safe($_GET["code"])."'");

$sisExist = mysql_num_rows($CheckCode);

if($sisExist > 0){

$getAccountInformation = mysql_fetch_array($CheckCode);

$updatePassword = mysql_query("UPDATE users SET
password='".md5(make_safe($_GET["password"]))."'
WHERE
id='".make_safe($getAccountInformation["userid"])."'");
```

```
        if($updatePassword){

                                $deleteRecord      =      mysql_query("DELETE      FROM
forget_passwords WHERE userid='".$.$getAccountInformation["userid"]."");

                                if($deleteRecord){

                                        echo "1";

                                }else{

                                        echo "Try Again Later ! Error in DB";

                                }

                                }else{

                                        echo "Try Again Later ! Error in DB";

                                }

                                }else{

                                        die("Invalid Code!");

                                }

                                }else{

                                        die("Please Fill All Fields");

                                }

                                }else(Rosok)
```

#### 4.5.1.1.4 Profile Request

The profile request was used to update the user's password or profile information. After verifying the call source, the profile request handler checked the request type, whether it is was a *changePassword* or *changeInformation* request. If it was a *changePassword* request, the provided user ID and new password were used to update the user's password. The provided new password was transferred to MD5 hash before storing it in the *users* table. If the new password was not provided by the user with the request, then an error message was passed to the EVA app.

```

if($SecureKey == @$_GET['secure']){

if(@$_GET['changePassword']){

    if(@$_GET['id'] && @$_GET['newpassword']){

        $update_password = mysql_query("UPDATE users SET
password='".md5(make_safe($_GET["newpassword"])) ." ' WHERE
id='".make_safe($_GET["id"])."");

        if($update_password){

            echo "1";

        }

    }else{

        echo "Please Fill a password Field";

    }
}

```

For the request type *changeInformation*, all of the allowed fields of user information were updated after validation. If the user profile information was updated successfully, the profile request handler sent back number 1 to the EVA app as an indication of the successful request. If one or more of the required fields was not provided by the user, the handler sent *Please Fill all Fields* to the EVA app. Finally, if the request came from somewhere other than the EVA app, the *Invalid SecureKey* message was sent to the request source.

```

}else if(@$_GET["changeInformation"]){

    if(@$_GET["id"] && @$_GET["firstname"] && @$_GET["lastname"] &&
@$_GET["age"] && @$_GET["email"] && @$_GET["nationality"]){

        if (!filter_var($_GET['email'], FILTER_VALIDATE_EMAIL)) {

            die( "This email not vaild!");

        }

        $update_information = mysql_query("UPDATE users SET

```

```
firstname="'.make_safe($_GET["firstname"])."',
lastname="'.make_safe($_GET["lastname"])."',
age="'.make_safe($_GET["age"])."',
email="'.make_safe($_GET["email"])."',
nationality="'.make_safe($_GET["nationality"])."' WHERE
id="'.make_safe($_GET["id"])."'";

if($update_information){

    echo "1";

}

}else{

    echo "Please Fill all Fields";

}

}

}else{

    echo "Invalid SecureKey";

}
```

#### 4.5.1.2 Tasks

The task handler provided task details to the EVA app. It started by verifying the request source and the task ID. The provided task ID was used to query the tasks' table to retrieve the details of the requested task. If the query returned more than a zero record, the task handler started the response with the successful indicator (number 1) and the task details (Task ID, Task Name, Task Description, Task Image, Location URL) followed the successful indicator. The following example illustrates the expected response from this request:

*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 promotion materials on the 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*

If the task ID was not found, the handler returned the following response:

*0,There is no tasks listed!*

If the passed secure key did not match *\$SecureKey*, the request died and printed the *Secured! File* message.

```

if(!empty($_GET["secure"]))

{

    if(!empty($_GET["task_id"]) and $_GET['secure'] != $SecureKey)

    {

        die("Secured! File");

    }

    $query = "SELECT * FROM tasks where id
    =".make_safe($_GET['task_id'])."";

    $checktask = mysql_query($query);

    $getInfo = mysql_fetch_array($checktask);

    $getNumTask = mysql_num_rows($checktask);

    if($getNumTask > 0 )

    {

        echo
        "1, ".$getInfo['id'].", ".$getInfo['name'].", ".$getInfo['des'].", ".$getIn
        fo['img_url'].", ".$getInfo['time'].", ".$getInfo['location_url']."";

    }else{

        echo "0,There is no tasks listed!" ;

    }

}

else{

    die("Please Fill All Field!");

}

```

#### 4.5.1.3 AR game

The AR game handler stored the users' AR game scores. Therefore, every time the users played the game, their scores were posted and stored to the EVA DB through the AR game handler. The users' IDs, scores, and the current date and time were stored to keep tracking the users' AR game performance. When the user completed the AR game a call was made to the AR game handler to store the user's results. The user's IDs, scores, Task ID, and the secure key were passed with this call. After verifying the existence of these data with the call and matching the secure key with the predefined *\$SecureKey*, the handler stored the following data at *Play* table: Task ID, User ID, Current Date Time, and score.

```
if(!empty($_GET['user_id']) and !empty($_GET['task_id']) and
!empty($_GET['score'])) and !empty($_GET['secure']))

{

    if($_GET['secure'] != $SecureKey)

    {

        die("Secured! File");

    }

    $insertQuery = "INSERT INTO
play(id,task_id,user_id,date_time,score)
VALUES (NULL,'" .make_safe($_GET['task_id'])."', '" .make_safe($_GET['user_
id'])."', '" .date('Y/m/d h/m/s')."', '" .make_safe($_GET['score'])."'");

    $insert_score = mysql_query($insertQuery);

    if ($insert_score)

    {

        echo "1,'" .$_GET['score']."',Score updated successfully";

    } else {

        echo "0,Error updating score: " . mysql_error();

    }

}
```

```
}
```

#### 4.5.1.4 App usages

The App usages handler was used to track the users' usage of the EVA app versions. Therefore, whenever an interface of the EVA app versions was launched, the handler called the App usages handler to store the users' activities. The secure key, interface name, and user ID were sent with every call made to the handler. Firstly, the App usages handler started with verifying the provided data if they were passed with the request. If so, then it verified the passed secure key, whether it matched the *\$SecureKey* store at the back-end or not. If the request passed the verification procedures then the current date and time of the server, which was set at Sydney time zone, were assigned to a variable called *\$todayDateTime*. Then finally, an insert statement was executed with the following details: User ID, Current Date Time, and Action.

```
if(!empty($_GET['user_id']) and !empty($_GET['secure']) and
!empty($_GET['action']))

{

    if($_GET['secure'] != $SecureKey){

        die("Secured! File");

    }

    $todayDateTime = date("Y-m-d H:i:s");

    $insertQuery = "INSERT INTO app_usages(id,user_id,date_time,action)
VALUES (NULL, '".make_safe($_GET['user_id'])."', '". $todayDateTime."', '".make_sa
fe($_GET['action'])."')";

    $insertQueryTask = mysql_query($insertQuery);

    if ($insertQueryTask)

    {

        echo "1".$_GET['action'].",Action inserted successfully";

    } else {
```

```
        echo "0,Insert Error:" . mysql_error();

        die();

    }

}

else {

    echo "0,Some of the parameters of post order not Recived";

}
```

#### 4.5.2 EVA MySQL DB

The EVA database was designed and established for the purpose of this study; therefore, it had only the required entities and attributes for simplicity. The following subsections cover the Entity-Relationship diagram (ER) and entities of the EVA database.

##### 4.5.2.1 Entity-relationship diagram of the EVA database

An ER diagram is a very effective method of graphically illustrating conceptual schema for databases to provide information about it in the system and its entities' relationships. The ER diagram (Figure 4.20) represents the schema of EVA database. There were five entities in the EVA database: *users*, *tasks*, *plays*, *app\_usages*, and *forget\_passwords* tables. The relationship between the *users* entity and *app\_usages* entity was a one-to-many relationship, as a user could have many records in the *app\_usages* entity.

Likewise, the relationship between the *users* entity and *plays* entity was a one-to-many relationship. The relationship type connecting *tasks* entity and *plays* entity was a one-to-many relationship. Lastly, the *forget\_passwords* entity and *users* entity had a one-to-one relationship.



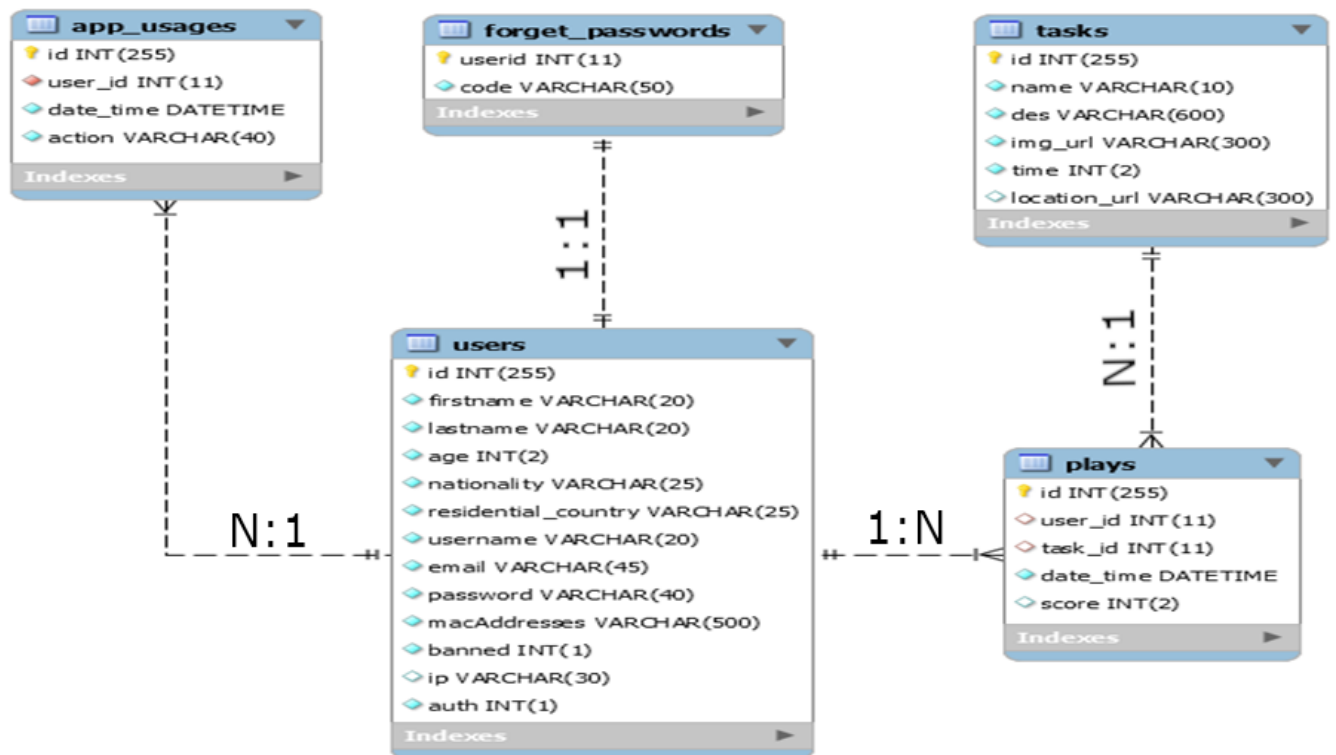


Figure 4.20 Entity-relationship diagram of EVA database

#### 4.5.2.2 Entities

The EVA database had five entities: *users*, *tasks*, *plays*, *app\_usages* and *forget\_passwords* and will be discussed in the following subsections.

##### 4.5.2.2.1 Users

The *users* table had a number of attributes, such as ID, firstname, lastname, age, nationality, residential\_country, username, email, password, banned, macAddresses, ip, and 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 is VARCHAR(20).
- **Lastname:** is the last name of the user. The data type of this attribute is VARCHAR(20).

- **Age:** is the age of the user. The data type of this attribute is INT (2).
- **Nationality:** is the nationality of the user. The data type of this attribute is VARCHAR (25).
- **Residential\_country:** is the residential country of the user. The data type of this attribute is VARCHAR (25).
- **Username:** is the username of the user. The data type of this attribute is VARCHAR (20).
- **Email:** is the email address of the user. The data type of this attribute is VARCHAR (45).
- **Password:** is the password of the user. The password was stored as MD5 hash. The data type of this attribute is VARCHAR (40).
- **Banned:** is the banned status of the user. It is utilised to ban a specific user from using the 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 users' devices. The data type of this attribute is VARCHAR (500).
- **IP:** is the IP address of the user. It is used to ban users by their IP address. The data type of this attribute is 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).

Table 4.3 shows an example of data stored in a *User* table.

*Table 4.3 Example data of a User table*

<b>id</b>	21
<b>firstname</b>	Majed
<b>lastname</b>	Alrowaily
<b>age</b>	34
<b>nationality</b>	Saudi
<b>residential_country</b>	Australia

<b>username</b>	username
<b>email</b>	<a href="#">user@email.com</a>
<b>password</b>	MD5 hash Password
<b>macAddresses</b>	User Device macAddresse
<b>banned</b>	0
<b>ip</b>	User IP address
<b>auth</b>	1

#### 4.5.2.2.2 Tasks

The *Tasks* table had 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 is VARCHAR(10).
- **Des:** is the description of the task. The data type of this attribute is VARCHAR(600).
- **Img\_url:** is the URL link of the task image. The data type of this attribute is VARCHAR(300).
- **Time:** is the time of the task, in seconds. This attribute is used by the AR game for timing. The data type of this attribute is INT (2).
- **Location\_url:** is the URL link of the task location. It is a Google map link for the task location. The data type of this attribute is VARCHAR (300).

Table 4.4 illustrates example data of a *Tasks* table.

*Table 4.4 Example data of a Tasks table*

id	name	des	img_url	time	location_url
1	Task 1	In this task you are required to visit the specified location on the above picture ...	IMG_5042.JPG	40	<a href="https://goo.gl/maps/gS9hwAxoFrL2">https://goo.gl/maps/gS9hwAxoFrL2</a>

#### 4.5.2.2.3 Plays

The *Plays* table had 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 the *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 the *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 corresponding data stored in the *Plays* table are shown in Table 4.5.

*Table 4.5 Example data of Plays table*

id	user_id	task_id	date_time	score
10	21	3	2017-04-06 06:18:15	4
11	21	3	2017-04-06 06:18:55	11

#### 4.5.2.2.4 App Usages

The *App\_Usages* table had 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 the EVA interface was accessed by the EVA app. The data type of this attribute is VARCHAR (40).

An example of data stored in App\_Usages table is shown in Table 4.6.

*Table 4.6 Example data of App\_Usages table*

id	user_id	date_time	action
795	21	2017-04-06 06:17:30	uAfterLoginV3
796	21	2017-04-06 06:17:32	uARheyTosser
797	21	2017-04-06 06:17:45	uARgame

#### 4.5.2.2.5 Forgot\_passwords

The *Forgot\_passwords* table had 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 the EVA http handler to verify the users' accounts before resetting their passwords. The data type of this attribute is VARCHAR (50).

An example data of a Forgot\_passwords table is illustrated in

Table 4.7.

*Table 4.7 Example data of Forgot\_Passwords table*

userid	code

36	2327505773864686
----	------------------

#### 4.5.3 EVA Admin Portal

The EVA admin portal was a basic web tool which allows the administrator of the EVA mobile app to manage three aspects: User Profiles, Tasks, and AR game. When the admin used the web browser to access the admin portal, the login UI required his/her login details (Figure 4.21).



*Figure 4.21 Login UI of EVA Admin Portal*

Figure 4.22 illustrates all the user information; admin had the option to update, ban, and delete any user.

Eva Control Panel												
Users   Tasks   AR Game												Logout
Accounts Manager												
First Name	Last Name	Username	Age	Nationality	Email	Auth	IP	Ban/unban (FROM DEVICE)	Ban/unban (FROM IP)	Change Password	Update Information	Delete Account
John	Doe	john.doe	35	USA	john.doe@eva.com	Active	192.168.1.1	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Jane	Smith	jane.smith	28	UK	jane.smith@eva.com	Active	192.168.1.2	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Mike	Johnson	mike.johnson	42	Canada	mike.johnson@eva.com	Active	192.168.1.3	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Sarah	Williams	sarah.williams	31	Australia	sarah.williams@eva.com	Active	192.168.1.4	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
David	Brown	david.brown	25	Germany	david.brown@eva.com	Active	192.168.1.5	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Emily	White	emily.white	33	France	emily.white@eva.com	Active	192.168.1.6	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Chris	Black	chris.black	29	Italy	chris.black@eva.com	Active	192.168.1.7	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Alice	Green	alice.green	38	Spain	alice.green@eva.com	Active	192.168.1.8	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Bob	Gray	bob.gray	45	Japan	bob.gray@eva.com	Active	192.168.1.9	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Anna	Lee	anna.lee	27	South Korea	anna.lee@eva.com	Active	192.168.1.10	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Tom	Kim	tom.kim	36	India	tom.kim@eva.com	Active	192.168.1.11	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Lisa	Ng	lisa.ng	30	Singapore	lisa.ng@eva.com	Active	192.168.1.12	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Mark	Wong	mark.wong	40	China	mark.wong@eva.com	Active	192.168.1.13	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Michelle	Chen	michelle.chen	26	Taiwan	michelle.chen@eva.com	Active	192.168.1.14	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Kevin	Lin	kevin.lin	34	Hong Kong	kevin.lin@eva.com	Active	192.168.1.15	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Patricia	Nguyen	patricia.nguyen	32	Vietnam	patricia.nguyen@eva.com	Active	192.168.1.16	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
James	Pham	james.pham	29	Philippines	james.pham@eva.com	Active	192.168.1.17	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Olivia	Tran	olivia.tran	37	Thailand	olivia.tran@eva.com	Active	192.168.1.18	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Benjamin	Nguyen	benjamin.nguyen	24	Malaysia	benjamin.nguyen@eva.com	Active	192.168.1.19	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Sophia	Lim	sophia.lim	39	Indonesia	sophia.lim@eva.com	Active	192.168.1.20	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Lucas	Nguyen	lucas.nguyen	23	South Africa	lucas.nguyen@eva.com	Active	192.168.1.21	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Isabella	De Vries	isabella.devries	30	Netherlands	isabella.devries@eva.com	Active	192.168.1.22	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Matthew	Van der Meer	matthew.van.der.meer	35	Netherlands	matthew.van.der.meer@eva.com	Active	192.168.1.23	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Charlotte	De Vries	charlotte.devries	28	Netherlands	charlotte.devries@eva.com	Active	192.168.1.24	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
William	Van der Meer	william.van.der.meer	41	Netherlands	william.van.der.meer@eva.com	Active	192.168.1.25	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Amelia	De Vries	amelia.devries	26	Netherlands	amelia.devries@eva.com	Active	192.168.1.26	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Benjamin	Van der Meer	benjamin.van.der.meer	33	Netherlands	benjamin.van.der.meer@eva.com	Active	192.168.1.27	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Harriet	De Vries	harriet.devries	31	Netherlands	harriet.devries@eva.com	Active	192.168.1.28	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Robert	Van der Meer	robert.van.der.meer	44	Netherlands	robert.van.der.meer@eva.com	Active	192.168.1.29	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Evelyn	De Vries	evelyn.devries	29	Netherlands	evelyn.devries@eva.com	Active	192.168.1.30	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
George	Van der Meer	george.van.der.meer	36	Netherlands	george.van.der.meer@eva.com	Active	192.168.1.31	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Victoria	De Vries	victoria.devries	27	Netherlands	victoria.devries@eva.com	Active	192.168.1.32	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Christopher	Van der Meer	christopher.van.der.meer	40	Netherlands	christopher.van.der.meer@eva.com	Active	192.168.1.33	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Madeline	De Vries	madeline.devries	25	Netherlands	madeline.devries@eva.com	Active	192.168.1.34	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Anthony	Van der Meer	anthony.van.der.meer	38	Netherlands	anthony.van.der.meer@eva.com	Active	192.168.1.35	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Grace	De Vries	grace.devries	32	Netherlands	grace.devries@eva.com	Active	192.168.1.36	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Henry	Van der Meer	henry.van.der.meer	43	Netherlands	henry.van.der.meer@eva.com	Active	192.168.1.37	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Chloe	De Vries	chloe.devries	24	Netherlands	chloe.devries@eva.com	Active	192.168.1.38	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Isaac	Van der Meer	isaac.van.der.meer	37	Netherlands	isaac.van.der.meer@eva.com	Active	192.168.1.39	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Abigail	De Vries	abigail.devries	28	Netherlands	abigail.devries@eva.com	Active	192.168.1.40	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Jack	Van der Meer	jack.van.der.meer	42	Netherlands	jack.van.der.meer@eva.com	Active	192.168.1.41	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Madison	De Vries	madison.devries	26	Netherlands	madison.devries@eva.com	Active	192.168.1.42	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Alexander	Van der Meer	alexander.van.der.meer	39	Netherlands	alexander.van.der.meer@eva.com	Active	192.168.1.43	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Ella	De Vries	ella.devries	30	Netherlands	ella.devries@eva.com	Active	192.168.1.44	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Jonathan	Van der Meer	jonathan.van.der.meer	45	Netherlands	jonathan.van.der.meer@eva.com	Active	192.168.1.45	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Scarlett	De Vries	scarlett.devries	27	Netherlands	scarlett.devries@eva.com	Active	192.168.1.46	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Benjamin	Van der Meer	benjamin.van.der.meer	34	Netherlands	benjamin.van.der.meer@eva.com	Active	192.168.1.47	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Penelope	De Vries	penelope.devries	31	Netherlands	penelope.devries@eva.com	Active	192.168.1.48	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Samuel	Van der Meer	samuel.van.der.meer	46	Netherlands	samuel.van.der.meer@eva.com	Active	192.168.1.49	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Julia	De Vries	julia.devries	29	Netherlands	julia.devries@eva.com	Active	192.168.1.50	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Matthew	Van der Meer	matthew.van.der.meer	35	Netherlands	matthew.van.der.meer@eva.com	Active	192.168.1.51	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Alfred	De Vries	alfred.devries	41	Netherlands	alfred.devries@eva.com	Active	192.168.1.52	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Josephine	Van der Meer	josephine.van.der.meer	28	Netherlands	josephine.van.der.meer@eva.com	Active	192.168.1.53	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Harvey	De Vries	harvey.devries	33	Netherlands	harvey.devries@eva.com	Active	192.168.1.54	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Elizabeth	Van der Meer	elizabeth.van.der.meer	40	Netherlands	elizabeth.van.der.meer@eva.com	Active	192.168.1.55	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Frederick	De Vries	frederick.devries	44	Netherlands	frederick.devries@eva.com	Active	192.168.1.56	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Isabella	Van der Meer	isabella.van.der.meer	26	Netherlands	isabella.van.der.meer@eva.com	Active	192.168.1.57	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Charles	De Vries	charles.devries	38	Netherlands	charles.devries@eva.com	Active	192.168.1.58	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Charlotte	Van der Meer	charlotte.van.der.meer	30	Netherlands	charlotte.van.der.meer@eva.com	Active	192.168.1.59	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
William	De Vries	william.devries	42	Netherlands	william.devries@eva.com	Active	192.168.1.60	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Amelia	Van der Meer	amelia.van.der.meer	27	Netherlands	amelia.van.der.meer@eva.com	Active	192.168.1.61	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Benjamin	De Vries	benjamin.devries	35	Netherlands	benjamin.devries@eva.com	Active	192.168.1.62	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Harriet	Van der Meer	harriet.van.der.meer	31	Netherlands	harriet.van.der.meer@eva.com	Active	192.168.1.63	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Robert	De Vries	robert.devries	43	Netherlands	robert.devries@eva.com	Active	192.168.1.64	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Evelyn	Van der Meer	evelyn.van.der.meer	29	Netherlands	evelyn.van.der.meer@eva.com	Active	192.168.1.65	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
George	De Vries	george.devries	36	Netherlands	george.devries@eva.com	Active	192.168.1.66	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Victoria	Van der Meer	victoria.van.der.meer	25	Netherlands	victoria.van.der.meer@eva.com	Active	192.168.1.67	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Christopher	De Vries	christopher.devries	39	Netherlands	christopher.devries@eva.com	Active	192.168.1.68	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Madeline	Van der Meer	madeline.van.der.meer	28	Netherlands	madeline.van.der.meer@eva.com	Active	192.168.1.69	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Anthony	De Vries	anthony.devries	32	Netherlands	anthony.devries@eva.com	Active	192.168.1.70	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Grace	Van der Meer	grace.van.der.meer	37	Netherlands	grace.van.der.meer@eva.com	Active	192.168.1.71	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Henry	De Vries	henry.devries	45	Netherlands	henry.devries@eva.com	Active	192.168.1.72	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Chloe	Van der Meer	chloe.van.der.meer	24	Netherlands	chloe.van.der.meer@eva.com	Active	192.168.1.73	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Isaac	De Vries	isaac.devries	34	Netherlands	isaac.devries@eva.com	Active	192.168.1.74	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Abigail	Van der Meer	abigail.van.der.meer	29	Netherlands	abigail.van.der.meer@eva.com	Active	192.168.1.75	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Jack	De Vries	jack.devries	40	Netherlands	jack.devries@eva.com	Active	192.168.1.76	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Madison	Van der Meer	madison.van.der.meer	26	Netherlands	madison.van.der.meer@eva.com	Active	192.168.1.77	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Alexander	De Vries	alexander.devries	38	Netherlands	alexander.devries@eva.com	Active	192.168.1.78	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Ella	Van der Meer	ella.van.der.meer	30	Netherlands	ella.van.der.meer@eva.com	Active	192.168.1.79	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Jonathan	De Vries	jonathan.devries	46	Netherlands	jonathan.devries@eva.com	Active	192.168.1.80	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Scarlett	Van der Meer	scarlett.van.der.meer	27	Netherlands	scarlett.van.der.meer@eva.com	Active	192.168.1.81	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Benjamin	De Vries	benjamin.devries	33	Netherlands	benjamin.devries@eva.com	Active	192.168.1.82	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Penelope	Van der Meer	penelope.van.der.meer	31	Netherlands	penelope.van.der.meer@eva.com	Active	192.168.1.83	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Samuel	De Vries	samuel.devries	47	Netherlands	samuel.devries@eva.com	Active	192.168.1.84	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Julia	Van der Meer	julia.van.der.meer	30	Netherlands	julia.van.der.meer@eva.com	Active	192.168.1.85	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Matthew	De Vries	matthew.devries	36	Netherlands	matthew.devries@eva.com	Active	192.168.1.86	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Alfred	Van der Meer	alfred.van.der.meer	41	Netherlands	alfred.van.der.meer@eva.com	Active	192.168.1.87	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Josephine	De Vries	josephine.devries	28	Netherlands	josephine.devries@eva.com	Active	192.168.1.88	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Harvey	Van der Meer	harvey.van.der.meer	33	Netherlands	harvey.van.der.meer@eva.com	Active	192.168.1.89	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Elizabeth	De Vries	elizabeth.devries	40	Netherlands	elizabeth.devries@eva.com	Active	192.168.1.90	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Frederick	Van der Meer	frederick.van.der.meer	44	Netherlands	frederick.van.der.meer@eva.com	Active	192.168.1.91	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Isabella	De Vries	isabella.devries	26	Netherlands	isabella.devries@eva.com	Active	192.168.1.92	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Charles	Van der Meer	charles.van.der.meer	38	Netherlands	charles.van.der.meer@eva.com	Active	192.168.1.93	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Charlotte	De Vries	charlotte.devries	30	Netherlands	charlotte.devries@eva.com	Active	192.168.1.94	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
William	Van der Meer	william.van.der.meer	42	Netherlands	william.van.der.meer@eva.com	Active	192.168.1.95	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Amelia	De Vries	amelia.devries	27	Netherlands	amelia.devries@eva.com	Active	192.168.1.96	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Benjamin	Van der Meer	benjamin.van.der.meer	35	Netherlands	benjamin.van.der.meer@eva.com	Active	192.168.1.97	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Harriet	De Vries	harriet.devries	31	Netherlands	harriet.devries@eva.com	Active	192.168.1.98	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Robert	Van der Meer	robert.van.der.meer	43	Netherlands	robert.van.der.meer@eva.com	Active	192.168.1.99	Active(Ban)	Active(Ban)	Change!	Update!	Delete!
Evelyn	De Vries	evelyn.devries	29	Netherlands	evelyn.devries@eva.com	Active	192.168.1.100	Active(Ban)	Active(Ban)	Change!	Update!	Delete!

**Figure 4.22 Users' Profiles UI of EVA Admin Portal**

The EVA app's required tasks could be managed, as shown in Figure 4.23. When the admin uploaded an image for a task, it was stored in the file resources directory on the EVA web server. Only the name of the uploaded image was stored in the task table as a text.

EVA Control Panel							
Users Tasks AR Game							Logout
Tasks Manager							
ID	Name	Description	Image	Time	Location URL	Update Information	Delete Task
1	Task 1	In this task you are required to visit the specified location on the above picture which is located in the space between E4B and E6A 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.	IMG_5042.JPG	40	https://goo.gl/maps/gS9hwAxoFrL2	Update!	Delete!
2	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.	IMG_3622.jpg	35	https://goo.gl/maps/r3u5fu7H4pR2	Update!	Delete!
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	Update!	Delete!
4	Task 4	Task 4 Description	IMG_3612.jpg	20	https://goo.gl/maps/w5N3Wk7MRQM2	Update!	Delete!
Copyright 2015 - 2018							

Figure 4.23 Task UI of EVA Admin Portal

Figure 4.24 shows the AR game data where the admin could monitor users' scores and filter the data by user id, task id, datetime, or score.

EVA Control Panel				
Users Tasks AR Game				Logout
AR game data				
Filter By : Please Select Value : btnFilter				
ID	User ID	Task ID	DateTime	Score
10	21	3	2017-04-06 06:18:15	4
11	21	3	2017-04-06 06:18:55	11
12	21	3	2017-04-06 06:19:40	14
13	21	3	2017-04-06 06:20:23	16
85	28	3	2017-04-28 01:04:19	7
86	30	3	2017-04-30 03:04:00	4
87	30	3	2017-04-30 03:04:46	2
88	30	3	2017-04-30 03:04:31	10
89	30	3	2017-04-30 03:04:52	8
90	30	3	2017-04-30 03:04:45	9
91	30	3	2017-04-30 03:04:56	9
92	30	3	2017-04-30 03:04:22	11
93	32	3	2017-05-01 08:05:51	11
94	32	3	2017-05-01 08:05:36	1
95	32	3	2017-05-01 08:05:45	10
Copyright 2015 - 2018				

Figure 4.24 AR Game UI of EVA Admin Portal

#### 4.5.4 File Resources Directory

The file resources directory was a simple file directory that stored all the tasks' image files on the EVA web server. When the administrator added or updated a task, the image was uploaded in this



directory. The EVA app downloaded the task image from this directory, when the users accessed the task UI on the EVA app.

#### **4.6 Chapter Summary**

The key to producing a successful AR mobile app is choosing the right tools to serve the development needs. Therefore, in the development stage of this study, Vuforia SDK and Unity game engine were utilised to develop the AR and AR game versions of the EVA apps for both the Australian and Saudi case studies. Vuforia SDK mainly supports the marker-based AR system and this study used an anti-littering poster as a marker for the EVA AR and AR game versions. The EVA apps in both case studies deployed similar content but with different translations: Arabic and English. Unity game engine has been used widely among game developers because of the many features that support them to develop amazing and enjoyable mobile games. Fortunately, Vuforia SDK is supported and integrated perfectly with Unity.

The back-end components of the EVA app versions were developed from scratch. EVA RESTful API was developed using PHP language as the VM web server, which hosts the back-end components, runs on a Linux operating system. EVA RESTful API was used to handle the communication between the EVA app versions and EVA MySQL database. EVA MySQL DB stores different data related to EVA apps content such as users, tasks, plays, and app usages. The EVA admin portal was developed to allow the administrator of the EVA app system easy access to the system data.

To sum up, this chapter described the approach that was taken to develop the mobile AR application (EVA). Different components were utilised during the implementation stage, such as Unity (game engine), Vuforia (AR library), MySQL (Database), and Apache (Web Server). The minimum system requirements for developing a mobile AR app for this project were highlighted in the chapter. The system architecture of the EVA application has two main sets of components, which are the front-end and back-end components. Each of these components were covered in detail. The following chapter will cover the data analysis procedure and illustrate the experimental results.

# **CHAPTER 5: DATA ANALYSIS AND RESULTS**

### **5.1 Introduction**

This chapter describes the data analysis methodology and the experimental results. The experimental study was conducted in two different places: Saudi Arabia and Australia. An initial analysis was done to determine any cultural differences between the two case studies. A two independent sample t-test (equal variances not assumed) was conducted to establish if there are any significant differences between the responses of the Saudi participants and the Australian participants. Post-V3 data which are the participants' responses after using EVA AR with gamification element, was used for this analysis. The means for post-V3 data are listed in Table A8.1 and the results from the independent sample t-test are given in Table A8.2 in the appendix section. The results in Table A8.2 indicate that there are no differences in the responses of the Saudi participants and the Australian participants for post-V3 data. This may be because around 65% of the participants shared the same cultural background. Therefore, we generalised the analysis of the data to express a broader view. The data analysis methodology and the results are highlighted in the following subsections.

### **5.2 Data Analysis Methodology**

This section discusses the approaches taken to analyse the data collected in this research. The type of investigation governs the most suitable data analysis methods. In this research, a number of data analysis methods were applied to answer the research questions such as descriptive statistics, reliability analysis, scale and subscale scoring, and multivariate analysis. The aims of the analysis are explained in the following subsection and each of the data analysis methods mentioned previously are discussed separately.

#### **5.2.1 Aims of The Analysis**

This research is a case study in the use of augmented reality for promoting anti-litter behaviours in Saudi Arabia and Australia. The EVA apps were translated and deployed in Arabic, with similar content to the English versions, for the Arabic case study. The selected treatment locations for both the Australian and the Saudi case studies were identified as having high levels of littering behaviour. The aims of the data analysis and modelling are:

1. To describe the demographic profile of the participants.
2. To describe the mobile and AR usage.
3. To describe the littering profile of the participants.
4. To establish the reliability of the scales used in the survey.
5. To address the research questions from this research, which are

- a. Research Question 1: What are the correlations between the Big Five personality traits (OCEAN) and the acceptance of the environmental awareness augmented reality app (EVA), as measured by C-TAM-TPB and Perceived Enjoyment?
  - b. Research Question 2: What are the correlations between independent variables of C-TAM-TPB and Perceived Enjoyment and the study dependent variables?
  - c. Research Question 3: To what extent does Technology Acceptance of EVA mediate the relationship between the independent and dependent variables of the anti-littering research model?
  - d. Research Question 4: Is there a significant difference between the mean littering score of V1 (control) and V2, and V1 (control) and V3?
6. To describe the participants' post application use profile.

### **5.2.2 Frequency Counts and Descriptive Statistics**

The frequency distributions (counts and percentages) were tabulated for all questions with a categorical response (nominal or ordinal). The trends were summarised, based upon whether the majority (more than 50% of the participants) of the responses were located. The skewness of the distributions (e.g. where the highest frequencies were located) was recorded where applicable. When there were multiple responses to one question, responses were analysed by making multiple response sets for each variable for analysis. Summary statistics (e.g. means or medians) have been reported for questions with a continuous response.

### **5.2.3 Reliability Analysis**

To ensure consistency, the scale items were subjected to reliability tests utilising the Cronbach Alpha as a measure. Cronbach's alpha is a measure of internal consistency. It measures how closely a set of items are related to a group. It is an ideal tool to find out whether the items of a survey scale are actually measuring the intended variable. Thus, it measures the reliability of the method of measurement (IDRE, 2019). Most researchers use Cronbach alpha for this purpose. Some examples of research works in which this value was estimated and reviewed are those of Bland and Altman (1997), Gliem and Gliem (2003) and Kilpatrick et al. (2003). A 0.7 or above alpha value was considered reliable (Reynaldo & Santos, 1999) and the set of items were internally consistent in measuring the intent of each factor. Two scales were used in the research namely, the littering scale and the application use scale. The Cronbach Alpha values have been calculated and reported for the two scales at all time points and the results are presented in section 6.3.2.

The littering scale consisted of the subscales PE, SN, PBC, ATU, BI and LB. This scale was used in the pre-survey, and after the apps V1, V2, and V3 were used. The application use scale consisted

of subscales PEOU, PU, PE, ATU, UI, UB, SN, and PBC. This scale was used after the apps V1, V2, and V3 were used. The expansions and definitions of these are given in the list of abbreviations and in Tables 4.1, 4.2 and 4.3 of Methodology chapter.

#### **5.2.4 Scale and Subscale Scoring**

Variable scores were created from values of littering, application use and the BFI-10 personality test scales used in the research. The BFI-10 is a short version for measuring personality. It was chosen to cut down participant's time, because of the large number of surveys included in this study. We did not want to overwhelm the participants with an extended version of personality scale.

The littering scale was used both in pre and post surveys, before and after the use of apps V1, V2, and V3. The BFI-10 personality test scale was used only after the applications had been tested. Therefore, separate variable scoring systems were adopted for analysis. Scores are created to represent a quantifiable number using the qualitative answers to the survey questions (converted from Likert scale). It is more efficient to deal with scores rather than all individual qualitative items. The usefulness of variable scoring in survey research is explained in Crossman (2018) and Snapsurveys (2019).

For each time point, the subscale scores for the littering scale have been calculated as an average of the individual items comprising the respective subscale.

For each time point, the subscale scores for the application use scale have been calculated as the average of the individual items comprising the respective subscale.

The subscale scores for the BFI-10 personality test scale have been calculated as per the guidelines of Rammstedt and John (2007). The subscales that have been extracted from the scale are called: Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness.

Prior to conducting statistical analysis involving the subscale scores, the assumptions of parametric statistics have been inspected. The Shapiro-Wilk test was used to check the statistical significance of the normal distribution of the continuous variables at  $\alpha = .001$ . Depending on the outcome of the test, parametric or non-parametric statistics and techniques have been utilised. The usefulness of this method for testing normality of the data has been demonstrated by many authors like Shapiro and Wilk (1965), Royston (1983), Srivastava and Hui (1987) and Razali and Wah (2011).

### **5.2.5 Multivariate Analysis**

The main multivariate analysis techniques used for addressing the aims of data analysis were Spearman's correlation, multiple linear regression, and a paired t-test

Spearman's correlation analysis is a useful non-parametric technique to test for the strength and direction of association between a pair of variables (Tabachnick & Fidell, 2007). This technique has been used to test for the nature of association between the personality traits, littering subscale scores, and application use subscale scores.

Regression modelling is a useful technique to model the strength and direction of relationship between one or more independent variables and a dependent variable (Tabachnick & Fidell, 2007). The regression modelling technique of multiple linear regression has been utilised to gain insights into the significant predictors of anti-littering behaviour. Independent or explanatory variables were selected for inclusion into the multiple regression model using a stepwise method and a .05 criterion of statistical significance. The assumptions of multiple regression, including linearity of the relationship between dependent and independent variables; independence of errors; homoscedasticity; and normality of errors, were tested for, and met, for all the models.

A paired t-test is a useful test to compare the mean of two variables, data for which has been collected from the same set of people (Tabachnick & Fidell, 2007). A paired t-test was used to compare the littering behaviours between V1 and V2, and V1 and V3.

A .05 level of significance was used as the criteria for statistical significance for all multivariate analyses.

The results obtained from the analyses of data are described in the subsequent sections.

### 5.3 Results

#### 5.3.1 User Profile

This section presents a summary of the participant and business demographics as per the data collected from the survey.

##### 5.3.1.1 Demographics

This study had a sample size of 90. The demographic profile of the participants is summarised in Table 5.1. There were an almost equal number of participants from Australia (n=44, 48.9%) and Saudi Arabia (n=46, 51.1%) and the majority of the participants were male (n=62, 68.9%). An almost equal number of participants were assigned to each of the three groups A (n=29, 32.2%), B (n=30, 33.3%), and C (n=31, 34.4%). The top three groups with respect to the highest education completed were people with a Bachelor's degree (n=33, 36.7%), people with a Master's degree (n=24, 26.7%), and people with a Diploma (n=13, 14.4%). The top two groups represented with respect to current employment status were people who were students (n=43, 47.8%) and people who were employed full-time (n=30, 33.3%). The top three age groups that were represented were 18-25 year olds (n=36, 40%), 26-35 year olds (n=33, 36.7%), and 36-45 year olds (n=16, 17.8%). The top two ethnic groups that were represented were North African and Middle Eastern (n=58, 64.4%), and Southern and Central Asian (n=10, 11.1%).

*Table 5.1 Descriptive Statistics for Participant Demographics*

VARIABLE	Number (N)	%
<b>Case Study</b>		
Australia	44	48.9
Saudi Arabia	46	51.1
<b>Gender</b>		
Male	62	68.9
Female	27	30.0
Prefer not to answer	1	1.1
<b>Assigned Group</b>		
Group A	29	32.2
Group B	30	33.3
Group C	31	34.4
<b>Education</b>		
High school	11	12.2
Diploma	13	14.4
Bachelor Degree	33	36.7

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VARIABLE	Number (N)	%
Postgraduate Diploma	3	3.3
Master's Degree	24	26.7
Doctoral Degree	4	4.4
Prefer not to answer	2	2.2
<b>Employment Status</b>		
Full-time	30	33.3
Part-time	5	5.6
Retired	1	1.1
Housewife	4	4.4
Student	43	47.8
Unemployed	5	5.6
Prefer not to answer	2	2.2
<b>Age Group</b>		
18 - 25 years old	36	40.0
26 - 35 years old	33	36.7
36 - 45 years old	16	17.8
46 - 55 years old	2	2.2
56 - 65 years old	1	1.1
<b>Ethnic Group</b>		
Oceanian	6	6.7
North African and Middle Eastern	58	64.4
Southeast Asian	2	2.2
Northeast Asian	5	5.6
Southern and Central Asian	10	11.1
Persian	2	2.2
African	6	6.7
Russian	1	1.1

### 5.3.1.2 Mobile and AR Use

Tables 5.2-5.4 display the participant's mobile app user profiles. The majority of the participants indicated that they were either experienced or very experienced with mobile phones (n=59, 65.6%), and 45.5% (n=41) of participants indicated that they were not as experienced with mobile games. Just over half the participants indicated that they were inexperienced or very inexperienced with AR mobile games (n=47, 52.2%).



***Table 5.2 What is your general experience with mobile devices?***

	Frequency	Percent
Very Inexperienced	2	2.2
Inexperienced	3	3.3
Neutral	26	28.9
Experienced	44	48.9
Very Experienced	15	16.7
Total	90	100.0

***Table 5.3 What is your general experience with mobile games?***

	Frequency	Percent
Very Inexperienced	8	8.9
Inexperienced	11	12.2
Neutral	30	33.3
Experienced	30	33.3
Very Experienced	11	12.2
Total	90	100.0

**Table 5.4 What is your general experience with AR mobile games (e.g. Pokémon GO)?**

	Frequency	Percent
Very Inexperienced	25	27.8
Inexperienced	22	24.4
Neutral	27	30.0
Experienced	10	11.1
Very Experienced	6	6.7
Total	90	100.0

### 5.3.1.3 Litter

The responses of the participants with respect to questions about litter are summarised in Table 5.5 to Table 5.19. The vast majority of the participants indicated that litter was a concern for them (n=82, 91.1%) and their top three reasons that it is bad for the environment, it is a hazard to human health, and is unsightly. The majority of the participants indicated that they either have a lot of control or a great deal of control over their behavioural change (n=52, 57.8%) and they indicated that they were either a lot motivated, or a great deal motivated, about living in a green environment (n=71, 78.9%). A similar trend, indicating either a lot or a great deal of motivation, was seen when the participants were asked about their level of motivation for changing their own littering behaviour (n=60, 66.6%). About one-fifth of the participants indicated they believed litter to be a big problem in their university campus (n=17, 18.9%). The vast majority of the participants indicated that litter prevention in their university campus was important or very important (n=80, 88.9%).

Most of the participants had been at their university campus for less than 2 years (n=58, 64.4%) and believed that the amount of litter at their University campus had stayed the same (n=18, 56.3%) during this time. The majority of the participants indicated that they had not seen, read, or heard any ads or public service messages related to litter or littering in the last year (n=48, 53.3%). The top three channels where people saw, read, and heard about such ads were social media, billboards,

and television. When asked if the litter control messages on the signboards in the university campus were visible and relevant, a higher proportion of participants (n=33, 36.7%) indicated that they agreed or strongly agreed compared to participants who disagreed or strongly disagreed (n=22, 24.5%). The majority of the participants either strongly agreed or agreed that the litter problem in the university campus severely affected the environment and animals (n=58, 64.4%).

Most of the participants were non-smokers (n=75, 83.3%). When the smokers were asked how they usually disposed of their cigarette butts, the top two groups of respondents said they used a personal ashtray or an ashtray bin (n=4, 33.3%) or they threw it on the ground (n=4, 33.3%). When asked an open-ended question about where the litter eventually ends up, a wide variety of responses were obtained, however a notable proportion of the participants believed that the litter was burned. Similarly, an open-ended question was asked about the litter locations in the university; some of the prominent themes were car parks, food courts, smoking zones, and University squares.

*Table 5.5 Is litter a concern to you?*

	Frequency	Percent
Yes	82	91.1
No	8	8.9
Total	90	100.0

**Table 5.6 Why is litter a concern to you?**

	Responses		Percent of Cases
	N	Percent	
It is bad for the environment	60	34.3%	74.1%
It is dangerous to animals	26	14.9%	32.1%
It is unsightly	41	23.4%	50.6%
It is a hazard to human health	44	25.1%	54.3%
Other (please specify)	4	2.3%	4.9%
Total	175	100.0%	216.0%

- a. Dichotomy group tabulated at value 1.
- b. The percent of responses is calculated using the total number of responses (175) as this a multiple choice question
- c. The percent of cases is calculated using the total number of participants in the study (90).

**Table 5.7 How much control do you think that you have over your behavioural change? (in other words: How strong is your will power?)**

	Frequency	Percent
A great deal	17	18.9
A lot	35	38.9
A moderate amount	31	34.4
A little	6	6.7
None at all	1	1.1
Total	90	100.0

***Table 5.8 How motivated are you about living in a green environment?***

	Frequency	Percent
A great deal	32	35.6
A lot	39	43.3
A moderate amount	17	18.9
A little	2	2.2
Total	90	100.0

***Table 5.9 How motivated are you to change your own littering behaviour?***

	Frequency	Percent
A great deal	40	44.4
A lot	20	22.2
A moderate amount	15	16.7
A little	9	10.0
None at all	6	6.7
Total	90	100.0

**Table 5.10** *In your opinion, how big of a problem is litter along the university campus? Would you say it is a....*

	Frequency	Percent
Big problem	17	18.9
Moderate problem	32	35.6
Small problem	22	24.4
Not a problem at all	5	5.6
Don't know	14	15.6
Total	90	100.0

**Table 5.11** *In your opinion, how important is litter prevention in the university campus? Would you say it's:*

	Frequency	Percent
Very Important	47	52.2
Important	33	36.7
Neither Important nor Unimportant	9	10.0
Not At All Important	1	1.1
Total	90	100.0

**Table 5.12 How long have you been in the university campus?**

	Frequency	Percent
Less than two years	58	64.4
2-4 years	23	25.6
5-10 years	7	7.8
More than 10 years	2	2.2
Total	90	100.0

**Table 5.13 Has the amount of litter in the university campus changed over the last two years? Would you say there is:**

	Frequency	Percent	Valid Percent
More litter today than two years ago?	6	6.7	18.8
Less litter today than two years ago?	8	8.9	25.0
About the same amount as two years ago?	18	20.0	56.3
Total	32	35.6	100.0
Response missing	58	64.4	
Total	90	100.0	

- a) The percent is calculated using the total number of participants in the study (90).
- b) The valid percent is calculated using the total number of responses (32)

**Table 5.14 Have you seen, read, or heard any ads or public service messages related to litter or littering in the last year?**

	Frequency	Percent
Yes	42	46.7
No	48	53.3
Total	90	100.0

**Table 5.15 Where did you see, read, or hear the ad(s) or public service message(s)?**

	Responses		Percent of Cases
	N	Percent	
Radio	5	6.3%	12.2%
Television	11	13.8%	26.8%
Newspaper	5	6.3%	12.2%
Social Media	27	33.8%	65.9%
Magazine	6	7.5%	14.6%
Billboard	17	21.3%	41.5%
Friend	4	5.0%	9.8%
Other	3	3.8%	7.3%
Don't Know/Can't Remember	2	2.5%	4.9%
Total	80	100.0%	195.1%



- a. Dichotomy group tabulated at value 1.
- b. The percent of responses is calculated using the total number of responses (80) as this a multiple choice question.
- c. The percent of cases is calculated using the total number of participants responded to this question (42). This question is related to the previous question in Table 5.14

**Table 5.16** *The litter control messages on the signboards in the university campus are visible and relevant.*

	Frequency	Percent
Strongly Disagree	15	16.7
Disagree	7	7.8
Neither Agree nor Disagree	35	38.9
Agree	25	27.8
Strongly Agree	8	8.9
Total	90	100.0

**Table 5.17** *The litter problem in the university campus severely affects the environment and the animals.*

	Frequency	Percent
Strongly Disagree	2	2.2
Disagree	3	3.3
Neither Agree nor Disagree	27	30.0
Agree	39	43.3
Strongly Agree	19	21.1

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Total	90	100.0
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*Table 5.18 Do you smoke?*

	Frequency	Percent
Yes	12	13.3
No	75	83.3
Prefer not to answer	3	3.3
Total	90	100.0

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*Table 5.19 When you are on the university campus, do you USUALLY dispose of cigarette butts...?*

	Frequency	Percent	Valid Percent
By using a personal ashtray or ashtray bin	4	4.4	33.3
By using something else	3	3.3	25.0
By throwing it on the ground	4	4.4	33.3
Or does it vary	1	1.1	8.3
Total	12	13.3	100.0
Response missing	78	86.7	
Total	90	100.0	

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- a) The percent is calculated using the total number of participants in the study (90)
- b) The valid percent is calculated using the total number of responses (12)
-

#### 5.3.1.3.1 User Attitudes

The participants were asked a range of questions about attitudes to littering. The responses to these questions are summarised in Table 5.20 to Table 5.26. The participants tended to agree to the following statements:

- They don't think just one piece of trash matters.
- They think someone else will pick it up.
- There isn't a trashcan or bag nearby.
- They didn't consider the item they dropped to be litter.
- They don't care.

The participants tended to disagree with the following statements:

- They don't have time to dispose of the litter properly.
- They didn't even realise that they had littered (unintentional littering).

**Table 5.20 They don't think their one piece of trash matters.**

	Frequency	Percent
Disagree	2	2.2
Somewhat disagree	3	3.3
Neutral	6	6.7
Somewhat agree	17	18.9
Agree	34	37.8
Strongly agree	28	31.1
Total	90	100.0

*Table 5.21 They think someone else will pick it up.*

	Frequency	Percent
Strongly disagree	1	1.1
Disagree	4	4.4
Somewhat disagree	11	12.2
Neutral	12	13.3
Somewhat agree	14	15.6
Agree	21	23.3
Strongly agree	27	30.0
Total	90	100.0

*Table 5.22 There isn't a trashcan or bag nearby.*

	Frequency	Percent
Strongly disagree	7	7.8
Disagree	4	4.4
Somewhat disagree	12	13.3
Neutral	9	10.0
Somewhat agree	31	34.4
Agree	18	20.0
Strongly agree	9	10.0
Total	90	100.0

**Table 5.23** *They didn't consider the item they dropped to be litter.*

	Frequency	Percent
Strongly disagree	9	10.0
Disagree	10	11.1
Somewhat disagree	13	14.4
Neutral	12	13.3
Somewhat agree	14	15.6
Agree	20	22.2
Strongly agree	12	13.3
Total	90	100.0

**Table 5.24** *They don't have time to dispose of the litter properly.*

	Frequency	Percent
Strongly disagree	15	16.7
Disagree	11	12.2
Somewhat disagree	22	24.4
Neutral	12	13.3
Somewhat agree	13	14.4
Agree	12	13.3
Strongly agree	5	5.6
Total	90	100.0

*Table 5.25 They don't care.*

	Frequency	Percent
Strongly disagree	1	1.1
Disagree	1	1.1
Somewhat disagree	4	4.4
Neutral	11	12.2
Somewhat agree	10	11.1
Agree	30	33.3
Strongly agree	33	36.7
Total	90	100.0

*Table 5.26 They didn't even realize that they had littered (unintentional littering).*

	Frequency	Percent
Strongly disagree	7	7.8
Disagree	17	18.9
Somewhat disagree	13	14.4
Neutral	13	14.4
Somewhat agree	18	20.0
Agree	16	17.8
Strongly agree	6	6.7
Total	90	100.0

## 5.3.1.3.2 Littering Habits

The participants were asked a range of questions about how likely they would be to litter in certain situations. The responses to these questions are summarised in Table 5.27 to Table 5.33. The responses tended towards the unlikely end of the scale for the following statements:

- In an area that is clean.
- In your neighbourhood.
- When holding an empty beverage cup or bottle and there are no trash cans available.
- When holding a gum wrapper and there are no trashcans available.
- When smoking a cigarette and there is no ash tray available (if applicable).
- When you know a cleanup crew will be coming by to pick it up.
- When nobody is around to see you.

*Table 5.27 In an area that is clean.*

	Frequency	Percent
Extremely unlikely	54	60.0
Moderately unlikely	6	6.7
Slightly unlikely	10	11.1
Slightly likely	9	10.0
Moderately likely	8	8.9
Extremely likely	3	3.3
Total	90	100.0

*Table 5.28 In your neighbourhood.*

	Frequency	Percent
Extremely unlikely	40	44.4
Moderately unlikely	15	16.7
Slightly unlikely	9	10.0
Neutral	5	5.6
Slightly likely	10	11.1
Moderately likely	6	6.7
Extremely likely	5	5.6
Total	90	100.0

*Table 5.29 When holding an empty beverage cup or bottle and there are no trash cans available.*

	Frequency	Percent
Extremely unlikely	24	26.7
Moderately unlikely	13	14.4
Slightly unlikely	16	17.8
Neutral	11	12.2
Slightly likely	10	11.1
Moderately likely	9	10.0
Extremely likely	7	7.8
Total	90	100.0



**Table 5.30 When holding a gum wrapper and there are no trashcans available.**

	Frequency	Percent
Extremely unlikely	26	28.9
Moderately unlikely	10	11.1
Slightly unlikely	10	11.1
Neutral	9	10.0
Slightly likely	9	10.0
Moderately likely	10	11.1
Extremely likely	16	17.8
Total	90	100.0

**Table 5.31 When smoking a cigarette and there is no ash tray available (if applicable).**

	Frequency	Percent
Extremely unlikely	36	40.0
Moderately unlikely	5	5.6
Slightly unlikely	13	14.4
Neutral	19	21.1
Slightly likely	7	7.8
Moderately likely	5	5.6
Extremely likely	5	5.6
Total	90	100.0

*Table 5.32 When you know a cleanup crew will be coming by to pick it up.*

	Frequency	Percent
Extremely unlikely	27	30.0
Moderately unlikely	7	7.8
Slightly unlikely	15	16.7
Neutral	11	12.2
Slightly likely	18	20.0
Moderately likely	9	10.0
Extremely likely	3	3.3
Total	90	100.0

*Table 5.33 When nobody is around to see you.*

	Frequency	Percent
Extremely unlikely	36	40.0
Moderately unlikely	15	16.7
Slightly unlikely	9	10.0
Neutral	10	11.1
Slightly likely	11	12.2
Moderately likely	5	5.6
Extremely likely	4	4.4
Total	90	100.0

## 5.3.1.3.3 Picking up Litter

The participants were asked a range of questions about how likely they would be to pick up a piece of litter in certain situations. The responses to these questions are summarised in Table 5.34 to Table 5.36. The participant responses tended towards the unlikely end of the scale for the following statement:

- Something someone else dropped.

The participant responses were towards the likely end of the scale for the following statements:

- Something you dropped.
- Something someone else dropped on your property.

*Table 5.34 Something you dropped.*

	Frequency	Percent
Extremely unlikely	1	1.1
Slightly unlikely	4	4.4
Neutral	1	1.1
Slightly likely	5	5.6
Moderately likely	22	24.4
Extremely likely	57	63.3
Total	90	100.0

*Table 5.35 Something someone else dropped.*

	Frequency	Percent
Extremely unlikely	18	20.0
Moderately unlikely	8	8.9

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Slightly unlikely	12	13.3
Neutral	14	15.6
Slightly likely	32	35.6
Moderately likely	5	5.6
Extremely likely	1	1.1
Total	90	100.0

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*Table 5.36 Something someone else dropped on your property.*

	Frequency	Percent
Moderately unlikely	1	1.1
Slightly unlikely	5	5.6
Neutral	6	6.7
Slightly likely	11	12.2
Moderately likely	26	28.9
Extremely likely	41	45.6
Total	90	100.0

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#### 5.3.1.3.4 Littering Awareness

The participants were asked a range of questions about their effectiveness when it comes to certain strategies for discouraging people to litter. The responses to these questions are summarised in Table 5.37 to Table 5.42. The participants' responses were towards the effective end of the scale for the following statements:

- Provide more trashcans on university campuses;
- Provide more educational programs about the litter problem.

- Increased enforcement of litter laws.
- Provide “litter hotline/websites” to report letter violations.
- Public awareness campaigns.
- Provide additional funding for cleaning up litter.

**Table 5.37 Provide more trashcans on your university campus.**

	Frequency	Percent
Extremely effective	33	36.7
Very effective	34	37.8
Moderately effective	15	16.7
Slightly effective	5	5.6
Not effective at all	3	3.3
Total	90	100.0

**Table 5.38 Provide more educational programs about the litter problem.**

	Frequency	Percent
Extremely effective	31	34.4
Very effective	24	26.7
Moderately effective	25	27.8
Slightly effective	5	5.6
Not effective at all	5	5.6
Total	90	100.0

*Table 5.39 Increased enforcement of litter laws.*

	Frequency	Percent
Extremely effective	42	46.7
Very effective	24	26.7
Moderately effective	17	18.9
Slightly effective	6	6.7
Not effective at all	1	1.1
Total	90	100.0

*Table 5.40 Provide “litter hotline/websites” to report litter violations.*

	Frequency	Percent
Extremely effective	31	34.4
Very effective	30	33.3
Moderately effective	18	20.0
Slightly effective	7	7.8
Not effective at all	4	4.4
Total	90	100.0

*Table 5.41 Public awareness campaigns.*

	Frequency	Percent
Extremely effective	25	27.8
Very effective	33	36.7
Moderately effective	22	24.4
Slightly effective	8	8.9
Not effective at all	2	2.2
Total	90	100.0

*Table 5.42 Provide additional funding for cleaning up litter.*

	Frequency	Percent
Extremely effective	18	20.0
Very effective	31	34.4
Moderately effective	25	27.8
Slightly effective	8	8.9
Not effective at all	8	8.9
Total	90	100.0

## 5.3.1.3.5 Litter Items

When asked about the items that the participants themselves would have discarded as litter in the past month, the top few responses, excluding the cases where the participants indicated that they had not littered, were small pieces of paper, food wrappers, and food.

**Table 5.43** *What are the items that you yourself might have discarded as litter in the past month?*

		Responses		Percent of Cases
		N	Percent	
Litter Behaviour	Small pieces of paper (receipts, lottery tickets, gum wrappers)	34	24.6%	37.8%
	Cigarette butts	9	6.5%	10.0%
	Other food wrappers (chip bags/candy)	22	15.9%	24.4%
	Food / organic material, raw food	18	13.0%	20.0%
	Other	12	8.7%	13.3%
	Have not littered in past month	35	25.4%	38.9%
	Don't know	8	5.8%	8.9%
Total		138	100.0%	153.3%

a. Dichotomy group tabulated at value 1.



5.3.1.3.6 Litter disposal

When asked what the participants do when they are out and they need to dispose of their trash, the top few responses were:

- Put in a trash can
- Hold onto it until I find a place for proper disposal.

*Table 5.44 When I am out and need to dispose of my trash, I*

		Responses		Percent of Cases
		N	Percent	
Litter Behaviour	Drop it where ever I am	7	4.6%	7.8%
	Put it in a trash can	62	40.5%	68.9%
	Leave it behind	5	3.3%	5.6%
	Hold onto it until I find a place for proper disposal	49	32.0%	54.4%
	Put it in a recycling bin	25	16.3%	27.8%
	Other (please specify)	5	3.3%	5.6%
Total		153	100.0%	170.0%

a. Dichotomy group tabulated at value 1.

5.3.1.3.7 Acceptance of Anti-Littering Behaviour Factors

The participants were asked a range of questions about various aspects relating to litter. The responses to these questions are summarised in Table 5.45 to Table 5.64. The participants tended to agree with all the statements:

- PE1: Performing litter prevention behaviour is enjoyable;
- PE2 Performing litter prevention behaviour is fun;
- PE3: Performing litter prevention behaviour is entertaining;

- PE4: Performing litter prevention behaviour is pleasant;
- SN1: People who influence me would think that I should not litter at the university campus;
- SN2: People who are important to me would think that I should not litter at the university campus;
- SN3: People whose opinions are valued to me would prefer that I should not litter at the university campus;
- PBC1: I would be able to apply litter prevention behaviour efficiently at the university campus;
- PBC2: I have adequate resources, knowledge, and ability to apply litter prevention behaviour;
- PBC3: Applying litter prevention behaviour would be absolutely within my control;
- ATU1: Litter prevention behaviour at the university campus is beneficial;
- ATU2: Litter prevention behaviour at the university campus is good;
- ATU3: Litter prevention behaviour at the university campus is pleasant;
- ATU4: Litter prevention behaviour at the university campus is a wise idea;
- ATU5: Litter prevention behaviour helps save our environment;
- BI1: I intend to apply litter prevention behaviour at the university campus;
- BI2: I intend to apply litter prevention behaviour in littered locations at the university campus;
- BI3: I intend to apply litter prevention behaviour in clean locations at the university campus;
- LB1: I have used litter prevention behaviour at the university campus; and
- LB2: I will continue using litter prevention behaviour at the university campus.

**Table 5.45 PE1: Performing litter prevention behaviour is enjoyable.**

	Frequency	Percent
Strongly disagree	5	5.6
Disagree	3	3.3
Somewhat disagree	8	8.9
-		

Neutral	21	23.3
Somewhat agree	22	24.4
Agree	16	17.8
Strongly agree	15	16.7
Total	90	100.0

**Table 5.46 PE2: Performing litter prevention behaviour is fun.**

	Frequency	Percent
Strongly disagree	2	2.2
Disagree	9	10.0
Somewhat disagree	14	15.6
Neutral	23	25.6
Somewhat agree	23	25.6
Agree	12	13.3
Strongly agree	7	7.8
Total	90	100.0

**Table 5.47 PE3: Performing litter prevention behaviour is entertaining.**

	Frequency	Percent
Strongly disagree	6	6.7
Disagree	9	10.0
Somewhat disagree	8	8.9

Neutral	28	31.1
Somewhat agree	21	23.3
Agree	13	14.4
Strongly agree	5	5.6
Total	90	100.0

**Table 5.48 PE4: Performing litter prevention behaviour is pleasant.**

	Frequency	Percent
Strongly disagree	3	3.3
Disagree	2	2.2
Somewhat disagree	7	7.8
Neutral	24	26.7
Somewhat agree	23	25.6
Agree	21	23.3
Strongly agree	10	11.1
Total	90	100.0

**Table 5.49 SN1: People who influence me would think that I should not litter at the university campus.**

	Frequency	Percent
Strongly disagree	2	2.2
Disagree	2	2.2
Somewhat disagree	9	10.0

Neutral	22	24.4
Somewhat agree	23	25.6
Agree	22	24.4
Strongly agree	10	11.1
Total	90	100.0

**Table 5.50 SN2: People who are important to me would think that I should not litter at the university campus.**

	Frequency	Percent
Strongly disagree	4	4.4
Disagree	3	3.3
Somewhat disagree	9	10.0
Neutral	20	22.2
Somewhat agree	18	20.0
Agree	23	25.6
Strongly agree	13	14.4
Total	90	100.0

**Table 5.51 SN3: People whose opinions are valued to me would prefer that I should not litter at the university campus.**

	Frequency	Percent
Strongly disagree	1	1.1
Disagree	6	6.7

Somewhat disagree	4	4.4
Neutral	17	18.9
Somewhat agree	22	24.4
Agree	30	33.3
Strongly agree	10	11.1
Total	90	100.0

**Table 5.52 PBC1: I would be able to apply litter prevention behaviour efficiently at the university campus.**

	Frequency	Percent
Strongly disagree	3	3.3
Somewhat disagree	7	7.8
Neutral	20	22.2
Somewhat agree	24	26.7
Agree	17	18.9
Strongly agree	19	21.1
Total	90	100.0

**Table 5.53 PBC2: I have adequate resources, knowledge, and ability to apply litter prevention behaviour.**

	Frequency	Percent
Strongly disagree	4	4.4
Disagree	5	5.6

Somewhat disagree	8	8.9
Neutral	16	17.8
Somewhat agree	20	22.2
Agree	21	23.3
Strongly agree	16	17.8
Total	90	100.0

**Table 5.54 PBC3: Applying litter prevention behaviour would be absolutely within my control.**

	Frequency	Percent
Strongly disagree	2	2.2
Somewhat disagree	6	6.7
Neutral	19	21.1
Somewhat agree	23	25.6
Agree	21	23.3
Strongly agree	19	21.1
Total	90	100.0

**Table 5.55 ATU1: Litter prevention behaviour at the university campus is beneficial.**

	Frequency	Percent
Strongly disagree	3	3.3
Disagree	1	1.1
Somewhat disagree	2	2.2

---

Neutral	7	7.8
Somewhat agree	20	22.2
Agree	36	40.0
Strongly agree	21	23.3
Total	90	100.0

---

**Table 5.56 ATU2: Litter prevention behaviour at 0074he university campus is good.**

	Frequency	Percent
Strongly disagree	2	2.2
Disagree	1	1.1
Somewhat disagree	5	5.6
Neutral	8	8.9
Somewhat agree	25	27.8
Agree	30	33.3
Strongly agree	19	21.1
Total	90	100.0

---

**Table 5.57 ATU3: Litter prevention behaviour at the university campus is pleasant.**

	Frequency	Percent
Strongly disagree	2	2.2
Disagree	3	3.3
Somewhat disagree	4	4.4



Neutral	22	24.4
Somewhat agree	16	17.8
Agree	25	27.8
Strongly agree	18	20.0
Total	90	100.0

**Table 5.58 ATU4: Litter prevention behaviour at the university campus is a wise idea**

	Frequency	Percent
Strongly disagree	1	1.1
Somewhat disagree	5	5.6
Neutral	7	7.8
Somewhat agree	24	26.7
Agree	32	35.6
Strongly agree	21	23.3
Total	90	100.0

**Table 5.59 ATU5: Litter prevention behaviour helps save our environment.**

	Frequency	Percent
Strongly disagree	1	1.1
Disagree	1	1.1
Somewhat disagree	4	4.4
Neutral	8	8.9

Somewhat agree	11	12.2
Agree	21	23.3
Strongly agree	44	48.9
Total	90	100.0

**Table 5.60 BI1: I intend to apply litter prevention behaviour at the university campus.**

	Frequency	Percent
Strongly disagree	4	4.4
Disagree	1	1.1
Somewhat disagree	9	10.0
Neutral	22	24.4
Somewhat agree	14	15.6
Agree	18	20.0
Strongly agree	22	24.4
Total	90	100.0

**Table 5.61 BI2: I intend to apply litter prevention behaviour in littered locations at the university campus.**

	Frequency	Percent
Strongly disagree	4	4.4
Disagree	2	2.2
Somewhat disagree	6	6.7

Neutral	20	22.2
Somewhat agree	16	17.8
Agree	19	21.1
Strongly agree	23	25.6
Total	90	100.0

**Table 5.62 BI3: I intend to apply litter prevention behaviour in clean locations at the university campus.**

	Frequency	Percent
Strongly disagree	5	5.6
Disagree	2	2.2
Somewhat disagree	10	11.1
Neutral	21	23.3
Somewhat agree	12	13.3
Agree	20	22.2
Strongly agree	20	22.2
Total	90	100.0

**Table 5.63 LB1: I have used litter prevention behaviour at the university campus.**

	Frequency	Percent
Strongly disagree	4	4.4
Somewhat disagree	10	11.1

Neutral	22	24.4
Somewhat agree	14	15.6
Agree	21	23.3
Strongly agree	19	21.1
Total	90	100.0

*Table 5.64 LB2: I will continue using litter prevention behaviour at the university campus.*

	Frequency	Percent
Strongly disagree	4	4.4
Disagree	1	1.1
Somewhat disagree	5	5.6
Neutral	20	22.2
Somewhat agree	10	11.1
Agree	27	30.0
Strongly agree	23	25.6
Total	90	100.0

**5.3.2 Reliability Analysis**

Cronbach's alpha for the littering scale pre-survey and after using the apps V1, V2, and V3 are shown in Table 5.65 below.

*Table 5.65 Cronbach's alpha - Littering scale*

Sub-scale	Number of Items (N)	Pre-Survey	V1	V2	V3
PE	4	.907	.961	.957	.946
SN	3	.845	.961	.948	.959
PBC	3	.860	.907	.913	.935
ATU	5	.901	.911	.942	.952
BI	3	.960	.920	.937	.961
LB	2	.873	.932	.946	.916

Cronbach's alpha for the application use scale after using the apps V1, V2, and V3 is shown in Table 5.66 below.

*Table 5.66 Cronbach's alpha - Application use scale*

Sub-scale	Number of Items (N)	V1	V2	V3
PEOU	5	.904	.894	.949
PU	6	.946	.946	.969
PE	4	.968	.976	.968
ATU	6	.950	.949	.958
UI	3	.984	.971	.970
UB	2	.719	.745	.740
SN	3	.937	.970	.980
PBC	3	.885	.868	.874

Since Cronbach's alphas for the littering and application use scaled at all time points were greater than .7, the items from these scales were deemed fit (reliable) to be used in subsequent analysis.

### 5.3.3 Subscale Scoring

The summary statistics for the various subscales that were scored using the survey data are shown in Table 5.67.

*Table 5.67 Summary statistics for subscale scores*

Statistic	Valid	Missing	Mean	Median	SD	IQR	Min.	Max.
Pre Littering PE	90	0	4.54	4.75	1.34	1.50	1.00	7.00
Pre Littering SN	90	0	4.91	5.00	1.27	2.00	1.33	7.00
Pre Littering PBC	90	0	5.07	5.33	1.32	1.75	1.00	7.00
Pre Littering ATU	90	0	5.54	5.80	1.14	1.40	1.00	7.00
Pre Littering BI	90	0	5.03	5.00	1.59	2.00	1.00	7.00
Pre Littering LB	90	0	5.14	5.00	1.50	2.00	1.00	7.00
V1 Littering PE	90	0	4.81	4.88	1.39	2.00	1.00	7.00
V1 Littering SN	90	0	5.18	5.33	1.48	2.00	1.00	7.00
V1 Littering PBC	90	0	5.22	5.67	1.31	1.42	2.00	7.00
V1 Littering ATU	90	0	5.56	5.80	1.12	1.60	2.60	7.00
V1 Littering BI	90	0	5.11	5.17	1.56	2.33	1.00	7.00
V1 Littering LB	90	0	5.12	5.00	1.52	2.50	1.00	7.00
V2 Littering PE	90	0	5.28	5.25	1.11	1.31	2.00	7.00
V2 Littering SN	90	0	5.49	6.00	1.26	1.33	1.00	7.00
V2 Littering PBC	90	0	5.45	5.67	1.18	1.33	2.00	7.00
V2 Littering ATU	90	0	5.84	6.00	0.96	1.00	2.00	7.00

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Statistic	Valid	Missing	Mean	Median	SD	IQR	Min.	Max.
V2 Littering BI	90	0	5.48	6.00	1.37	2.00	1.00	7.00
V2 Littering LB	90	0	5.48	5.75	1.37	1.50	1.00	7.00
V3 Littering PE	90	0	5.57	6.00	1.33	1.56	1.00	7.00
V3 Littering SN	90	0	5.63	6.00	1.43	2.00	1.00	7.00
V3 Littering PBC	90	0	5.59	6.00	1.42	1.75	1.00	7.00
V3 Littering ATU	90	0	5.97	6.20	1.10	1.20	1.00	7.00
V3 Littering BI	90	0	5.41	6.00	1.65	2.08	1.00	7.00
V3 Littering LB	90	0	5.48	6.00	1.60	2.00	1.00	7.00
V1 APP PEOU	90	0	5.45	5.60	1.06	1.40	3.00	7.00
V1 APP PU	90	0	4.65	4.83	1.34	1.88	1.00	7.00
V1 APP PE	90	0	4.18	4.50	1.64	2.50	1.00	7.00
V1 APP ATU	90	0	4.73	5.00	1.34	2.20	1.00	7.00
V1 APP UI	90	0	4.87	5.00	1.33	2.00	1.00	7.00
V1 APP UB	90	0	4.39	4.75	1.60	2.13	1.00	7.00
V1 APP SN	90	0	4.19	4.33	1.42	1.75	1.00	7.00
V1 APP PBC	90	0	4.80	5.00	1.38	1.50	1.00	7.00
V2 APP PEOU	90	0	5.69	6.00	0.92	1.00	2.00	7.00
V2 APP PU	90	0	5.17	5.50	1.15	1.50	1.17	7.00
V2 APP PE	90	0	5.08	5.50	1.38	1.75	1.00	7.00
V2 APP ATU	90	0	5.29	5.67	1.20	1.21	1.83	7.00

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Statistic	Valid	Missing	Mean	Median	SD	IQR	Min.	Max.
V2 APP UI	90	0	5.36	5.67	1.17	1.00	2.00	7.00
V2 APP UB	90	0	4.97	5.25	1.53	2.00	1.00	7.00
V2 APP SN	90	0	4.74	5.00	1.57	2.00	1.00	7.00
V2 APP PBC	90	0	5.19	5.33	1.24	1.33	1.00	7.00
V3 APP PEOU	90	0	5.50	6.00	1.40	1.60	1.00	7.00
V3 APP PU	90	0	5.41	5.67	1.40	1.42	1.00	7.00
V3 APP PE	90	0	5.46	6.00	1.51	2.00	1.00	7.00
V3 APP ATU	90	0	5.50	6.00	1.41	1.67	1.00	7.00
V3 APP UI	90	0	5.63	6.00	1.37	1.67	1.00	7.00
V3 APP UB	90	0	5.04	5.00	1.61	2.50	1.00	7.00
V3 APP SN	90	0	5.00	5.33	1.78	2.67	1.00	7.00
V3 APP PBC	90	0	5.39	5.67	1.34	1.67	1.00	7.00
BFI - Extraversion	90	0	2.96	3.00	0.77	1.00	1.00	5.00
BFI - Agreeableness	89	1	2.10	2.00	0.71	1.00	1.00	3.50
BFI - Conscientiousness	90	0	2.52	2.50	0.79	1.00	1.00	4.00
BFI - Neuroticism	90	0	3.24	3.00	0.82	0.63	1.50	5.00
BFI - Openness	90	0	2.70	3.00	0.59	0.50	1.50	4.00

A Shapiro-Wilk test of normality was conducted to establish if the subscale scores could be assumed to be from a normally distributed population. The results of the test are shown in Table 5.68. The significance values for the majority of the subscale scores were less than 0.001, hence, most of the subscale scores cannot be assumed to be from a normally distributed population at



$p < .001$ . Therefore, subsequently, non-parametric techniques and statistics have been used where required.

*Table 5.68 Test of normality*

	Shapiro-Wilk		
	Statistic	df	Sig.
Pre Littering PE	.974	89	.075
Pre Littering SN	.948	89	.001
Pre Littering PBC	.954	89	.003
Pre Littering ATU	.923	89	<.001
Pre Littering BI	.918	89	<.001
Pre Littering LB	.907	89	<.001
V1 Littering PE	.964	89	.015
V1 Littering SN	.907	89	<.001
V1 Littering PBC	.928	89	<.001
V1 Littering ATU	.925	89	<.001
V1 Littering BI	.920	89	<.001
V1 Littering LB	.915	89	<.001
V2 Littering PE	.944	89	.001
V2 Littering SN	.871	89	<.001
V2 Littering PBC	.911	89	<.001
V2 Littering ATU	.858	89	<.001
V2 Littering BI	.890	89	<.001

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V2 Littering LB	.885	89	<.001
V3 Littering PE	.879	89	<.001
V3 Littering SN	.844	89	<.001
V3 Littering PBC	.855	89	<.001
V3 Littering ATU	.796	89	<.001
V3 Littering BI	.844	89	<.001
V3 Littering LB	.832	89	<.001
V1 APP PEOU	.956	89	.004
V1 APP PU	.961	89	.010
V1 APP PE	.947	89	.001
V1 APP ATU	.959	89	.007
V1 APP UI	.960	89	.008
V1 APP UB	.927	89	<.001
V1 APP SN	.952	89	.002
V1 APP PBC	.913	89	<.001
V2 APP PEOU	.919	89	<.001
V2 APP PU	.922	89	<.001
V2 APP PE	.873	89	<.001
V2 APP ATU	.895	89	<.001
V2 APP UI	.894	89	<.001
V2 APP UB	.910	89	<.001

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V2 APP SN	.905	89	<.001
V2 APP PBC	.893	89	<.001
V3 APP PEOU	.857	89	<.001
V3 APP PU	.876	89	<.001
V3 APP PE	.841	89	<.001
V3 APP ATU	.862	89	<.001
V3 APP UI	.850	89	<.001
V3 APP UB	.923	89	<.001
V3 APP SN	.882	89	<.001
V3 APP PBC	.908	89	<.001
BFI - Extraversion	.955	89	.004
BFI - Agreeableness	.931	89	<.001
BFI - Conscientiousness	.945	89	.001
BFI - Neuroticism	.945	89	.001
BFI - Openness	.918	89	<.001

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### 5.3.4 Answers to The Research Questions

Statistical analysis that answers the three main research questions is presented below.

#### 5.3.4.1 Research Question 1

What are the correlations between the big five personality traits (OCEAN) and the acceptance of environmental awareness augmented reality app (EVA) as measured by C-TAM-TPB and Perceived Enjoyment?

## 5.3.4.1.1 V1

The Spearman's correlations between the Big Five personality traits and the V1 application use subscale scores are shown in Table 5.69. The following significant correlations have been obtained between:

1. Agreeableness was positively correlated with conscientiousness.
2. Agreeableness was negatively correlated with PE (Perceived Enjoyment), Attitude Towards Using (ATU), application Usage Intention (UI) and Subjective Norms (SN).
3. Conscientiousness was negatively correlated with Perceived Enjoyment.
4. Neuroticism was positively correlated with Perceived Ease Of Use (PEOU).
5. PEOU was positively correlated with Perceived Usefulness (PU), ATU, UI, application Usage Behaviour (UB) and Perceived Behavioural Control (PBC).
6. All mutual correlations of PU, PE, ATU, UI, UB and SN were highly significant and positive, excepting PEOU with PE and SN.

In the case of these relationships, the participants used mobile application without AR or AR with Gamification. So, they were just like ordinary use of mobile apps. Out of the five Big Five personality traits (OCEAN), openness and extraversion had no role in determining the effects of using different apps for antilittering behaviour. Neuroticism had positive influence only on PEOU, which was H1.1B in this study. In the case of Conscientiousness, contrary to positive relationship hypothesised H1.4G, the obtained relationship was negative. A number of relationships were obtained for Agreeableness, but all negative, which are against the hypothesised positive relationships. The mutual correlation between Agreeableness and Conscientiousness was not hypothesised. The positive relationships of PEOU were aligned with the respective hypotheses, excluding PE. Other mutual positive correlations support the respective hypotheses.

*Table 5.69 Correlations between the big five personality traits and the application use subscale scores - V1*

	BFI - Extraversion	BFI - Agreeableness	BFI - Conscientiousness	BFI - Neuroticism	BFI - Openness	V1 APP PEOU	V1 APP PU	V1 APP PE	V1 APP ATU	V1 APP UI	V1 APP UB	V1 APP SN
BFI - Agreeableness	-.141											
BFI - Conscientiousness	.036	.223*										
BFI - Neuroticism	-.085	-.185	-.186									
BFI - Openness	-.057	-.131	-.062	-.129								
V1 APP PEOU	-.203	.006	.003	.210*	-.108							
V1 APP PU	-.182	-.135	-.142	.134	.130	.464**						
V1 APP PE	-.072	-.253*	-.207*	.047	.132	.169	.768**					
V1 APP ATU	-.114	-.277**	-.096	-.030	.162	.252*	.786**	.908**				
V1 APP UI	-.101	-.307**	-.084	-.062	.138	.264*	.763**	.886**	.971**			

	BFI - Extraversion	BFI - Agreeableness	BFI - Conscientiousness	BFI - Neuroticism	BFI - Openness	V1 APP PEOU	V1 APP PU	V1 APP PE	V1 APP ATU	V1 APP UI	V1 APP UB	V1 APP SN
V1 APP UB	-.189	-.013	-.108	-.010	.041	.300**	.595**	.529**	.499**	.501**		
V1 APP SN	-.174	-.243*	-.016	-.031	.152	.172	.523**	.564**	.640**	.620**	.646**	
V1 APP PBC	-.139	-.132	-.181	.136	.053	.392**	.619**	.492**	.561**	.549**	.595**	.504**

\*\*, Correlation is significant at the 0.05 level (2-tailed).

\*\*, Correlation is significant at the 0.01 level (2-tailed).

#### 5.3.4.1.2 V2

The Spearman's correlations between the Big Five personality traits and the V2 application use subscale scores are shown in Table 5.70. The following significant correlations have been obtained between:

1. Agreeableness was positively related with Conscientiousness.
2. Agreeableness was negatively correlated with ATU, UI, and SN.
3. Openness was positively correlated with PE.

In this case, the participants used mobile apps with AR functionality. Notably, compared to the case of V1, the number of relationships of the Big Five factors in this case were fewer. Neuroticism and Extraversion were not related to any of the app use variables.

4. Mutual relationships among all app use variables were highly significant and positive.

The relationship of Agreeableness with Conscientiousness was similar to the case with V1 above. Agreeableness was not correlated with PE as was the case of V1, but the relationships with other

three variables were noted here also. In the case of V1, there was no role for openness in determining the app use variables. Here, Openness was positively correlated with PE.

**Table 5.70 Correlations between the Big Five personality traits and the application use subscale scores - V2**

	BFI - Extraversion	BFI - Agreeableness	BFI - Conscientiousness	BFI - Neuroticism	BFI - Openness	V2 APP PEOU	V2 APP PU	V2 APP PE	V2 APP ATU	V2 APP UI	V2 APP UB	V2 APP SN
BFI - Agreeableness	-.141											
BFI - Conscientiousness	.036	.223*										
BFI - Neuroticism	-.085	-.185	-.186									
BFI - Openness	-.057	-.131	-.062	-.129								
V2 APP PEOU	-.149	-.072	.010	.109	-.107							
V2 APP PU	-.102	-.191	-.032	-.087	.203	.498**						
V2 APP PE	-.102	-.053	.085	-.129	.239*	.334**	.696**					
V2 APP ATU	-.085	-.235*	-.043	-.079	.184	.422**	.737**	.797**				

	BFI - Extraversion	BFI - Agreeableness	BFI - Conscientiousness	BFI - Neuroticism	BFI - Openness	V2 APP PEOU	V2 APP PU	V2 APP PE	V2 APP ATU	V2 APP UI	V2 APP UB	V2 APP SN
V2 APP UI	-.059	-.269*	-.011	-.158	.170	.324**	.669**	.684**	.941**			
V2 APP UB	-.142	-.125	-.112	.027	-.019	.454**	.705**	.541**	.516**	.425**		
V2 APP SN	-.170	-.258*	-.079	-.043	.114	.417**	.701**	.562**	.623**	.544**	.757**	
V2 APP PBC	-.165	-.146	-.126	.043	.037	.456**	.763**	.654**	.646**	.553**	.756**	.690**

\*\*, Correlation is significant at the 0.05 level (2-tailed).

\*\*, Correlation is significant at the 0.01 level (2-tailed).

#### 5.3.4.1.3 V3

The Spearman's correlations between the Big Five personality traits and the V3 application use subscale scores are shown in Table 5.71. The following significant correlations have been obtained between:

1. Agreeableness was positively correlated with Conscientiousness
2. Agreeableness was negatively correlated with PE, UI, and SN.
3. Conscientiousness was positively correlated with UI.
4. Neuroticism and PBC were positively correlated.

In this case, the participants used an AR Game in their mobile app. Again, Openness failed to provide any relationships, thus rejecting all hypotheses related to it. The positive correlation of Agreeableness with Conscientiousness was maintained in the same way as with V1 and V2. A new positive relationship of Conscientiousness with UI (instead of the negative relationship with PE in



the case of V1) was noted. Negative relationships of Agreeableness with UI and SN continued, with PE was restored (as in the case of V1) and that with ATU (noted in the case of V2) was not found here. If Neuroticism was positively correlated with PEOU in the case of V1, here it was with PBC.

Generally applicable to all the above correlation results of V1, V2 and V3, the positive relationships obtained support for the hypotheses, negative relationships do not support the hypotheses and absence of relationships support alternate hypotheses listed in Methodology chapter. The consistent mutual relationship between Agreeableness and Conscientiousness, which was not hypothesised, may suggest an indirect effect of either with app usage behaviour. The implications of these relationships in answering research questions and validating the research model, will be discussed in the Discussion chapter.

**Table 5.71 Correlations between the Big Five personality traits and the application use subscale scores - V3**

	BFI - Extraversion	BFI - Agreeableness	BFI - Conscientiousness	BFI - Neuroticism	BFI - Openness	V3 APP PEOU	V3 APP PU	V3 APP PE	V3 APP ATU	V3 APP UI	V3 APP UB	V3 APP SN
BFI - Agreeableness	-.141											
BFI - Conscientiousness	.036	.223*										
BFI - Neuroticism	-.085	-.185	-.186									
BFI - Openness	-.057	-.131	-.062	-.129								

	BFI - Extraversion	BFI - Agreeableness	BFI - Conscientiousness	BFI - Neuroticism	BFI - Openness	V3 APP PEOU	V3 APP PU	V3 APP PE	V3 APP ATU	V3 APP UI	V3 APP UB	V3 APP SN	V3 APP PBC
V3 APP PEOU	.049	-.179	.111	.063	-.133								
V3 APP PU	-.100	-.178	.101	.186	.018	.647**							
V3 APP PE	-.115	-.231*	.164	.107	.067	.604**	.866**						
V3 APP ATU	-.105	-.195	.156	.079	.111	.517**	.849**	.903**					
V3 APP UI	-.078	-.217*	.233*	.057	.034	.504**	.796**	.866**	.955**				
V3 APP UB	-.188	.026	.102	.107	-.067	.510**	.756**	.679**	.672**	.625**			
V3 APP SN	-.107	-.216*	.047	.042	.090	.498**	.761**	.716**	.722**	.661**	.716**		
V3 APP PBC	-.050	-.069	.052	.250*	-.100	.606**	.799**	.665**	.678**	.622**	.693**	.701**	

\*\*, Correlation is significant at the 0.05 level (2-tailed).

\*\*, Correlation is significant at the 0.01 level (2-tailed).

#### 5.3.4.2 Research Question 2

What are the correlations between the independent variables of C-TAM-TPB and Perceived Enjoyment and the study's dependent variables?

## 5.3.4.2.1 V1

The Spearman's correlations between the application use subscale scores and the littering subscale scores are shown in Table 5.72. The results of the analysis indicated that most of the correlations between the application use subscale scores and the littering subscale scores were positive and significant for V1. These findings support the hypotheses formed on the respective relationships. However, no relationship was obtained for PEOU vs littering PE, SN; PE, ATU vs littering SN, BI, LB and UI vs littering SN, PBC, BI, LB. In these cases, the alternate null hypotheses are supported.

**Table 5.72 Correlations between the application use subscale scores and the littering subscale scores - V1**

	V1 APP PEOU	V1 APP PU	V1 APP PE	V1 APP ATU	V1 APP UI	V1 APP UB	V1 APP SN	V1 APP PBC	V1 Littering PE	V1 Littering SN	V1 Littering PBC	V1 Littering ATU	V1 Littering BI
V1 APP PU	.464**												
V1 APP PE	.169	.768**											
V1 APP ATU	.252*	.786**	.908**										
V1 APP UI	.264*	.763**	.886**	.971**									
V1 APP UB	.300**	.595**	.529**	.499**	.501**								
V1 APP SN	.172	.523**	.564**	.640**	.620**	.646**							
V1 APP PBC	.392**	.619**	.492**	.561**	.549**	.595**	.504**						

	V1 APP PEOU	V1 APP PU	V1 APP PE	V1 APP ATU	V1 APP UI	V1 APP UB	V1 APP SN	V1 APP PBC	V1 Littering PE	V1 Littering SN	V1 Littering PBC	V1 Littering ATU	V1 Littering BI
V1 Littering PE	.388**	.503**	.555**	.564**	.533**	.358**	.385**	.262*					
V1 Littering SN	.361**	.256*	.167	.181	.181	.521**	.406**	.404**	.480**				
V1 Littering PBC	.458**	.299**	.256*	.217*	.193	.447**	.235*	.476**	.563**	.759**			
V1 Littering ATU	.526**	.412**	.286**	.331**	.332**	.438**	.362**	.432**	.656**	.676**	.759**		
V1 Littering BI	.447**	.221*	.102	.071	.075	.562**	.243*	.363**	.425**	.761**	.754**	.654**	
V1 Littering LB	.416**	.243*	.135	.112	.106	.539**	.337**	.308**	.477**	.780**	.732**	.642**	.890**

\*\*, Correlation is significant at the 0.05 level (2-tailed).

\*\*, Correlation is significant at the 0.01 level (2-tailed).

#### 5.3.4.2.2 V2

The Spearman's correlations between the application use subscale scores and the littering subscale scores are shown in Table 5.73. The results of the analysis indicated that most of the correlations between the application use subscale scores and the littering subscale scores were positive and significant for V2, supporting the respective hypotheses of relationships. Those not related were: ATU vs littering SN, PBC, BI; UI vs littering SN, PBC, BI, LB, thus supporting alternate hypotheses.

**Table 5.73 Correlations between the application use subscale scores and the littering subscale scores - V2**

	V2 APP PEOU	V2 APP PU	V2 APP PE	V2 APP ATU	V2 APP UI	V2 APP UB	V2 APP SN	V2 APP PBC	V2 Littering PE	V2 Littering SN	V2 Littering PBC	V2 Littering ATU	V2 Littering BI
V2 APP PU	.498**												
V2 APP PE	.334**	.696**											
V2 APP ATU	.422**	.737**	.797**										
V2 APP UI	.324**	.669**	.684**	.941**									
V2 APP UB	.454**	.705**	.541**	.516**	.425**								
V2 APP SN	.417**	.701**	.562**	.623**	.544**	.757**							
V2 APP PBC	.456**	.763**	.654**	.646**	.553**	.756**	.690**						
V2 Littering PE	.532**	.432**	.374**	.411**	.345**	.394**	.389**	.380**					
V2 Littering SN	.306**	.297**	.171	.153	.080	.484**	.379**	.368**	.515**				
V2 Littering PBC	.482**	.360**	.208*	.132	.073	.538**	.338**	.484**	.517**	.732**			

	V2 APP PEOU	V2 APP PU	V2 APP PE	V2 APP ATU	V2 APP UI	V2 APP UB	V2 APP SN	V2 APP PBC	V2 Littering PE	V2 Littering SN	V2 Littering PBC	V2 Littering ATU	V2 Littering BI
V2 Littering ATU	.559**	.378**	.261*	.326**	.241*	.467**	.362**	.503**	.659**	.716**	.718**		
V2 Littering BI	.509**	.402**	.222*	.158	.062	.621**	.326**	.516**	.604**	.734**	.816**	.722**	
V2 Littering LB	.484**	.435**	.244*	.239*	.123	.666**	.418**	.488**	.523**	.709**	.670**	.710**	.864**

\*\*, Correlation is significant at the 0.05 level (2-tailed).

\*\*, Correlation is significant at the 0.01 level (2-tailed).

#### 5.3.4.2.3 V3

The Spearman's correlations between the application use subscale scores and the littering subscale scores are shown in Table 5.74. The results of the analysis indicated that all the correlations between the application use subscale scores and the littering subscale scores were positive and significant for V3.

**Table 5.74 Correlations between the application use subscale scores and the littering subscale scores - V3**

	V3 APP PEOU	V3 APP PU	V3 APP PE	V3 APP ATU	V3 APP UI	V3 APP UB	V3 APP SN	V3 APP PBC	V3 Littering PE	V3 Littering SN	V3 Littering PBC	V3 Littering ATU	V3 Littering BI
V3 APP PU	.647**												
V3 APP PE	.604**	.866**											
V3 APP ATU	.517**	.849**	.903**										
V3 APP UI	.504**	.796**	.866**	.955**									
V3 APP UB	.510**	.756**	.679**	.672**	.625**								
V3 APP SN	.498**	.761**	.716**	.722**	.661**	.716**							
V3 APP PBC	.606**	.799**	.665**	.678**	.622**	.693**	.701**						
V3 Littering PE	.545**	.601**	.624**	.548**	.505**	.553**	.500**	.509**					
V3 Littering SN	.308**	.322**	.267*	.297**	.301**	.487**	.452**	.414**	.570**				
V3 Littering PBC	.400**	.496**	.400**	.385**	.328**	.656**	.488**	.568**	.610**	.744**			

## CHAPTER 5: DATA ANALYSIS AND RESULTS

	V3 APP PEOU	V3 APP PU	V3 APP PE	V3 APP ATU	V3 APP UI	V3 APP UB	V3 APP SN	V3 APP PBC	V3 Littering PE	V3 Littering SN	V3 Littering PBC	V3 Littering ATU	V3 Littering BI
V3 Littering ATU	.402**	.439**	.400**	.428**	.415**	.497**	.349**	.490**	.523**	.704**	.792**		
V3 Littering BI	.263*	.374**	.339**	.306**	.231*	.577**	.324**	.367**	.499**	.631**	.817**	.717**	
V3 Littering LB	.289**	.388**	.307**	.287**	.248*	.606**	.356**	.454**	.520**	.706**	.812**	.725**	.865**

\*\*, Correlation is significant at the 0.05 level (2-tailed).

\*\*, Correlation is significant at the 0.01 level (2-tailed).

It is noteworthy that there is an increasing trend of positive relationships from V1 to V3. In the case of V1, 10 correlations were not significant, It reduced to seven in the case of V2. There was no case of non-significant relationships in the case of V3.



### 5.3.4.3 Research Question 3

To what extent does Technology Acceptance of EVA mediate the relationship between the independent and dependent variables of the anti-littering research model?

#### 5.3.4.3.1 V1

A multiple linear regression model was fit to establish if the main effects of the Big Five personality traits and the application use subscale scores are significant predictors of anti-littering behaviour for V1. This was done as a prerequisite to the mediation analysis. If the main effects of the Big Five personality traits were not significant predictors of anti-littering behaviour, the application use subscale scores cannot have a mediating effect on the relationship between the Big Five personality traits and anti-littering behaviour for V1.

The results of the analysis indicated that in the case of V1, APP Usage Behaviour, APP Attitude Towards Using, and APP Perceived Ease Of Use accounted for a significant proportion of Anti-Littering Behaviour,  $R^2 = .527$ ,  $F(2, 86) = 36.370$ ,  $p < .001$ . The model is shown in Figure 3.1. Thus, 52.7% of the variation in the dependent variable, LB was explained by attitude towards using, perceived ease of use and usage behaviour. These three variables being variables of TAM (Fred D Davis, 1985).

However, none of the Big Five personality traits were found to be a significant predictor of anti-littering behaviour. This indicates absence of a mediation effect by the application use subscale scores on the relationship between Big Five personality traits and anti-littering behaviour. The big five personality traits are: neuroticism, extroversion, openness, conscientiousness and agreeableness. The meaning of this result is: these traits are adequate and are able to promote the anti-littering behaviour; therefore, there is need for any additional variable as a mediating or moderating factor.

*Table 5.75 Regression model - V1*

Model	Unstandardised Coefficients		Standardised Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2.128	.642	-	3.318	.001

V1 APP UB	.679	.085	.715	8.013	<.001
V1 APP ATU	-.468	.100	-.412	-4.688	<.001
V1 APP PEOU	.404	.115	.281	3.504	.001

#### 5.3.4.3.2 V2

A multiple linear regression model was fit to establish if the main effects of the Big Five personality traits and the application use subscale scores were significant predictors of anti-littering behaviour for V2. This was done as a prerequisite to the mediation analysis. If the main effects of the Big Five personality traits was not a significant predictor of anti-littering behaviour, there cannot be a mediation effect of the application use subscale scores on the relationship between the Big Five personality traits and anti-littering behaviour for V2.

The results of the analysis indicated that V2 APP UB, V2 APP PE, and V2 APP PEOU accounted for a significant proportion of V2 Littering LB,  $R^2 = .596$ ,  $F(3, 85) = 41.867$ ,  $p < .001$ . The model is shown in Table 5.76. However, none of the Big Five personality traits were found to be a significant predictor of anti-littering behaviour indicating that there cannot be a mediating effect of the application use subscale scores on the relationship between the Big Five personality traits and anti-littering behaviour.

**Table 5.76 Regression model - V2**

Model	Unstandardised Coefficients		Standardised Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	1.465	.623	-	2.352	.021
V2 APP UB	.691	.077	.769	9.012	<.001
V2 APP PE	-.323	.082	-.325	-3.943	<.001
V2 APP PEOU	.392	.111	.263	3.527	.001

#### 5.3.4.3.3 V3

A multiple linear regression model was fit to establish if the main effects of the Big Five personality traits and the application use subscale scores were significant predictors of anti-littering behaviour for V3. This was done as a prerequisite to the mediation analysis. If the main effects of the Big Five personality traits was not a significant predictor of anti-littering behaviour, there cannot be a mediating effect of the application use subscale scores on the relationship between the Big Five personality traits and anti-littering behaviour for V3.

The results of the analysis indicated that V3 APP UB and V3 APP ATU accounted for a significant proportion of V3 Littering LB,  $R^2 = .518$ ,  $F(2, 86) = 46.267$ ,  $p < .001$ . The model is shown in Table 5.77. However, none of the Big Five personality traits were found to be a significant predictor of anti-littering behaviour indicating that there cannot be a mediating effect of the application use subscale scores on the relationship between the Big Five personality traits and anti-littering behaviour.

**Table 5.77: Regression model - V3**

Model	Unstandardised Coefficients		Standardised Coefficients		t	Sig.
	B	Std. Error	Beta			
(Constant)	2.986	.492			6.071	<.001
V3 APP UB	.874	.097	.878		8.980	<.001
V3 APP ATU	-.349	.111	-.307		-3.140	.002

#### 5.3.4.4 Research Question 4

Is there a significant difference between the mean littering score of V1 (control) and V2, and V1 (control) and V3?

The results of the paired t-test indicated that there was a significant difference between the littering scores between V1 and V2 ( $t(89) = -3.54$ ,  $p = .001$ ) and between V1 and V3 ( $t(89) = -2.61$ ,  $p = .011$ ). It should be noted that the mean difference between the littering scores of V2 and V1, and littering

scores of V3 and V1 was the same i.e. 0.36.

**Table 5.78 Paired Samples Statistics**

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	V1 Littering LB	5.12	90	1.52	.16
	V2 Littering LB	5.48	90	1.37	.14
Pair 2	V1 Littering LB	5.12	90	1.52	.16
	V3 Littering LB	5.48	90	1.60	.17

**Table 5.79 Paired Samples Correlations**

		N	Correlation	Sig.
Pair 1	V1 Littering LB & V2 Littering LB	90	.781	<.001
Pair 2	V1 Littering LB & V3 Littering LB	90	.659	<.001

*Table 5.80 T-test results*

		Paired Differences					t	df	Sig. (2-tailed )
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	V1 Littering LB - V2 Littering LB	-.36	.97	.10	-.56	-.16	-3.54	89	.001
Pair 2	V1 Littering LB - V3 Littering LB	-.36	1.29	.14	-.63	-.08	-2.61	89	.011

### 5.3.5 Post Survey

The participants were asked a range of questions about the changes in their behavioural intention after using the applications. The participants' responses to these questions are summarised in

Table 5.81 to

Table 5.83. The results indicated that the EVA V3 (AR Game) brought about the most change in the participants' behavioural intentions.

**Table 5.81** *How much do you think that using the following software has helped change your behavioural intention? - EVA V1 Standard Mobile App (without AR)*

	Frequency	Percent
A great deal	8	8.9
A lot	14	15.6
A moderate amount	35	38.9
A little	26	28.9
None at all	7	7.8
Total	90	100.0

**Table 5.82** *How much do you think that using the following software has helped change your behavioural intention? - EVA V2 (AR) App*

	Frequency	Percent
A great deal	20	22.2
A lot	39	43.3
A moderate amount	24	26.7
A little	2	2.2
None at all	5	5.6
Total	90	100.0

**Table 5.83 How much do you think that using the following software has helped change your behavioural intention? – EVA V3 (AR Game)**

	Frequency	Percent
A great deal	50	55.6
A lot	14	15.6
A moderate amount	14	15.6
A little	5	5.6
None at all	7	7.8
Total	90	100.0

The participants were asked a range of questions about the changes in their littering behavioural intention after using the applications. The participants' responses to these questions are summarised in Table 5.84 to Table 5.86. The results indicated that the EVA V3 (AR Game) brought about the most change in the participants' littering behavioural intention.

**Table 5.84 How much do you think that you have changed your littering behavioural intention after using the following software? - EVA V1 Standard Mobile App (without AR)**

	Frequency	Percent
A great deal	7	7.8
A lot	19	21.1
A moderate amount	30	33.3
A little	26	28.9
None at all	8	8.9
Total	90	100.0



**Table 5.85** *How much do you think that you have changed your littering behavioural intention after using the following software? - EVA V2 (AR) App*

	Frequency	Percent
A great deal	21	23.3
A lot	37	41.1
A moderate amount	20	22.2
A little	8	8.9
None at all	4	4.4
Total	90	100.0

**Table 5.86** *How much do you think that you have changed your littering behavioural intention after using the following software? - EVA V3 (AR Game)*

	Frequency	Percent
A great deal	41	45.6
A lot	17	18.9
A moderate amount	18	20.0
A little	8	8.9
None at all	6	6.7
Total	90	100.0

The participants were asked a range of questions about the changes in their littering behavioural intention after reviewing the various litter prevention approaches. The participants' responses to these questions are summarised in Table 5.87 to

Table 5.91. The results indicated that the top three approaches were nominated to be: AR Games, AR Videos, and AR images.

***Table 5.87 How effective would you say the following litter prevention approaches have been in changing your littering behavioural intention? – Videos***

	Frequency	Percent
Extremely effective	23	25.6
Very effective	25	27.8
Moderately effective	20	22.2
Slightly effective	14	15.6
Not effective at all	8	8.9
Total	90	100.0

***Table 5.88 How effective would you say the following litter prevention approaches have been in changing your littering behavioural intention? - Images***

	Frequency	Percent
Extremely effective	13	14.4
Very effective	25	27.8
Moderately effective	29	32.2
Slightly effective	17	18.9
Not effective at all	6	6.7
Total	90	100.0

**Table 5.89 How effective would you say the following litter prevention approaches have been in changing your littering behavioural intention? - AR Videos**

	Frequency	Percent
Extremely effective	37	41.1
Very effective	27	30.0
Moderately effective	16	17.8
Slightly effective	5	5.6
Not effective at all	5	5.6
Total	90	100.0

**Table 5.90 How effective would you say the following litter prevention approaches have been in changing your littering behavioural intention? - AR Images**

	Frequency	Percent
Extremely effective	25	27.8
Very effective	27	30.0
Moderately effective	29	32.2
Slightly effective	4	4.4
Not effective at all	5	5.6
Total	90	100.0

**Table 5.91 How effective would you say the following litter prevention approaches have been in changing your littering behavioural intention? - AR Game**

	Frequency	Percent
Extremely effective	38	42.2
Very effective	26	28.9
Moderately effective	12	13.3
Slightly effective	7	7.8
Not effective at all	7	7.8
Total	90	100.0

The participants were asked to rate the environment at the location of the tasks for V1, V2 and V3. The participants' responses to these questions are summarised in Table 5.92 to Table 5.94. The results indicated that the participants found the environment in V3 to be most littered, next was V2, and lastly V1.

**Table 5.92 How do you describe the environment (in term of littering status) in each of the following task's locations during your visit? – EVA V1 Task**

	Frequency	Percent
Minimal or No Litter	30	33.3
Slightly Littered	45	50.0
Littered	10	11.1
I haven't been there	5	5.6
Total	90	100.0

**Table 5.93 How do you describe the environment (in term of littering status) in each of the following task's locations during your visit? - EVA V2 Task**

	Frequency	Percent	Valid Percent	Cumulative Percent
Minimal or No Litter	29	32.2	32.6	32.6
Slightly Littered	41	45.6	46.1	78.7
Littered	17	18.9	19.1	97.8
I haven't been there	2	2.2	2.2	100.0
Total	89	98.9	100.0	
Response missing	1	1.1		
Total	90	100.0		

**Table 5.94 How do you describe the environment (in term of littering status) in each of the following task's locations during your visit? - EVA V3 Task**

	Frequency	Percent
Minimal or No Litter	23	25.6
Slightly Littered	36	40.0
Littered	23	25.6
I haven't been there	8	8.9
Total	90	100.0

The participants were asked if they had completed the tasks V1, V2, and V3 and how many times they had visited the tasks' locations. The responses are summarised in Table 5.95 to Table 5.98. The results indicated that most of the people had used all three applications. The average visit per app was 1.

**Table 5.95 Did you complete EVA V1 task?**

	Frequency	Percent
Yes	79	87.8
No	11	12.2
Total	90	100.0

**Table 5.96 Did you complete EVA V2 task?**

	Frequency	Percent
Yes	82	91.1
No	8	8.9
Total	90	100.0

**Table 5.97 Did you complete EVA V3 task?**

	Frequency	Percent
Yes	82	91.1
No	8	8.9
Total	90	100.0

**Table 5.98 Did you complete the following tasks, if yes how many times did you visit the tasks' locations?**

	Minimum	Maximum	Mean	SD
EVA V1	0	2	1	0
EVA V2	0	4	1	0
EVA V3	0	7	1	1

### **5.4 Chapter Summary**

The data of the experimental study from the two cases were merged and analysed as one set because of the significant number of same culture participants that appeared in both cases. Different data analysis methodologies, discussed in section 6.2, were used to analyse and answer the research questions, such as frequency counts, descriptive statistics, reliability analysis, scale and subscale scoring, and multivariate analysis. The results are highlighted in section 6.3. The results of post V1, V2 and V3 show that none of the Big Five personality traits were found to be a significant predictor of anti-littering behaviour. However, there was a significant difference between the littering scores between V1 and V2 ( $t(89)=-3.54, p=.001$ ) and between V1 and V3 ( $t(89)=-2.61, p=.011$ ). Additionally, the results indicated that the EVA V3 (AR Game) brought about the most change in the participants' littering behavioural intention and the top three approaches were ranked as AR Games, AR Videos, and AR images.

The next chapter is going to discuss the results of this chapter and compare them with the previous work.

# **CHAPTER 6: Evaluation of Results**



## 6.1 Introduction

This chapter discusses the research findings and the reported findings from the previous literature. The primary aim of this study is to investigate the acceptance of technology to promote anti-littering behaviour using plain mobile apps, mobile AR and mobile AR with gamification.

The main research questions are:

- Research Question 1: What are the correlations between the Big Five personality traits (OCEAN) and the acceptance of the environmental awareness augmented reality app (EVA), as measured by the combined model of TAM, TPB, and the Perceived Enjoyment (PE) factor?
- Research Question 2: What are the correlations between the independent variables of the combined model of TAM, TPB, and Perceived Enjoyment (PE) and the study's dependent variables?
- Research Question 3: To what extent does Technology Acceptance of EVA mediate the relationship between the independent and dependent variables of the anti-littering research model?
- Research Question 4: Is there a significant difference between the mean littering scores of V1 (control) and V2, and V1 (control) and V3?

What follows are the findings reported in the previous chapter are explained and interpreted and alternate explanations are examined. After discussing the main findings of this study, the discussions will focus on how the findings answer the research questions through verification of hypotheses. Based on the outcomes of these discussions, the final conclusions are drawn.

### 6.1.1 Motivation

The environment of our planet suffers from the irresponsible use of the world's natural resources. Regardless of how developed a country is, littering behaviour can be encountered, at least to some extent. Many methods have been used to discourage people from littering in public places and promoting anti-littering behaviour. Out of these methods, augmented reality (AR) holds promise. However, there has been a lack of research regarding the use of AR to promote anti-littering behaviour in Australia and Saudi Arabia. This research was undertaken to fill this research gap.

#### 6.1.1.1 General Trends About Littering

Litter was admitted to be a major concern by almost all participants with varying reasons. Littering was recognised as a problem on their university campus and so was the need for litter prevention. In an Australian study, E. Williams et al. (1997) found that people of all ages and social backgrounds practised littering. People under 25 littered when in a group and those above 25 littered when they were alone. These results support our findings. The unemployed did more littering than others. The higher the education, the lower the tendency to litter. KESAB (2011) also

noted that younger people and women littered less for various reasons depending upon their socioeconomic levels. At the same socio-economic level, older people littered less than younger people.

Smaller items and organics were perceived as more acceptable for littering. Littering was more common at railway stations, park benches, bus shelters, and outside large buildings. Already littered places became more littered. People tended not to litter, if they were likely to be noticed, in their own backyard, and in areas which were tidy. Littering was justified if it was perceived that everyone was doing it, the person was drunk, or when none could see the person (as in driving). A small percentage of people believed littering was their right. Thus, attitudes and contexts determined littering behaviour.

People denied littering when confronted. Younger people and women were more frank than others to admit to littering. Most people admitted littering was an environmental issue; but practised littering very frequently. Most people considered cigarettes as litter, in spite of it being the most commonly littered item.

In a study on littering in South Australia (KESAB, 2011), it was noted that people's excuses included littering due to laziness, non-availability of bins at the spot, the attitude that someone else will pick it up, seeing others littering, and as a subconscious activity. The need to direct awareness and guerrilla marketing-like efforts at littering spots was stressed for increased effectiveness. Actions before littering were more effective than those used after to correct the behaviour. Use of existing bins needs to be maximised. Social enforcement (via social sites) was more effective than monetary enforcement and demonstration of the negative effects to the environment through methods like mobile games approach and AR, with or without gaming methods.

### **6.1.2 The Key Findings**

The results of this thesis indicate that AR app EVA with or without gaming (V3 and V2) was more effective than a standard mobile application (V1) in affecting behavioural change towards anti-littering behaviour. A moderate to great deal of change in littering behavioural intention were observed most in the case of the AR Game compared to the other two. With respect to their effectiveness, the top three approaches nominated by the participants, based on their experiences were: AR Games, AR Videos, and AR images.

Since this research has been conducted, in the last four years, some examples of AR applications for perception and behaviour changes unrelated to littering have been cited by Azuma (1997).

However, have been provided by Kirschner (2018), EPANSW (2017b), Hoyle (2016), Forde (2015), Australia (2018), StanfordWoods (2018a) and Coskun and Erbug (2014), (B. Kim, 2015), Froehlich (2015), Trendhunter (2018) and by Nichols (2018). These works support the findings of this study.

Kirschner (2018) provided a specific example of a mobile AR application to promote anti-littering behaviour, called *Literati*. Other examples of social networking sites to report littering place, type, and location (EPANSW, 2017b), include a photography social network, Littergram (Hoyle, 2016), a See it-Say it Android and iPhone application (Forde, 2015), and a smartphone application for registered persons in Western Australia (Australia, 2018) to report throwing of litter from vehicles. Some gaming applications with AR have been reported by StanfordWoods (2018a) and Coskun and Erbug (2014). Some examples of gamification were described by B. Kim (2015), while Froehlich (2015) discussed ecotropism as an AR Gaming example to promote efficient recycling or disposal of trash (Froehlich, 2015). A report in Trendhunter (2018) gave some gaming applications for reducing litter in cities, for example fun games are used in London to prevent throwing cigarettes and gum on the ground, based on betting on leading football players and; Coca-Cola had a Batak challenge game to attract people to recycle bottles during the Rugby World Cup. Finally, a robot has been used with a gaming application for keeping the Chicago River free from floating litter (Nichols, 2018). These findings demonstrate the scope for use of specific anti-littering applications with or without gaming in mobile phones. This research also showed similar results. Hence the cited works support the findings obtained in this research.

The intention to use mobile applications was highest in AR version with gaming. When AR was used with or without Gaming, the application use subscales had a direct effect on anti-littering behaviour. But no effect of the Big Five personality traits was observed. As application use subscales were variables of TPB/TAM, this is a clear indication of how anti-littering behaviour can be brought about using TPB/TAM characteristics rather than trying to influence through the Big Five traits.

The effect of AR on behaviour change through social influence was demonstrated by Botella, et al. (2011) and, specifically on changing littering behaviour, by Rangoni and Jager (2017). AR with gaming was found useful to promote antilittering behaviour by Crowley et al. (2012). AR dioramas were used by Marsh et al. (2017) to promote a clean Great Barrier Reef. Warren and Champion (2014) found Linked Open Data (LOD) can be used for generating games for antilittering promotion. According to M. Williams et al. (2005), enhanced mobile technologies for AR in

spatial practices could be used for antilittering behaviour also. Forlano (2015) also discussed the use of AR for digital configuration of smart littering alerts, garbage collection, and recycling systems to integrate digital and physical realities. Schermer (2009) pointed out the possibility of using AR for accessing relevant information to change littering behaviour. According to the findings of McCarty and Shrum (1994), although the individual values of excitement, fun, and enjoyment were important for recycling solid wastes, it did not necessarily result in a permanent behavioural change. Thus, voluntary change may lead to enjoyment, whether it is with AR, AR with gaming, or any other.

## **6.2 Evaluation of User profiles**

The user profiles on the relationship between the Big Five personalities and TRA/TPB were discussed in general by Picazo-Vela et al. (2010) and Ajzen (2011), by Conner and Abraham (2001) on exercise and health protection behaviour, by Hoyt et al. (2009) on exercise behaviour and by Teh et al (2011) and Mahmood, Qureshi, and Shahbaz (2011) in knowledge sharing. The models used by these authors for behaviour change may be valid in the case of littering behaviour change. Picazo-Vela et al. (2010) obtained relationship of four of the Big Five factors (except openness) with behavioural intention towards a review of users of online trade. According to Azjen (2011) the Big Five traits influence the TPB variables when a person tries to compare himself/herself with others. Conner and Abraham (2001) noted a partial mediation by cognitions on the effect of conscientiousness on intentions regarding goal-directed activities in health protection. Hoyt et al (2009) found extraversion and conscientiousness of the five factor model and self-discipline independently predicting exercise behaviour. Activity and self-discipline and the TPB variables of affective attitude, instrumental attitude and subjective norm affected exercise behaviour indirectly. This effect was mediated through intention and perceived behavioural control. Neuroticism (anxiety) of the Big Five moderated the relationship between the intention and behaviour. Teh et al (2011) noted attitude towards knowledge sharing to be positively related with extraversion, neuroticism and subjective norm and negative relationship for openness to experience with the. Both attitude towards knowledge sharing and subjective norm were independently related with the intention to share knowledge, which significantly influenced the actual knowledge sharing behaviour.

### **6.2.1 Evaluation of Demographics**

In our experiments, the user profiles of participants indicated that more than one third were male, most of them had some college education, were either students or full-time employees, and aged 18-45 years old.

Considering the Australian findings of E. Williams et al. (1997), littering behaviour is not limited to any age group or social background, but youngsters show group littering behaviour. About 78% of the participants were youngsters (35 years and below) and therefore the majority of the participants tended to litter when they were in a group. The employed, or those with higher education, littered less. In this study, over 80% were students or fully employed. If we consider students as employed, littering behaviour drops down. Women litter less, according to KESAB (2011). However, only about 30% of participants were female. Older people littered less. Only about 20% of participants were older than 35 years. Taking the two findings by E. Williams et al. (1997) and KESAB (2011) together, group littering behaviour is expected to be greater among 55% of the participants. Miranda and Bynum (2002) showed that community characteristics of demographic and socio-economic factors are important factors that determine people's littering and dumping behaviour.

### **6.2.2 Evaluation of Mobile and AR User Experience**

About 65% of the participants had good experience with using mobile applications, however, only about 45% of them had experience in mobile games. Statista (Statista, 2017) reported the percentage of internet users who use smartphones to play games ranged from 71% in Asia-Pacific to 50% in Europe. The observed trend in this study was less than the lowest reported. The superior effectiveness of ARGames, therefore, is not influenced by their previous experience in playing mobile games.

### **6.2.3 Evaluation of Littering and Anti-Littering Behaviour**

#### **6.2.3.1 Exposure to Anti-Littering Messages and Campaigns**

Littering was perceived as a serious problem by most participants, most of them agreeing on the causes of it being a serious problem. However, the level of seriousness of littering in the University was perceived to be small to moderate by about 69% of participants although a much smaller 19% considered it as a serious issue. On the other hand, about 89% of them stated that littering prevention was very important. In effect, all of the total 88% who rated littering as a very serious to small problem, wanted steps to prevent littering in the University. A report by (Cox, King, & Hughes, 2015) for Zero Waste Scotland found that people's understanding of the impact of littering depended on the type of litter. Certain types of litter were viewed as serious problems and certain others were not. When a mechanism for clearing the litter was always available, the benefits of prevention were not realised adequately. The littering problem was perceived to be less serious when there was a permanent mechanism to remove them. The reason for littering was more seriously regarded than the act of littering itself and littering monitoring is easier with people's

ability to identify sites of very serious littering. Context-specific messages and messages challenging the perception of clean up versus prevention, explaining reason for littering and blaming others for littering (so that they examine their own littering behaviour) and changing views about littering in social interactions can be used as clear communication strategies to prevent littering and promote anti-littering behaviour. However, the participants' exposure to awareness messages in various media was not high, either in public places or on the University campus.

#### **6.2.3.2 Perceptions of how others litter and recent littering materials by participants.**

Most people did not respond to the question on disposal of cigarette butts, but this is not important as about 84% did not smoke. The excuses for littering were a don't care attitude, not considering that what they throw is litter, thinking that someone else will pick it up, absence of a trashcan or bag nearby, thinking that throwing just one piece does not matter, or no time to dispose. Unintentional littering also occurred to some extent. The Community Change Consultants (CCC) reported in 2012 that the most frequent reason for littering was laziness (E. Williams et al., 1997). In Australia, littering occurred even when bins were available and littering, especially of cigarettes, occurred around the bins. Use of bins was more common during 11 am to 2 pm, but littering was most common around 4 pm. Cigarettes were the most commonly littered item and beverage containers were the least commonly littered item. Sometimes, people put parts of items into the bins and forgot others. A large number of people littered cigarettes while they put other objects into the bins. Wedging (putting disposable objects into small spaces where they will not be seen), undertaking (burying disposables under something else), and foul shooting (throwing from a distance and missing the bin, thus leaving the object on the ground) were common. This study did not include these types of littering behaviour.

#### **6.2.3.3 Participants own likely littering and littering prevention behaviour.**

People have been shown to be less likely to litter a clean area or neighbourhood also when holding a piece of litter or smoking and no trash can is available, the possibility of a clean-up crew coming later, and dropping it where they are when nobody is around. Wanger (2014) also observed littering when no one was around and when there was already some litter. Littering in clean places was rare. Littering was more common when trash bins are far away. An NTU work reported that in Singapore, littering had increased as they had confidence that the cleaners would remove it anyway. Picking up something dropped by someone else was more unlikely, unless they had dropped it themselves or it was on their own property.

Most people expressed strong will power for behavioural change and motivation for living in a

green environment and changing littering behaviour. However, more of them said they were unlikely to litter under a variety of situations favourable for littering. Most of them were likely to remove litter if it directly concerned them.

E. Williams et al.'s (1997) study on littering behaviour in Australia noted people both just leaving and deliberately placing litter with low awareness that what they were really doing was littering. Littering occurred even when bins were available and littering, especially of cigarettes, occurred around the bins. Use of bins was more common during 11 am to 2 pm and littering was most common around 4 pm. Cigarettes were most commonly littered and beverage containers were least commonly littered.

#### **6.2.3.4 Views about anti-littering methods and their effectiveness.**

More trashcans, educational programmes, regulatory and persuasive tactics, hotlines/websites to report littering, public awareness campaigns, additional funding for cleaning, of anti-littering methods were largely supported by participants. Support for awareness programmes and media and public education campaigns existed in the recommendations given by CCC in 2012. In the UK (KingdomUK, n.d.-a), the effect of litter strewn all around in public places affected the pride of residents in an area. The effect of littering on health, the environment, and economy also worked as deterrents to littering by the residents in the area. According to Bell (2012), public-spirited persons will not litter and will also remove litter dropped by someone else.

#### **6.2.3.5 Perceptions and attitudes about litter prevention methods.**

Litter prevention behaviour was pleasant, enjoyable, fun, and entertaining. Readiness, backed with knowledge and ability for antilitter behaviour and the desirability of litter prevention on the university campus, for a variety of reasons, was endorsed by most participants. Many people claimed they were already doing litter prevention behaviour and wanted to continue it.

Many of them wanted to apply litter prevention behaviour in either clean (to prevent any litter entering) or littered (remove current litter and prevent further littering) locations. The participants desired that influential, important, and valuable people for them should not think that they practise littering (as it is bad). The UK report (KingdomUK, n.d.-a) and the findings of Bell (2012) showed that littering and anti-littering behaviour are related to many factors related to personal attitude and perception.

### 6.3 Main Contributions

This thesis research contributed to the issue of littering and its prevention by using AR-enabled mobile applications by answering the following research questions. This research primarily contributes in filling the gap of knowledge related to the acceptance of AR technology and gamification for promoting anti-littering behaviour. Second, it contributes through providing three technology acceptance models for promoting anti-littering behaviour using three versions of EVA mobile app (standard mobile app, AR mobile app, and AR mobile app with gamification element activated).

#### 6.3.1 Answers to The Research Questions

**Research Question 1:** What are the correlations between the Big Five personality traits (OCEAN) and the acceptance of the environmental awareness augmented reality app (EVA) as measured by C-TAM-TPB and Perceived Enjoyment?

The main relationships obtained can be summarised and compared among V1, V2 and V3 as given below-

V1-

1. Agreeableness was positively correlated with conscientiousness.
2. Agreeableness was negatively correlated with PE (Perceived Enjoyment), Attitude Towards Using (ATU), application Usage Intention (UI) and Subjective Norms (SN).
3. Conscientiousness was negatively correlated with Perceived Enjoyment.
4. Neuroticism was positively correlated with Perceived Ease Of Use (PEOU).
5. PEOU was positively correlated with Perceived Usefulness (PU), ATU, UI, application Usage Behaviour (UB) and Perceived Behavioural Control (PBC).
6. All mutual correlations of PU, PE, ATU, UI, UB and SN were highly significant and positive, excepting PEOU with PE and SN.
7. Openness and Extroversion had no role in determining the effects of using different apps for antilittering behaviour.

V2-



1. Agreeableness was positively related with Conscientiousness with similar  $r$  value as V1.
2. Agreeableness was negatively correlated with ATU, UI, and SN, but not PE as in V1.
3. Openness was positively correlated with PE, unlike for V1.
4. Neuroticism (unlike V1), Conscientiousness (unlike V1) and Extraversion were not related with any of the variables.

V3-

1. Agreeableness was positively correlated with Conscientiousness, with similar  $r$  value as in the case of V1 and V2.
2. Agreeableness was negatively correlated with PE (as in V1), UI, and SN (as in V1, V2) but not with ATU (unlike V1, V2).
3. Conscientiousness was positively correlated with UI (unlike V1 OR V2), but not with PE (unlike V1).
4. Neuroticism and PBC were positively correlated (unlike V1, V2), but not with PEOU (unlike V1).
5. Extroversion and Openness were not correlated with any variable as in the case of V1.

Thus, there were variability in significance and direction of relationship for the Big Five traits across V1, V2 and V3. Notably, the relationship between Agreeableness and Conscientiousness was striking for two reasons: the  $r$  values were similar for all three cases and this relationship was not hypothesised. This may suggest a mediating or moderating role of either of the traits on the other in these relationships. Another noteworthy trend was that the number of significant relationships decreased from V1 through V3. In the Methodology chapter, positive relationships were hypothesised, and absence of relationships were given as alternate null hypotheses. So, negative relationships obtained reject the hypotheses either way. Absence of relationships obtained support alternate null hypotheses; which, in effect, is rejection of expected relationships from the literature.

The observed trends of relationships were partially supported by the results obtained by some research workers. Picazo-Vela et al. (2010) noted that, except Openness, other factors of the Big

Five were related with TPB/TAM variables. In this study, for V1, Extroversion was not correlated with any TPB/TAM variables for all the three cases. In addition, Openness was not correlated in the case of V1 and V3 and Neuroticism was not correlated with any variable in the case of V2. In any case, significant relationships were obtained only three out of five traits for all three mobile applications. Azjen (2011) only discussed the scope of the relationships of the five traits with TPB variables. Conner and Abraham (2001) observed a mediating effect of cognition on the relationship between conscientiousness with intention. We suspect a similar mediating effect of either Agreeableness or Conscientiousness on the relationship of the other with TPB/TAM variables of this study. Hoyt et al (2009) observed only two of the five variables (Extroversion and Conscientiousness) as related with behaviour. In this study, Extroversion was not related with any variables in all the three cases. Conscientiousness had no relationship with any variable in the case of V2 only. Teh et al (2011) had obtained positive relationships for Extroversion and Neuroticism with SN and negative relationship for Openness with Attitude to sharing. Again, in our study, Extroversion was not related with any variable in all the three cases; Neuroticism had some positive relationships in the case of V1 and V3 and Openness was positively related with PE only for V2.

Overall, there is some partial support for the findings of this study from other cited research works. Based on the above discussions, the answer to Research Question 1 is-

Some correlations with three or four traits of the Big Five personality traits (OCEAN) and the acceptance of the environmental awareness augmented reality app (EVA) as measured by C-TAM-TPB and Perceived Enjoyment were obtained. However, the direction of the relationships, in most cases, did not support the hypotheses formed. In the case of some relationships, the alternate null hypotheses were supported.

**Research Question 2:** What are the correlations between the independent variables of C-TAM-TPB and Perceived Enjoyment and the study's dependent variables?

V1- Most of the correlations between the application use subscale scores and the littering subscale scores were positive and significant for V1. These findings support the hypotheses formed on the respective relationships. However, no relationship was obtained for PEOU vs littering PE, SN; PE, ATU vs littering SN, BI, LB and UI vs littering SN, PBC, BI, LB. In these cases, the alternate null hypotheses are supported.

V2- Most of the correlations between the application use subscale scores and the littering subscale

scores were positive and significant for V2, supporting the respective hypotheses of relationships. Those not related were: ATU vs littering SN, PBC, BI; UI vs littering SN, PBC, BI, LB, thus supporting alternate hypotheses.

V3- All the correlations between the application use subscale scores and the littering subscale scores were positive and significant for V3. Hence, all hypotheses are supported in this case.

It is noteworthy that there is an increasing trend of positive relationships from V1 to V3. In the case of V1, 12 correlations were not significant. It reduced to seven in the case of V2. There was no case of non-significant relationships in the case of V3. Therefore, what differentiates the three cases of mobile applications, are the variables for which relationships were not found.

More instances of no relationship were observed for SN BI and LB in the case of V1. In the case of V2, both ATU and UI were involved in absent relationships with SN, PBC and BI and only UI with LB. All were significant and positive in the case of V3.

Here again, most published works did not deal with the relationship of TAM or TPB with littering behaviour specifically, but on environmentally-related and health-related behaviour only. The environmentally responsible behaviour of tourists to a Chinese tourist spot was found to be related with SN and positive behavioural control. But this was a survey finding of (Wang, Zhang, Yu, & Hu, 2018b) in which the variables of TPB were tested. Overall, there is some evidence for some relationships. But the exact variables of relationships seem to vary with the nature of study and the model tested for.

The above discussions favour the following as the likely answer to Research Question 2-

There is high degree of relationships between the independent variables of C-TAM-TPB and Perceived Enjoyment and the study's dependent variables. Most of the hypothesised relationships were supported in the case of V1 and V2 and all the relationships in the case of V3.

**Research Question 3:** To what extent does Technology Acceptance of EVA mediate the relationship between the independent and dependent variables of anti-littering research model?

Most of the factors of the Big Five traits were found to predict behaviour patterns and their changes in the works of Hoyt et al. (2009) and Teh' et al. (2011), although related to exercise and health.

According to the results of the multiple linear regression analysis, V1 APP UB, V1 APP ATU,

and V1 APP PEOU accounted for a significant proportion of V1 Littering LB. None of the Big Five personality traits were found to be a significant predictor of anti-littering behaviour indicating that there cannot be a mediating effect of the application use subscale scores on the relationship between the Big Five personality traits and anti-littering behaviour. V2 APP UB, V2 APP PE, and V2 APP PEOU accounted for a significant proportion of V2 Littering LB. V3 APP UB and V3 APP ATU accounted for a significant proportion of V3 Littering LB. However, there was no mediating effect of the application use subscale scores on the relationship between the Big Five personality traits and anti-littering behaviour for V2 and V3. This finding contradicts the results of Conner and Abraham (2001), who noted a partial mediation effect by cognition on the effect of conscientiousness on intention with respect to goal-directed activity in health protection. Crowley et al. (2012) also found benefits by using gaming with AR to discuss environmental issues, like littering in social platforms. AR-based dioramas (miniature 3D digital models) to explore a participant-driven narrative to raise awareness on factors disrupting and affecting the environment. Many other findings have also been discussed in the Literature Review chapter.

The answer to the third Research Question, based on the above discussions, is that-

Technology Acceptance of EVA mediate the relationship between the independent and dependent variables of anti-littering research model to a considerable extent, but not fully.

**Research Question 4:** Is there a significant difference between the mean littering score of V1 (control) and V2, and V1 (control) and V3?

The paired test showed significant differences between V1 and V2 and between V1 and V3. The pairs were significantly correlated too. V2 was superior to V1, but both V2 and V3 had the same means. Hence the difference between them was not significant. A comparison between VR with and without gaming did not lead to any significant advantage for gaming integrated VR, as was reported by (Vogel, Greenwood-Ericksen, Cannon-Bowers, & Bowers, 2006) in an academic context. As about 55% of the participants did not know how to play games on smartphones, both V2 and V3 were perceived similarly by them. This could be the reason for the observed no difference between V2 and V3.

The findings answer the research question 4 positively as-

There are significant differences between V1 and between V2 and V1 and V3.

### 6.3.2 Final Post Survey

The post-survey results revealed the change in behaviour due to EVA applications. V3 (AR Game)

was superior to both V2 (AR alone) and the control. AR alone was superior to the Control. Similar results were obtained with respect to actual change in behaviour also. The participants recommended AR Games, AR Videos, and AR images in that order, as the top three methods to change behaviour. The environment of location 3; where EVA V3 was used, was most littered, V2 less, and V1 least. Most of the participants had used all the three applications. The sites were visited at least once for each application. The AR Games application has been successfully used in a number of contexts by workers like Botella, et al. (2011) and Rangoni and Jager (2017).

### **6.3.3 Validity of The Research**

#### **6.3.3.1 Validation of The Research Model**

The basic hypothesis tested in this research was, whether the Big Five personality traits were positively correlated to the behaviour intention to utilise and accept an environmental awareness augmented reality app (EVA), as measured by the combination of Technology Acceptance Model and Theory of Planned Behaviour (C-TAM-TPB). A total of 126 hypotheses and alternate null hypotheses were formed and tested to answer the four research questions.

The Big Five personality traits are: extraversion, agreeableness, conscientiousness, neuroticism, and openness. The variables of C-TAM-TPB are: perceived usefulness, perceived ease of use, subjective norm, perceived behavioural control, attitude towards using, behavioural intention to use, and perceived enjoyment was also added as a variable. The research questions were based on these aspects.

In the case of Research Question 1 on the relationship between the Big Five and C-TAM-TPB, there were 70 hypotheses in all. Half of these hypotheses are null hypotheses, not positively related. Out of the 35 positive relationships hypothesised, four have been validated. Out of 35 null hypotheses, not positively related (automatically means either negative or no relationship), 10 negatives have been obtained. Thus, out of 70 hypotheses, only 14 were validated, counting V1, V2 and V3 separately. The validated hypotheses are listed below.

1. H1.1B: Measures of the personality type, neuroticism, have a positive linear relationship to the perceived ease of use of EVA app, as measured by C-TAM-TPB. V1.
2. H1.3G: Measures of the personality type, openness, have a positive linear relationship to the perceived enjoyment of the use of EVA app. V2.
3. H1.4F: Measures of the personality type, conscientiousness, have a positive linear relationship to the behavioural intention towards the use of EVA app, as measured by C-TAM-TPB. V3.

4. H1.1D: Measures of the personality type, neuroticism, have a positive linear relationship to the perceived behavioural control towards the use of EVA app, as measured by C-TAM-TPB. V3.
5. H1.4G0: Measures of the personality type, Conscientiousness, do not have a positive linear relationship to the PE to the use of EVA app. V1
6. H1.4G0: Measures of the personality type, Conscientiousness, do not have a positive linear relationship to the PE to the use of EVA app. V2.
7. H1.5C0: Measures of the personality type, Agreeableness, do not have a positive linear relationship to the SN towards the use of EVA app, as measured by C-TAM-TPB. V1.
8. H1.5C0: Measures of the personality type, Agreeableness, do not have a positive linear relationship to the SN towards the use of EVA app, as measured by C-TAM-TPB. V2.
9. H1.5C0: Measures of the personality type, Agreeableness, do not have a positive linear relationship to the SN towards the use of EVA app, as measured by C-TAM-TPB. V3.
10. H1.5E0: Measures of the personality type, Agreeableness, do not have a positive linear relationship to ATU of EVA app, as measured by C-TAM-TPB. V1.
11. H1.5E0: Measures of the personality type, Agreeableness, do not have a positive linear relationship to ATU of EVA app, as measured by C-TAM-TPB. V2.
12. H1.5F0: Measures of the personality type, Agreeableness, do not have a positive linear relationship to the UI of EVA app, as measured by C-TAM-TPB.V1.
13. H1.5F0: Measures of the personality type, Agreeableness, do not have a positive linear relationship to the UI of EVA app, as measured by C-TAM-TPB.V2.
14. H1.5F0: Measures of the personality type, Agreeableness, do not have a positive linear relationship to the UI of EVA app, as measured by C-TAM-TPB.V3.

Research question 2 was answered as most of the variables were correlated for V1, V2, and V3. Hence, out of 30 hypotheses, 15 hypotheses on positive correlations were validated. The other 15 were alternate hypotheses with no correlations. The 15 validated hypotheses are listed below.

1. H2A: Perceived usefulness has a positive relationship on intention to adopt and use EVA system.
2. H2B: Perceived usefulness has a positive relationship on the attitude towards the use of EVA system.
3. H2C: Perceived usefulness has a positive relationship on perceived behavioural control towards the use of EVA system.

4. H2D: Perceived usefulness has a positive relationship on perceived enjoyment towards the use of EVA system.
5. H2E: Perceived ease of use has a positive relationship on perceived behavioural control towards the use of EVA system.
6. H2F: Perceived ease of use has a positive relationship on perceived usefulness of EVA system.
7. H2G: Perceived ease of use has a positive relationship on the attitude towards the use of EVA system.
8. H2H: Perceived ease of use has a positive relationship on perceived enjoyment towards the use of EVA system.
9. H2I: Attitude has a positive relationship on intention to adopt and use EVA system.
10. H2J: Attitude has a positive relationship on perceived enjoyment towards the use of EVA system.
11. H2K: Perceived enjoyment has a positive relationship on intention to adopt and use EVA system.
12. H2L: Subjective norm has a positive relationship on intention to adopt and use EVA system.
13. H2M: Perceived behavioural control has a positive relationship on intention to adopt and use EVA system.
14. H2N: Perceived behavioural control has a positive relationship on behavioural use of EVA system.
15. H2O: Intention to adopt and use EVA system has a positive relationship on behavioural use of EVA system.

In the case of Research question 3, no mediation effect was obtained for V1, V2, or V3 in the regression models. So, out of 20 hypotheses, 10 hypotheses on no mediation were validated, which are listed below.

1. H3.1A0: Perceived enjoyment of EVA app does not mediate the relationship between anti-littering perceived enjoyment and anti-littering intention.
2. H3.2B0: Attitude towards EVA app does not mediate the relationship between anti-littering perceived enjoyment and anti-littering intention.
3. H3.5B0: Attitude towards EVA app does not mediate the relationship between anti-littering attitude and anti-littering intention.

4. H3.3C0: Perceived usefulness of EVA app does not mediate the relationship between anti-littering perceived enjoyment and anti-littering intention.
5. H3.6C0: Perceived usefulness of EVA app does not mediate the relationship between anti-littering attitude and anti-littering intention.
6. H3.4D0: Perceived ease of use of EVA app does not mediate the relationship between anti-littering perceived enjoyment and anti-littering intention.
7. H3.7D0: Perceived ease of use of EVA app does not mediate the relationship between anti-littering attitude and anti-littering intention.
8. H3.8E0: Perceived behaviour control of EVA app does not mediate the relationship between anti-littering perceived behaviour control and anti-littering intention.
9. H3.8F0: Perceived behaviour control of EVA app does not mediate the relationship between anti-littering perceived behaviour control and anti-littering behaviour.
10. H3.9G0: EVA App subjective norm does not mediate the relationship between anti-littering subjective norm and anti-littering intention.

Research Question 1 deals with the central characteristic of the research model proposed in the Methodology chapter. Unfortunately, this part was not validated well. On the other hand, the entire part of the model dealing with research question 2 has been validated, as only the alternate hypotheses of no or negative relationships were invalid. On the other hand, in the case of research question 3, the desired effect to validate the model had a positive mediating effect, but no mediating effect was noticed. Here, validation of the alternate hypotheses makes that part of the model related to research question 3 definitely invalid.

Overall, it can be said that the research model was partially validated. The following models (Figure 6.1, Figure 6.2 and Figure 6.3) are the validated models of technology acceptance for (EVA V1 standard mobile app , EVA V2 AR app and EVA V3 AR with gamification element) respectively. The second model proposed in this research (Figure 3.2) which was utilised to examine the relationships between the acceptance of the EVA app and anti-littering behaviour is rejected because there was no mediating effect was noticed.



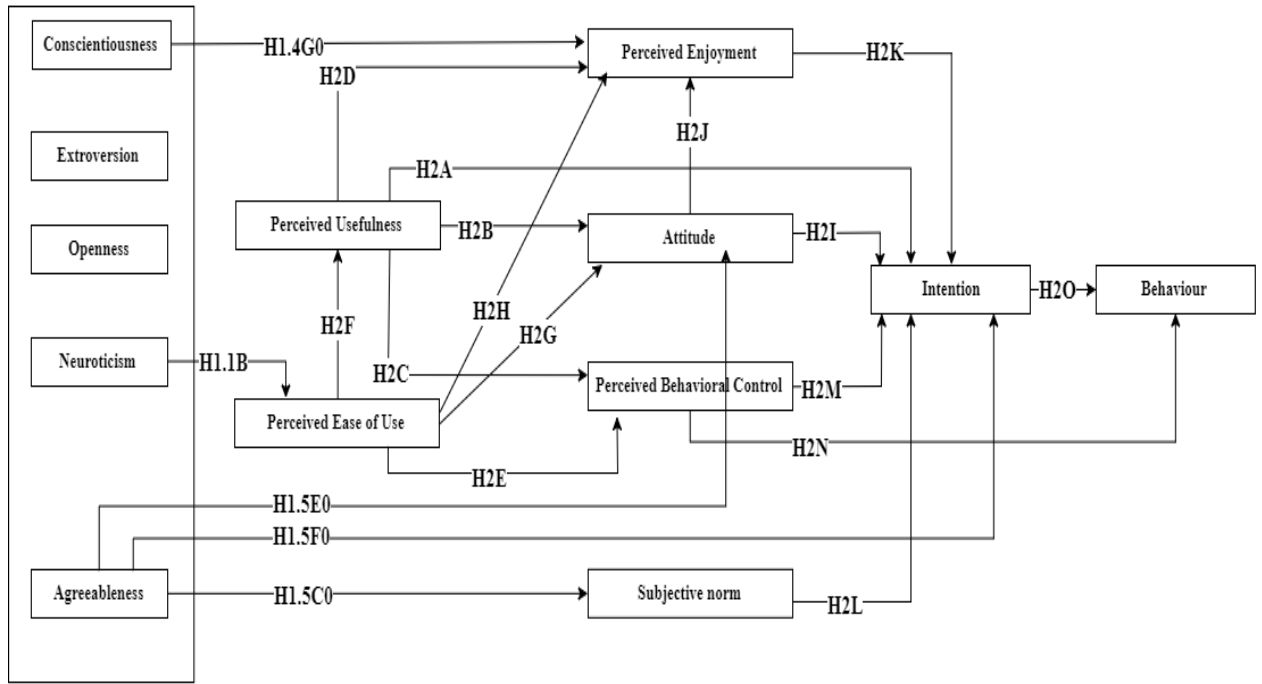


Figure 6.1 Validated Research model for technology acceptance of EVA V1

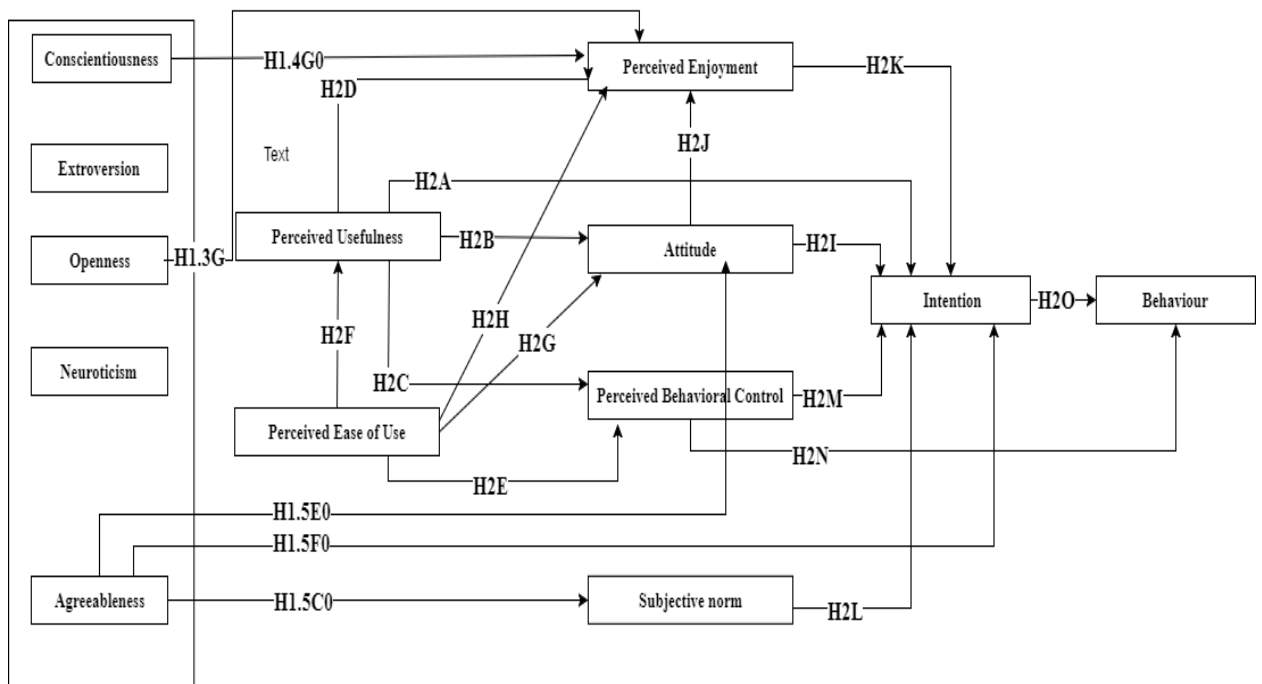
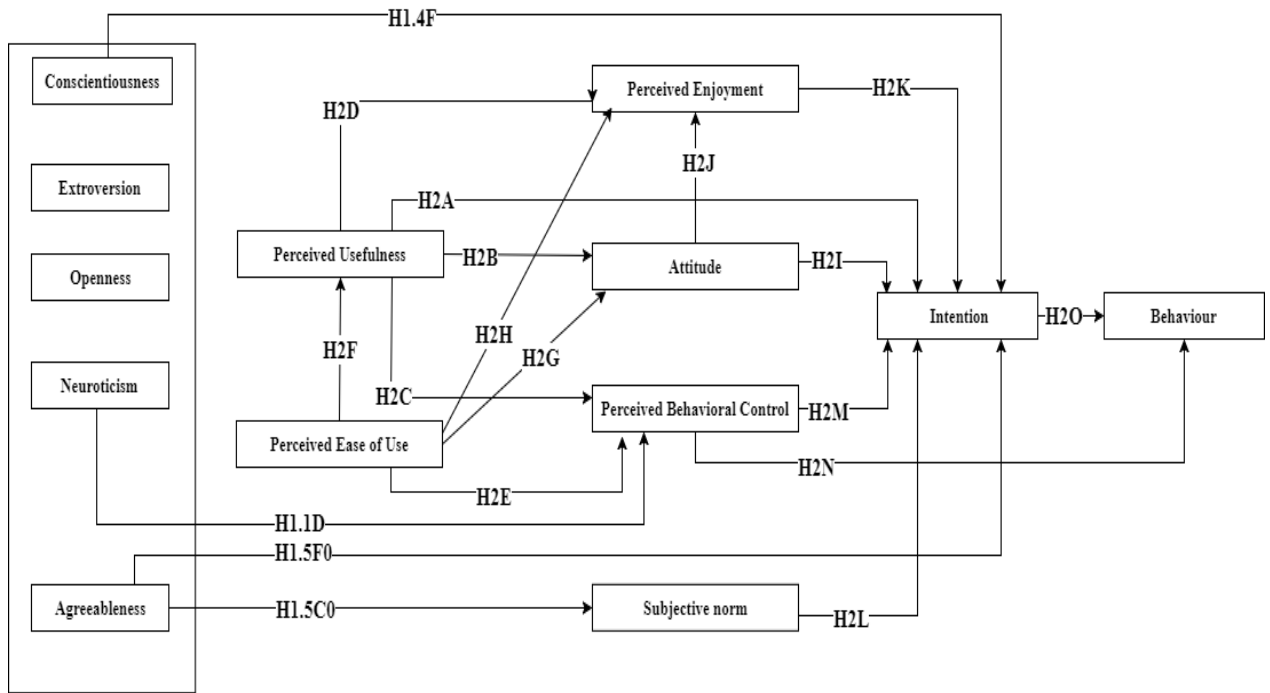


Figure 6.2 Validated Research model for technology acceptance of EVA V2



*Figure 6.3 Validated Research model for technology acceptance of EVA V3*

### 6.3.3.2 Alternate Explanations

The demographics show that about 30% of participants were females and the majority belonged to the student/employed younger age group. These are the very categories of population who do not litter frequently. This is supported by the finding that about 60-70% of them were less likely to litter in a clean or littered place. So, the survey participants were already showing littering behaviour considerably lower than noted among the public. Out of the 90 participants, 55% were not familiar with playing games using a smartphone. Asking them to play an AR Game may not have given the desired level of outcomes. For these reasons, AR or ARGames are less likely to affect the already low levels of littering behaviour in this University sample. Therefore, the findings did not support all the hypotheses and parts of the research questions.

### 6.3.3.3 Discussion

As per the aim, the study explored if and how behavioural changes toward anti-littering behaviour can be promoted using AR technology. Post-survey results revealed the change in behaviour due to the EVA applications. V3 (AR Game) was superior to V2 (AR alone) and the control. AR alone was superior to the Control. Similar results were obtained with respect to an actual change in behaviour also. The participants recommended AR Games, AR Videos, and AR images in that

order as the top three methods to change behaviour. The environment in V3 was most littered, V2 less, and V1 least. Thus, V3-AR Gaming- was proved to be a good way to change littering behaviour. The aim was achieved to this extent.

Most of the hypotheses of the Big Five personality traits were not positively correlated to the behaviour intention to utilise and accept an environmental awareness augmented reality app (EVA), as measured by the combination of Technology Acceptance Model and Theory of Planned Behaviour (C-TAM-TPB). Hence, this basic assumption was validated only partially in answer to the RQ1.

The correlations between the independent variables of C-TAM-TPB and Perceived Enjoyment and the study dependent variables were significant. Hence RQ2 was answered for the positive hypotheses. No mediation effect was detected in answer to RQ3.

The partial nature of the answers obtained for the research questions imposed limitations on the applicability of the findings in practice.

#### **6.3.3.4 Comparison Between A University Campus and A Public Place**

A university campus is a more controlled, relatively closed environment. It has a specific area. Rules and regulations can be set for desired behavioural norms, including littering. The community of the university is more educated and exposed to high levels of learning even if a person is not a student or faculty. Therefore, behavioural standards can be set and they will be followed by most people. In the closed environment of a university campus, it is easier to detect littering and identify the individual who does it. Appropriate actions are possible when a person practises littering and thus violates the university rules of a clean campus.

In contrast, public places are very much open and difficult to control. The area is vast and relatively less defined. Although the local administration/state/national authorities can issue rules and regulations, violations are relatively easy. Violations are very common and go unnoticed most of the time. There are all types of people of all ages, socio-economic status, and education. These factors introduce innumerable variations in littering behaviour. Standards set for behavioural norms are not followed by a large majority of the public. Unless they themselves will, littering prevention is much more difficult to achieve in public places compared to a university campus, be it AR or AR with gaming. Thus, the applicability of the findings of this research in a university campus is less certain in the case of public places.

### **6.3.3.5 Implications of The Findings**

The basic aspect of the model was the relationship of the Big Five traits with C-TAM-TPB. There have been many works connecting the Big Five traits with environmentally-related behaviour (Gifford & Nilsson, 2014; Kvasova, 2015; Milfont & Sibley, 2012). However, practically no work is available connecting the Big Five traits with littering specifically. The Big Five personality traits have been linked with TPB in a few works (Picazo-Vela et al., 2010; Ajzen, 2011). The link between the Big Five traits and TAM was explored by many researchers (Devaraj et al., 2008), by adapting to a social network acceptance model (Rosen & Kluemper, 2008; Svendsen, Johnsen, Almås-Sørensen, & Vittersø, 2013). However, a model connecting the Big Five traits with a combined model of TPB and TAM has not been reported hitherto. Therefore, this research is a pioneering effort in this direction.

On the other hand, the post-survey results showed the superiority of AR technologies in effecting a behavioural change in preventing littering. Thus, AR and, more effectively, AR with gaming can be used for behavioural change towards anti-littering and littering prevention behaviour.

### **6.4 Chapter Summary**

The findings described in the previous chapter were interpreted and explained with available supportive evidence from published works.

The most important message from this study was that AR with or without gaming was more effective than a standard mobile application in effecting a behavioural change towards anti-littering behaviour. Moderate to a great deal of change in littering behavioural intention were observed most in the case of the AR Game compared to the other two. Based on their experiences, the top three approaches nominated by the participants were: AR Games, AR Videos, and AR images with respect to their effectiveness.

Other important messages were that the intention to use applications was most for AR with gaming. When there was no AR or ARGame, the application use subscales had a direct effect on anti-littering behaviour. When either the AR or ARGame was used, the big personality traits had no effect. A clear indication of support for TPB or TRA was obtained in expression of anti-littering behaviour.

Only partial answers were obtained for the research questions. The research model was only partially validated. The part of the model dealing with the correlations between the Big Five personality traits (OCEAN) and the acceptance of the environmental awareness augmented reality

app (EVA), as measured by C-TAM-TPB, was not validated as most hypotheses on this aspect were not supported by the findings of this research. Correlations speculated in RQ2 were fully supported and there was no mediating effect expected in RQ3. Post-survey results showed a significant behaviour change towards anti-littering through the use of AR or AR Games, with no significant benefit by gaming with AR.

As an alternate explanation of the findings, it is possible that a large majority were already not littering or were in favour of antilittering, as the participants had a significant percentage of females, younger age range, higher level of education, student/employed status, and little skill in using smartphone games, as per the demographic data show. The closed, highly disciplined and easy to regulate and implement university environment also favoured the currently working system of litter control. Therefore, the participants may not be influenced much to change their already pro-preventive behaviour further by the use of AR, with or without games. However, they ranked AR Gaming, AR videos, and AR images as the most effective methods to promote antilittering behaviour in public contexts.

# **CHAPTER 7: Conclusions and Recommendations**

## **7.1 Introduction**

As stated before, the main aim of this study is to investigate the acceptance of technology to promote anti-littering behaviour using mobile apps, AR and gamification. Therefore, this study utilised mixed research methods to determine the correlations between the personality traits, anti-littering behaviour, and the acceptance, or non-acceptance, of the environmental awareness augmented reality app (EVA), as measured by C-TAM-TPB.

The significance of this research lies in the search for finding methods to prevent littering behaviour. Very few works have been done using behaviour models like TPB or TAM in the field of littering behaviour. Regulations to prevent littering behaviour exist in different states of Australia, but their effectiveness has been rarely researched. As mobiles with smart applications is widespread, it will be useful to examine the effectiveness of applications in preventing littering. AR and AR with gaming offered promise from the works largely done in health care sector. Most antilittering studies relied on self-reported surveys with inherent subjective bias. In this research direct experimental evidence supported with surveys was collected. This approach enhanced the validity of the work. Some useful findings were used for recommendation of methods to prevent littering in Australia. This goal was achieved to a considerable measure.

## **7.2 Main Findings from The Discussion Chapter, from Which Conclusions on The Following Points are Derived-**

AR with or without gaming was more effective than a standard mobile application in effecting a behavioural change towards anti-littering behaviour. A moderate to great deal of change in littering behavioural intention was observed most in the case of the AR Game compared to the other two. Based on their experiences, the participants nominated their top three approaches as: AR Games, AR Videos, and AR images with respect to their effectiveness.

## **7.3 Littering and Anti-Littering Behaviour**

### **7.3.1 General Pattern of Littering Behaviour in The University Campus and Profiles of People Engaged in Habitual Littering Behaviour.**

Littering is a serious enough problem on the university campus. Prevention of littering is, therefore, very important. The level of littering has stayed relatively the same on the campuses over the past two years. There are messages visible around the campus encouraging littering control campus. Littering is a serious threat to the environment and animals on the campus.

The profile of the campuses' population was towards antilittering behaviour, as a sizeable percentage was female, younger in age, had higher education levels, and greater employment/student status. Literature has showed these are factors in favour of reduced littering

behaviour.

People who do litter may think that one piece of litter may not matter; their concept of littering is different and excuse themselves with a don't care attitude combined with the belief that someone else will pick it up, there is no trashcan nearby, or they have no time to dispose of the litter.

### **7.3.2 Factors Increasing Littering Behaviour**

It has been shown that factors that increase littering behaviour are gender, with males littering more, age, with younger people littering more when in a group, and social status, with low levels of education and unemployment signalling proneness to littering.

### **7.3.3 Factors Reducing Littering Behaviour.**

Various motivations for reducing littering were a strong will not to litter, concern about the environment, changing littering behaviour, and a habitual practice of removing litter found in public places, even if not done by self.

### **7.3.4 How Littering Can Be Prevented.**

There are a variety of ways in which littering can be prevented. These include messages and advertisements at badly littered sites, regulatory measures, such as penalising those who litter, and methods of behaviour change, such as AR, with or without gaming.

### **7.3.5 Extent of Applicability of Theories and Theoretical Frameworks for Explaining Littering Behaviour and Promotion of Littering Prevention in Public Places.**

The partial answers obtained for the research questions lead to partial validation of the research model. Most of the hypotheses on correlations between the Big Five personality traits (OCEAN) and the acceptance of the environmental awareness augmented reality app (EVA), as measured by C-TAM-TPB, were not validated. Correlations speculated in RQ2 were fully supported. However, the mediating effect expected in RQ3 was not shown. Post-survey results showed significant behaviour change towards anti-littering with the use of AR or AR Games, with no significant benefit by gaming with AR.

As alternate explanation of the findings, it is possible that a large majority of participants were already not littering or were in favour of anti-littering, as a significant percentage of participants were female, of younger age, had higher levels of education, student/employed status. The closed, highly disciplined, and easy to regulate and implement university environment also favoured the currently working system of litter control. Therefore, the participants may not really be influenced to change their already pro-preventive behaviour further by the use of AR, with or without games. However, they ranked AR Gaming, AR videos, and AR images as the most effective methods to



promote antilittering behaviour in public contexts.

## **7.4 The Acceptance of An Anti-Littering AR App**

### **7.4.1 Application of Augmented Reality for Promoting Anti-Littering Messages.**

AR, with or without gaming, was widely accepted as the top method of promoting anti-littering behaviour in this research. So, the application of AR for such purposes has been established.

### **7.4.2 The Strongest Factors to Increase or Decrease The Probability of User Adoption of An Anti-Littering AR App.**

Familiarity with playing games using smartphones and being part of the younger generation are the most important factors to increase user adoption of an anti-littering AR application. The model relating the Big Five factors with C-TAM-TPB was only validated to a small extent. So, these cannot act as factors.

## **7.5 Limitations of This Study**

- 1) Although participants were selected from both Australia and Saudi Arabia and data for their numbers were given, no separate analysis of the two groups and their comparisons were given. The cultural effect of littering behaviour has been indicated in a few reports. This research could have tested the applicability of this. The data was not analysed separately as there was no significant difference in the initial attempt of analysis. It could be because around 65% of all the participants had the same cultural background.
- 2) University participants generally show more anti-littering behaviour than the public. This was demonstrated in the profile data.
- 3) If 55% of participants did not know how to play games with mobile smartphones, the desirability of AR and AR with gaming on such a sample is questionable.
- 4) The study posters, which were used by EVA V2 and V3 as an AR marker, were placed in outdoor spaces. Therefore, the markers were exposed to different climate conditions, which affected the condition of the markers themselves, as well as the application tracking functionality.
- 5) Although, all of the EVA application versions posted records of all user activities to the EVA system's backend, the recorded data was not reliable as some of the data was lost due to an internet connection issue with the app.

## **7.6 Recommendations**

### **7.6.1 Recommendations for Motivating People Not to Litter, Targeting Habitual Litterers.**

- For targeting habitual litterers, ads, displaying messages at littering sites, regulatory measures, and methods for remote identification of litterers when they do it, are recommended.

- AR, with or without gaming, is useful for changing littering behaviour over time.

#### **7.6.2 Recommendations for Local Administrations to Prevent Littering Behaviour.**

Providing sufficient trash cans at convenient places with displayed messages on the consequences of littering at other places, clearing teams, remote technologies to identify litterers, and punitive measures against identified litterers are recommended to local administrations.

#### **7.6.3 Recommendations to The Government on Policies, Laws, and Regulations to Prevent Littering.**

- Large scale awareness and education programmes on environmental, health, social and economic harms of littering and practices to reduce litter need to be held at as many places as possible.
- Ads and messages in media with AR and AR with gaming should also be done.

#### **7.6.4 Recommendations to Volunteer Organisations and Individuals Who Clean Public Places and Promote Anti-Littering and Litter Prevention.**

If no message goes to the litterer, the cleaning work will continue eternally. So, it is recommended that when cleaning is done it be done in the presence of the identified litterer, so that littering will be reduced and eventually result in a reduction in cleaning requirements and thus costs.

#### **7.6.5 Recommendations to Research Workers on Further Research.**

- Systematic randomised controlled researches are required in modelling work.
- On practical issues, different methods of litter prevention and reduction through behaviour change needs to be tested.

#### **7.6.6 Recommendations to Public Personalities Like Politicians, Film Actors, Sportspersons, and Others.**

- Public personalities can use their influence among the masses to spread the anti-littering message in programmes they participate in, at public conventions on littering prevention, and other forums.
- They can also help other organisations engaged in littering prevention giving all types of support.

#### **7.7 Future Work**

The work conducted in this study can be improved through deploying an AR system outside the University. One angle is improving the gamification operations. The number of gamification elements can be increased and investigated more in an anti-littering AR game, for example, making the game more challenging, with additional levels and stages. The AR feature of the EVA app and EVA AR game can be improved by using marker-less AR instead of the marker-based target. In this way, the enjoyment of the AR app will be improved. Moreover, social network friends' lists can be utilised through AR anti-littering challenges, such as competing to collect AR trash in specific geo-locations, for example, a park. Also, social networks can be further used to investigate

users' thoughts in order to motivate anti-littering behaviour and these thoughts can be augmented in a littered environment.

### **7.8 Main Contribution to The Domain.**

Although TAM, TPB, and the Big Five traits have been studied in a few other fields, such as healthcare, business, and general environmental issues, specific work on linking them and linking them to littering were not available. The biggest contribution of the thesis is the investigation of technology acceptance in promoting environmental awareness and which technology is likely to have the greatest impact in intention to use the app. This research seems to be a pioneering effort in that direction. A more systematic future research attending to the limitations listed above should provide very useful results. This attempt is reserved for the future.

### **7.9 Chapter Summary**

An important aspect in the Australian context is the examination of the effectiveness of legal and regulatory provisions against littering in different states and provinces. Many preventive measures against littering, increasing awareness and education, and community activities are already being implemented in various states. However, a comprehensive stock take is missing. Once this is done, what is lacking and what needs to be done to move forward, will be clear. However, studies on these aspects require much resources and funds and are beyond the scope of a thesis project but deserve future attention.

The main conclusions, dimensions of littering, littering control and prevention methods, use of AR, and AR with gaming for behaviour change from littering to non-littering were outlined based on the findings of this research. There are many limitations of this work, which have been listed. Recommendations for various categories of stakeholders related to littering are listed.

Future work will attempt to address these limitations for a more systematic work. The obvious future work could be improving the gamification operation of the anti-littering AR app and investigating social networks such as using friends' lists in challenges and augmented shared anti-littering behaviour motivating thoughts. Additionally, the deployment of the study tool outside of the University campus would be another aspect to consider in future works.

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# Appendix

## Appendix 1. Ethics Approval



Dear Dr Kavakli-Thorne

RE: Ethics project entitled: "The Use of Mobile Augmented Reality for Promoting Anti-litter Behaviour: The Case of Saudi Arabia and Australia"

Ref number: 5201500904

The Faculty of Science and Engineering Human Research Ethics Sub-Committee has reviewed your application and granted final approval, effective 5/07/2016. You may now commence your research.

This research meets the requirements of the National Statement on Ethical Conduct in Human Research (2007). The National Statement is available at the following web site:

[http://www.nhmrc.gov.au/\\_files\\_nhmrc/publications/attachments/e72.pdf](http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/e72.pdf).

The following personnel are authorised to conduct this research:

Dr Manolya Kavakli-Thorne  
Mr Majed Abdullah R Alrowaily

NB. STUDENTS: IT IS YOUR RESPONSIBILITY TO KEEP A COPY OF THIS APPROVAL EMAIL TO SUBMIT WITH YOUR THESIS.

Please note the following standard requirements of approval:

1. The approval of this project is conditional upon your continuing compliance with the National Statement on Ethical Conduct in Human Research (2007).
2. Approval will be for a period of five (5) years subject to the provision of annual reports.

Progress Report 1 Due: 5/07/2017

Progress Report 2 Due: 5/07/2018

Progress Report 3 Due: 5/07/2019

Progress Report 4 Due: 5/07/2020

Final Report Due: 5/07/2021

NB. If you complete the work earlier than you had planned you must submit a Final Report as soon as the work is completed. If the project has been discontinued or not commenced for any reason, you are also required to submit a Final Report for the project.

Progress reports and Final Reports are available at the following website:

[http://www.research.mq.edu.au/for/researchers/how\\_to\\_obtain\\_ethics\\_approval/human\\_research\\_ethics/forms](http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/forms)

3. If the project has run for more than five (5) years you cannot renew approval for the project. You will need to complete and submit a Final Report and submit a new application for the project.

(The five year limit on renewal of approvals allows the Committee to fully re-review research in an environment where legislation, guidelines and requirements are continually changing, for example, new child protection and privacy laws).

4. All amendments to the project must be reviewed and approved by the Committee before implementation. Please complete and submit a Request for Amendment Form available at the following website:

[http://www.research.mq.edu.au/for/researchers/how\\_to\\_obtain\\_ethics\\_approval/human\\_research\\_ethics/forms](http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/forms)

5. Please notify the Committee immediately in the event of any adverse effects on participants or of any unforeseen events that affect the continued ethical acceptability of the project.

6. At all times you are responsible for the ethical conduct of your research in accordance with the guidelines established by the University. This information is available at the following websites:

<http://www.mq.edu.au/policy/>

[http://www.research.mq.edu.au/for/researchers/how\\_to\\_obtain\\_ethics\\_approval/human\\_research\\_ethics/policy](http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/policy)

If you will be applying for or have applied for internal or external funding for the above project it is your responsibility to provide the Macquarie University's Research Grants Management Assistant with a copy of this email as soon as possible. Internal and External funding agencies will not be informed that you have final approval for your project and funds will not be released until the Research Grants Management Assistant has received a copy of this email.

If you need to provide a hard copy letter of Final Approval to an external organisation as evidence that you have Final Approval, please do not hesitate to contact the Ethics Secretariat at the address below.

Please retain a copy of this email as this is your official notification of final ethics approval.

Yours sincerely,  
Human Research Ethics Sub-Committee  
Faculty of Science and Engineering  
Macquarie University  
NSW 2109

## **Appendix 2. Participants Information Sheets**



**MACQUARIE**  
University

### **Participant Information Sheet**

THE USE OF AUGMENTED REALITY FOR PROMOTING ANTI-LITTER BEHAVIOUR: THE CASE OF  
SAUDI ARABIA AND AUSTRALIA

#### **Introduction**

This project is being undertaken as part of a Doctor of Philosophy (PhD) research project by Majed Alrowaily. The project is not funded by any authority. Access to data obtained during the project will be accessed by Mr Majed Alrowaily as well as the supervisor, A/Prof Manolya Kavakli, who teaches at Macquarie University, after the participants being de-identified.

I would like to invite you to participate in this project, which aims to investigate the correlation between the perception of augmented reality (AR) technology, people's attitude towards anti-litter behaviour and their actual behaviour. AR is a technology, which enhances the perception of the real world through the camera of smart devices by overlaying computer-generated content tied to specific locations and/or activities.

#### **Participation**

To participate in this experiment, you need an Android tablet or Android phone. You may be able to use your own Android device. If you don't have one, please borrow the device from Sylvian Chow at the front office of Department of computing, E6A360. You are expected to be between the ages of 18 to 65 to participate in this study. If you are not between 18 and 65, you should not continue your participation. If you agree to participate, you can withdraw from participation at any time during the project without any questions or penalty. If you are a student at Macquarie University, your decision to participate will in no way impact upon your current or future relationship with the university.

Your participation will involve participating in using a mobile application called (EVA) during the experiment. You will be given a week to complete the experiment. There are three versions of EVA app and you will be asked to use them all.

The available EVA versions are:

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

Additionally, you will be involved in three tasks requiring you to visit different geo-locations at Macquarie University campus and perform anti-litter behaviour at those locations. Each of these tasks will be required during the usage of each of EVA versions. Randomly, you will be assigned to one of three groups. All the groups will use 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)

Your participation will involve participating in the following activities:

1. A Pre-questionnaire.
2. Using one of EVA app versions for completing the version task.
3. A post questionnaire of that version.
4. Repeat activity 2 and 3 for each EVA app version.
5. A final post-questionnaire.

All of the three tasks will take place in Macquarie University campus. The instructions of each task will be provided through EVA application. The collected data might be used in future for Human Research Ethics Committee-approved projects

### **Expected benefits**

This study will help raising the littering awareness of the students and staff members at Macquarie University and changing their intention to anti-litter. Therefore, environmental pollution at Macquarie University Campus will be prevented.

### **Risk**

This study is not associated with any potential risks or burdens.

### **Privacy**

Your identity will not be disclosed under any circumstances. You will be assigned a code and no link between the code and your identity. Disseminated data will be completely anonymous. All hard copy files will be locked in a filing cabinet and all soft

copy files will be stored in a secure cloud storage.

### **Consent to participate**

Clicking on the *accept button* at the online Consent Form, which is a similar version of this information sheet, is accepted as an indication of your consent to participate in this project. Please follow the guidelines on the worksheet to be able to participate in this experiment.

### **Further Information**

If you have any questions or need any further information, please do not hesitate to contact the research team members of the project.

Majed Alrowaily

A/Prof Manolya Kavakli

Email: [majed.alrowaily@students.mq.edu.au](mailto:majed.alrowaily@students.mq.edu.au)

Email: [manolya.kavakli@mq.edu.au](mailto:manolya.kavakli@mq.edu.au)



## Group A

### EVA: Augmented Reality in EnVironmental Awareness

Dear participant,

- Firstly, you are required to sign the Consent Form and fill the pre questionnaire which both can be accessed either by using the following link or QR code (**You can scan the QR code using any QR scanner app from Apple or Play stores**):
- [https://mqedu.qualtrics.com/jfe/form/SV\\_9WSrypRuUuQxnzT](https://mqedu.qualtrics.com/jfe/form/SV_9WSrypRuUuQxnzT)



- After completing the questionnaire, you are required to download **EVA (V1)** and register a new account through the app (**You can use this account to access all EVA versions**). You can use the following link or QR code to access the download page:

[https://play.google.com/apps/testing/com.VISORmq.EVA\\_AU\\_V1](https://play.google.com/apps/testing/com.VISORmq.EVA_AU_V1)



- Using **EVA (V1)**, look at the provided litter awareness materials and complete the task provided on the app.
- When you are done with the task, then fill the following questionnaire either by accessing the following link directly or scanning the provided QR code:





- [https://mqedu.qualtrics.com/jfe/form/SV\\_73vYBMiDxRHt7Hn](https://mqedu.qualtrics.com/jfe/form/SV_73vYBMiDxRHt7Hn)
- After completing the questionnaire, you are required to download **EVA (V2)** using the following link or QR code:

[https://play.google.com/apps/testing/com.VISORmq.EVA\\_AU\\_V2](https://play.google.com/apps/testing/com.VISORmq.EVA_AU_V2)



- Click on “**Task**” button at **EVA (V2)** and visit the task location. When you find the study poster on the provided location, click on “**AR Litter Awareness**” button and start scanning the study poster. Look at the provided litter awareness materials and complete the task provided on the app.
- When you are done with the task, then fill the following questionnaire either by accessing the following link directly or scanning the provided QR code:
- [https://mqedu.qualtrics.com/jfe/form/SV\\_ctMfssLTsSYAsUB](https://mqedu.qualtrics.com/jfe/form/SV_ctMfssLTsSYAsUB)



- After completing the questionnaire, you are required to download **EVA (V3)** using the following link or QR code:
- [https://play.google.com/apps/testing/com.VISORmq.EVA\\_AU\\_V3](https://play.google.com/apps/testing/com.VISORmq.EVA_AU_V3)



- Click on “**Task**” button at **EVA (V3)** and visit the task location. When you find the study poster on the provided location, click on “**AR Litter Awareness**” button and start scanning the study poster. Look at the provided litter awareness materials and complete the task provided on the app.
- When you are done with the task, then fill the following questionnaire either by accessing the following link directly or scanning the provided QR code:

[https://mqedu.qualtrics.com/jfe/form/SV\\_a9kBmxCq5NrLlo9](https://mqedu.qualtrics.com/jfe/form/SV_a9kBmxCq5NrLlo9)



Finally, complete the following questionnaire:

[https://mqedu.qualtrics.com/jfe/form/SV\\_6yRbZhTo35GzSVT](https://mqedu.qualtrics.com/jfe/form/SV_6yRbZhTo35GzSVT)





## Group B

### EVA: Augmented Reality in EnVironmental Awareness

Dear participant,

- Firstly, you are required to sign the Consent Form and fill the pre questionnaire which both can be accessed either by using the following link or QR code (**You can scan the QR code using any QR scanner app from Apple or Play stores**):
- [https://mqedu.qualtrics.com/jfe/form/SV\\_9WSrypRuUuQxnzT](https://mqedu.qualtrics.com/jfe/form/SV_9WSrypRuUuQxnzT)



- After completing the questionnaire, you are required to download **EVA (V2)** and register a new account through the app (**You can use this account to access all EVA versions**). You can use the following link or QR code to access the download page:

[https://play.google.com/apps/testing/com.VISORmq.EVA\\_AU\\_V2](https://play.google.com/apps/testing/com.VISORmq.EVA_AU_V2)



- Click on “**Task**” button at **EVA (V2)** and visit the task location. When you find the study poster on the provided location, click on “**AR Litter Awareness**” button and start scanning the study poster. Look at the provided litter awareness materials and complete the task provided on the app.
- When you are done with the task, then fill the following questionnaire either by accessing the following link directly or scanning the provided QR code:

- [https://mqedu.qualtrics.com/jfe/form/SV\\_ctMfssLTsSYAsUB](https://mqedu.qualtrics.com/jfe/form/SV_ctMfssLTsSYAsUB)



- After completing the questionnaire, you are required to download **EVA (V3)** using the following link or QR code:

[https://play.google.com/apps/testing/com.VISORmq.EVA\\_AU\\_V3](https://play.google.com/apps/testing/com.VISORmq.EVA_AU_V3)



- Click on “**Task**” button at **EVA (V3)** and visit the task location. When you find the study poster on the provided location, click on “**AR Litter Awareness**” button and start scanning the study poster. Look at the provided litter awareness materials and complete the task provided on the app.
- When you are done with the task, then fill the following questionnaire either by accessing the following link directly or scanning the provided QR code:

[https://mqedu.qualtrics.com/jfe/form/SV\\_a9kBmxCq5NrLlo9](https://mqedu.qualtrics.com/jfe/form/SV_a9kBmxCq5NrLlo9)



- After completing the questionnaire, you are required to download **EVA (V1)** using the following link or QR code:

[https://play.google.com/apps/testing/com.VISORmq.EVA\\_AU\\_V1](https://play.google.com/apps/testing/com.VISORmq.EVA_AU_V1)



- Using EVA(V1), look at the provided litter awareness materials and complete the task provided on the app.
- When you are done with the task, then fill the following questionnaire either by accessing the following link directly or scanning the provided QR code:



- [https://mqedu.qualtrics.com/jfe/form/SV\\_73vYBMiDxRHt7Hn](https://mqedu.qualtrics.com/jfe/form/SV_73vYBMiDxRHt7Hn)

Finally, complete the following questionnaire:

[https://mqedu.qualtrics.com/jfe/form/SV\\_6yRbZhTo35GzSVT](https://mqedu.qualtrics.com/jfe/form/SV_6yRbZhTo35GzSVT)





## Group C

### EVA: Augmented Reality in EnVironmental Awareness

Dear participant,

- Firstly, you are required to sign the Consent Form and fill the pre questionnaire which both can be accessed either by using the following link or QR code (**You can scan the QR code using any QR scanner app from Apple or Play stores**):
- [https://mqedu.qualtrics.com/jfe/form/SV\\_9WSrypRuUuQxnzT](https://mqedu.qualtrics.com/jfe/form/SV_9WSrypRuUuQxnzT)



- After completing the questionnaire, you are required to download **EVA (V3)** and register a new account through the app (**You can use this account to access all EVA versions**). You can use the following link or QR code to access the download page:

[https://play.google.com/apps/testing/com.VISORmq.EVA\\_AU\\_V3](https://play.google.com/apps/testing/com.VISORmq.EVA_AU_V3)



- Click on “**Task**” button at **EVA (V3)** and visit the task location. When you find the study poster on the provided location, click on “**AR Litter Awareness**” button and start scanning the study poster. Look at the provided litter awareness materials and complete the task provided on the app.
- When you are done with the task, then fill the following questionnaire either by accessing the following link directly or scanning the provided QR code:

[https://mqedu.qualtrics.com/jfe/form/SV\\_a9kBmxCq5NrLlo9](https://mqedu.qualtrics.com/jfe/form/SV_a9kBmxCq5NrLlo9)



- After completing the questionnaire, you are required to download **EVA (V1)** using the following link or QR code:

[https://play.google.com/apps/testing/com.VISORmq.EVA\\_AU\\_V1](https://play.google.com/apps/testing/com.VISORmq.EVA_AU_V1)



- Using **EVA (V1)**, look at the provided litter awareness materials and complete the task provided on the app.
- When you are done with the task, then fill the following questionnaire either by accessing the following link directly or scanning the provided QR code:

[https://mqedu.qualtrics.com/jfe/form/SV\\_73vYBMiDxRHt7Hn](https://mqedu.qualtrics.com/jfe/form/SV_73vYBMiDxRHt7Hn)



- After completing the questionnaire, you are required to download **EVA (V2)** using the following link or QR code:

[https://play.google.com/apps/testing/com.VISORmq.EVA\\_AU\\_V2](https://play.google.com/apps/testing/com.VISORmq.EVA_AU_V2)



- Click on “**Task**” button at **EVA (V2)** and visit the task location. When you find the study poster on the provided location, click on “**AR Litter Awareness**” button and start scanning the study poster. Look at the provided litter awareness materials and complete the task provided on the app.
- When you are done with the task, then fill the following questionnaire either by accessing the following link directly or scanning the provided QR code:
- [https://mqedu.qualtrics.com/jfe/form/SV\\_ctMfssLTsSYAsUB](https://mqedu.qualtrics.com/jfe/form/SV_ctMfssLTsSYAsUB)



Finally, complete the following questionnaire:

[https://mqedu.qualtrics.com/jfe/form/SV\\_6yRbZhTo35GzSVT](https://mqedu.qualtrics.com/jfe/form/SV_6yRbZhTo35GzSVT)





### **Appendix 3. Pre-Questionnaire**

QD1 Where is your current residential address?

- ☐ Sakaka, Saudi Arabia
- ☐ Sydney, Australia
- ☐ Other \_\_\_\_\_

QD2 Are you 18 years old or older?

- ☐ Yes -> Please continue to answer all questions below.
- ☐ No -> You are supposed to be between 18 and 65 to continue the study. Thanks for your participation so far. You are not required to complete the remainder of the study.

QD3 Which of the following age categories includes your age?

- ☐ 18-24 years old
- ☐ 25-34 years old
- ☐ 35-44 years old
- ☐ 45-54 years old
- ☐ 55 years or older
- ☐ Prefer not to answer

QD4 What is the highest level of educational qualification you have completed?

- ☐ High school
- ☐ Diploma
- ☐ Bachelor Degree
- ☐ Postgraduate Diploma
- ☐ Master's Degree
- ☐ Doctoral Degree
- ☐ Prefer not to answer

QD5 What is your employment status?

- ☐ Full-time
- ☐ Part-time
- ☐ Retired
- ☐ Housewife
- ☐ Student
- ☐ Unemployed
- ☐ Prefer not to answer

QA1 Is litter a concern to you?

- ☐ Yes
- ☐ No

QA2 If yes, why is litter a concern to you? (Check all that apply.)

- ☐ It is bad for the environment
- ☐ It is dangerous to animals
- ☐ It is unsightly
- ☐ It is a hazard to human health
- ☐ Other (please specify) \_\_\_\_\_

QA3 In your opinion, how big of a problem is litter along public parks in your city? Would you say it is a....

- ☐ Big problem
- ☐ Moderate problem
- ☐ Small problem
- ☐ Not a problem at all
- ☐ Don't know

QA4 In your opinion, how important is litter prevention in your city? Would you say it's:

- ☐ Very Important
- ☐ Important
- ☐ Neither Important nor Unimportant
- ☐ Somewhat Unimportant
- ☐ Not At All Important

QA5 How long have you been in your residential address?

- ☐ Less than two years [SKIP TO QA6]
- ☐ 2-4 years
- ☐ 5-10 years
- ☐ More than 10 years

QA6 Has the amount of litter in your city changed over the last two years? Would you say there is:

- ☐ More litter today than two years ago?
- ☐ Less litter today than two years ago?
- ☐ About the same amount as two years ago?

QA7 Have you seen, read, or heard any ads or public service messages related to litter or Littering in the last year?

- ☐ Yes
- ☐ No

QA8 IF YES TO QA7: Where did you see, read, or hear the ad(s) or public service message(s)?

- ☐ Radio
- ☐ Television
- ☐ Newspaper
- ☐ Social Media
- ☐ Magazine
- ☐ Billboard
- ☐ Friend
- ☐ Other \_\_\_\_\_
- ☐ Don't Know/Can't Remember

QA9 The litter control message on the signboards of the public parks in your city are visible and relevant.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree

QA10 The litter problem in your city severely affects the environment and the animals.

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neither Agree nor Disagree
- ☐ Disagree
- ☐ Strongly Disagree

QA11 Do you smoke?

- ☐ Yes
- ☐ No
- ☐ Prefer not to answer

QA12 IF YES in QA11: When you are in a park, do you USUALLY dispose of cigarette butts...?

- ☐ By using a personal ashtray or ashtray bin
- ☐ By using something else
- ☐ By throwing it on the ground
- ☐ Or does it vary

QA13 When we litter, where does the litter end up?

QA14 What are the most specific litter locations of concern to you?

QB1 Please indicate your level of agreement with each of the following statements about why people litter. Please use the categories:	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
They don't think their one piece of trash matters.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
They think someone else will pick it up.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There isn't a trashcan or bag nearby.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
They didn't consider the item they dropped to be litter.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
They don't have time to dispose of the litter properly.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
They don't care.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
They didn't even realize that they had littered (unintentional littering).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

QB2 Please indicate how likely you would be to litter in the following situations.	Very Likely	Likely	Undecided	Unlikely	Very Unlikely
In an area that is clean.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
In your neighborhood.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When holding an empty beverage cup or bottle and there are no trash cans available	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When holding a gum wrapper and there are no trashcans available.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When smoking a cigarette and there is no ash tray available (if applicable)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When you know a cleanup crew will be coming by to pick it up.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When nobody is around to see you.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

QB3 How likely are you to pick up a piece of litter in the following situations?	Very Likely	Likely	Unlikely	Very Unlikely
Something you dropped	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Something someone else dropped	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Something someone else dropped on your property	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

QB4 How effective are the following strategies at discouraging people from littering? Please use the following categories...	Very Effective	Effective	Neither Effective nor Ineffective	Ineffective	Very Ineffective
Provide more trashcans in public places	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Provide more educational programs about the litter problem	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Increased enforcement of litter laws	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Provide “litter hotline/websites” for citizens to report letter violations they observe	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Public awareness campaigns	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Provide additional funding for cleaning up litter	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (please specify)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

QB5 Can you think of items that you yourself might have discarded as litter (by litter we mean items that you did not put in a trash receptacle) in the past month? (Check all that apply)

- ☐ Small pieces of paper (receipts, lottery tickets, gum wrappers)
- ☐ Cigarette butts
- ☐ Other food wrappers (chip bags/candy)
- ☐ Food / organic material, raw food
- ☐ Other
- ☐ Have not littered in past month
- ☐ Don't know

QB6 When I am out and need to dispose of my trash, I... (Check all that apply)

- ☐ Drop it where ever I am
- ☐ Put it in a trash can
- ☐ Leave it behind
- ☐ Hold onto it until I find a place for proper disposal
- ☐ Put it in a recycling bin
- ☐ Other (please specify) \_\_\_\_\_



Model Please indicate your level of agreement with each of the following statements:	Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
PE5: Performing litter prevention behaviour is enjoyable.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE6: Performing litter prevention behaviour is fun.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE7: Performing litter prevention behaviour is entertaining.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE8: Performing litter prevention behaviour is pleasant.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SN4: People who influence me would think that I should not litter at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SN5: People who are important to me would think that I should not litter at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SN6: People whose opinions are valued to me would prefer that I should not litter at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PBC4: I would be able to apply litter prevention behaviour efficiently at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PBC5: I have adequate resources, knowledge, and ability to apply litter prevention behaviour.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PBC6: Applying litter prevention behaviour would be absolutely within my control.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATLPB1: Litter prevention behaviour at Macquarie university campus is beneficial.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

ATLPB2: Litter prevention behaviour at Macquarie university campus is good.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATLPB3: Litter prevention behaviour at Macquarie university campus is pleasant.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATLPB4: Litter prevention behaviour at Macquarie university campus is a wise idea	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATLPB5: Litter prevention behaviour helps save our environment.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LPI1: I intend to apply litter prevention behaviour at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LPI2: I intend to apply litter prevention behaviour in littered locations at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LPI3: I intend to apply litter prevention behaviour in clean locations at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LPB1: I have used litter prevention behaviour at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LPB3: I will continue using litter prevention behaviour at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## Appendix 4. Post EVA V1

Q; TTFApp Please indicate your level of agreement with each of the following statements:	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
PEOU1: I found EVA V1 Standard Mobile App easy to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PEOU2: Learning to use EVA V1 Standard Mobile App was easy for me.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PEOU3: My interaction with EVA V1 Standard Mobile App was clear and understandable.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PEOU4: It was easy for me to find information at EVA V1 Standard Mobile App .	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PEOU5: It would be easy for me to become more skillful and experienced with EVA V1 Standard	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Mobile App.							
PU1: Using EVA V1 Standard Mobile App would enhance my effectiveness in applying litter prevention behaviour.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PU2: Using EVA V1 Standard Mobile App would improve my litter prevention behaviour performance.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PU3: Using EVA V1 Standard Mobile App would increase my productivity in litter prevention behaviour.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PU4: Using EVA V1 Standard Mobile App would improve visualising the risk of littering behaviour	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PU5: I found EVA V1 Standard Mobile App useful.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PU6: Overall, using EVA V1 Standard Mobile App is advantageous	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE1: Using EVA V1 Standard Mobile App is	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

enjoyable.							
PE2: Using EVA V1 Standard Mobile App is fun.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE3: Using EVA V1 Standard Mobile App is entertaining.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE4: Using EVA V1 Standard Mobile App is pleasant.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATU1: I think that using EVA V1 Standard Mobile App is a good idea.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATU2: Implementing EVA V1 Standard Mobile App for promoting litter prevention behaviour is a wise idea	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATU3: I think that EVA V1 Standard Mobile App makes the litter prevention behaviour more interesting.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATU4: I think that using the EVA V1 Standard Mobile App is fun.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATU5: I think that I like	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

using EVA V1 Standard Mobile App to help save our environment.							
ATU6: It is desirable to use EVA V1 Standard Mobile App.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
UI1: I intend to use EVA V1 Standard Mobile App at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
UI2: I will use EVA V1 Standard Mobile App for helping litter prevention at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
UI3: I plan to use EVA V1 Standard Mobile App for supporting litter prevention at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
UB1: I used EVA V1 Standard Mobile App at Macquarie university campus during the experiment.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
UB2: I will continue using EVA V1 Standard Mobile App at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SN1: People who	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

influence me would think that I should use EVA V1 Standard Mobile App.							
SN2: People who are important to me would think that I should use the EVA V1 Standard Mobile App.	○	○	○	○	○	○	○
SN3: People whose opinions are valued to me would prefer that I should use EVA V1 Standard Mobile App.	○	○	○	○	○	○	○
PBC1: I would be able to use EVA V1 Standard Mobile App efficiently for applying litter prevention behaviour.	○	○	○	○	○	○	○
PBC2: I have adequate resources, knowledge, and ability to use EVA V1 Standard Mobile App.	○	○	○	○	○	○	○
PBC3: Using EVA V1 Standard Mobile App would be absolutely within my control.	○	○	○	○	○	○	○

TTFLittering_Behavio Please indicate your level of agreement with each of the following statements:	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
PE5: Performing litter prevention behaviour is enjoyable.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE6: Performing litter prevention behaviour is fun.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE7: Performing litter prevention behaviour is entertaining.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE8: Performing litter prevention behaviour is pleasant.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SN4: People who influence me would think that I should not litter at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SN5: People who are important to me would think that I should not litter at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SN6: People whose opinions are valued to me would prefer that I should not litter at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



PBC4: I would be able to apply litter prevention behaviour efficiently at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PBC5: I have adequate resources, knowledge, and ability to apply litter prevention behaviour.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PBC6: Applying litter prevention behaviour would be absolutely within my control.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATLPB1: Litter prevention behaviour at Macquarie university campus is beneficial.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATLPB2: Litter prevention behaviour at Macquarie university campus is good.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATLPB3: Litter prevention behaviour at Macquarie university campus is pleasant.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATLPB4: Litter prevention behaviour at Macquarie university campus is a wise idea	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATLPB5: Litter prevention behaviour helps save our environment.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

LPI1: I intend to apply litter prevention behaviour at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LPI2: I intend to apply litter prevention behaviour in littered locations at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LPI3: I intend to apply litter prevention behaviour in clean locations at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LPB1: I have used litter prevention behaviour at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LPB3: I will continue using litter prevention behaviour at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## Appendix 5. Post EVA V2

TTFApp Please indicate your level of agreement with each of the following statements:	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
PEOU1: I found EVA V2 (AR) App easy to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PEOU2: Learning to use EVA V2 (AR) App was easy for me.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PEOU3: My interaction with EVA V2 (AR) App was clear and understandable.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PEOU4: It was easy for me to find information at EVA V2 (AR) App.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PEOU5: It would be easy for me to become more skillful and experienced with EVA V2 (AR) App.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PU1: Using EVA V2 (AR) App would enhance my effectiveness in applying litter prevention behaviour.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PU2: Using EVA V2 (AR) App would improve my litter prevention behaviour	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

performance.							
PU3: Using EVA V2 (AR) App would increase my productivity in litter prevention behaviour.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PU4: Using EVA V2 (AR) App would improve visualising the risk of littering behaviour	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PU5: I found EVA V2 (AR) App useful.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PU6: Overall, using EVA V2 (AR) App is advantageous	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE1: Using EVA V2 (AR) App is enjoyable.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE2: Using EVA V2 (AR) App is fun.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE3: Using EVA V2 (AR) App is entertaining.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE4: Using EVA V2 (AR) App is pleasant.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATU1: I think that using EVA V2 (AR) App is a good idea.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

ATU2: Implementing EVA V2 (AR) App for promoting litter prevention behaviour is a wise idea	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATU3: I think that EVA V2 (AR) App makes the litter prevention behaviour more interesting.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATU4: I think that using the EVA V2 (AR) App is fun.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATU5: I think that I like using EVA V2 (AR) App to help save our environment.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATU6: It is desirable to use EVA V2 (AR) App.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
UI1: I intend to use EVA V2 (AR) App at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
UI2: I will use EVA V2 (AR) App for helping litter prevention at Macquarie university campus	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
UI3: I plan to use EVA V2 (AR) App for supporting litter prevention at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

UB1: I used EVA V2 (AR) App at Macquarie university campus during the experiment.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
UB2: I will continue using EVA V2 (AR) App at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SN1: People who influence me would think that I should use EVA V2 (AR) App.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SN2: People who are important to me would think that I should use the EVA V2 (AR) App.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SN3: People whose opinions are valued to me would prefer that I should use EVA V2 (AR) App.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PBC1: I would be able to use EVA V2 (AR) App efficiently for applying litter prevention behaviour.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PBC2: I have adequate resources, knowledge, and ability to use EVA V2 (AR) App.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PBC3: Using EVA V2 (AR) App would be absolutely	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

within my control.							
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TTFLittering_Behavio Please indicate your level of agreement with each of the following statements:	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
PE5: Performing litter prevention behaviour is enjoyable.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE6: Performing litter prevention behaviour is fun.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE7: Performing litter prevention behaviour is entertaining.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE8: Performing litter prevention behaviour is pleasant.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SN4: People who influence me would think that I should not litter at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SN5: People who are important to me would think that I should not litter at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SN6: People whose opinions are valued to me would prefer that I should not litter at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

PBC4: I would be able to apply litter prevention behaviour efficiently at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PBC5: I have adequate resources, knowledge, and ability to apply litter prevention behaviour.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PBC6: Applying litter prevention behaviour would be absolutely within my control.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATLPB1: Litter prevention behaviour at Macquarie university campus is beneficial.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATLPB2: Litter prevention behaviour at Macquarie university campus is good.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATLPB3: Litter prevention behaviour at Macquarie university campus is pleasant.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATLPB4: Litter prevention behaviour at Macquarie university campus is a wise idea	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATLPB5: Litter prevention behaviour helps save our environment.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LPI1: I intend to apply litter prevention behaviour at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



LPI2: I intend to apply litter prevention behaviour in littered locations at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LPI3: I intend to apply litter prevention behaviour in clean locations at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LPB1: I have used litter prevention behaviour at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LPB3: I will continue using litter prevention behaviour at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## Appendix 6. Post EVA V3

TTFApp Please indicate your level of agreement with each of the following statements:	Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Neutral (4)	Somewhat Agree (5)	Agree (6)	Strongly Agree (7)
PEOU1: I found EVA V3 (AR Game) easy to use.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PEOU2: Learning to use EVA V3 (AR Game) was easy for me.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PEOU3: My interaction with EVA V3 (AR Game) was clear and understandable.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PEOU4: It was easy for me to find information at EVA V3 (AR Game).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PEOU5: It would be easy for me to become more skillful and experienced with EVA V3 (AR Game).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PU1: Using EVA V3 (AR Game) would enhance my effectiveness in applying litter prevention behaviour.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PU2: Using EVA V3 (AR Game) would improve my litter prevention behaviour performance.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PU3: Using EVA V3 (AR Game) would increase my productivity in litter prevention behaviour.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PU4: Using EVA V3 (AR Game) would improve visualising the risk of littering behaviour	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PU5: I found EVA V3 (AR Game) useful.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

PU6: Overall, using EVA V3 (AR Game) is advantageous	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE1: Using EVA V3 (AR Game) is enjoyable.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE2: Using EVA V3 (AR Game) is fun.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE3: Using EVA V3 (AR Game) is entertaining.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE4: Using EVA V3 (AR Game) is pleasant.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATU1: I think that using EVA V3 (AR Game) is a good idea.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATU2: Implementing EVA V3 (AR Game) for promoting litter prevention behaviour is a wise idea	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATU3: I think that EVA V3 (AR Game) makes the litter prevention behaviour more interesting.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATU4: I think that using the EVA V3 (AR Game) is fun.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATU5: I think that I like using EVA V3 (AR Game) to help save our environment.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATU6: It is desirable to use EVA V3 (AR Game).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
UI1: I intend to use EVA V3 (AR Game) at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
UI2: I will use EVA V3 (AR Game) for helping litter prevention at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
UI3: I plan to use EVA V3 (AR Game) for supporting litter prevention at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
UB1: I used EVA V3 (AR Game) at Macquarie university campus	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

during the experiment.							
UB2: I will continue using EVA V3 (AR Game) at Macquarie university campus.	○	○	○	○	○	○	○
SN1: People who influence me would think that I should use EVA V3 (AR Game).	○	○	○	○	○	○	○
SN2: People who are important to me would think that I should use the EVA V3 (AR Game).	○	○	○	○	○	○	○
SN3: People whose opinions are valued to me would prefer that I should use EVA V3 (AR Game).	○	○	○	○	○	○	○
PBC1: I would be able to use EVA V3 (AR Game) efficiently for applying litter prevention behaviour.	○	○	○	○	○	○	○
PBC2: I have adequate resources, knowledge, and ability to use EVA V3 (AR Game).	○	○	○	○	○	○	○
PBC3: Using EVA V3 (AR Game) would be absolutely within my control.	○	○	○	○	○	○	○

<b>TTF</b> Littering_Behavio Please indicate your level of agreement with each of the following statements:	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
PE5: Performing litter prevention behaviour is enjoyable.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE6: Performing litter prevention behaviour is fun.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE7: Performing litter prevention behaviour is entertaining.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PE8: Performing litter prevention behaviour is pleasant.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SN4: People who influence me would think that I should not litter at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SN5: People who are important to me would think that I should not litter at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
SN6: People whose opinions are valued to me would prefer that I should not litter at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PBC4: I would be able to apply litter prevention behaviour efficiently at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PBC5: I have adequate resources, knowledge, and ability to apply litter prevention behaviour.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PBC6: Applying litter prevention behaviour would be absolutely within my control.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATLPB1: Litter prevention behaviour at Macquarie university campus is beneficial.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

ATLPB2: Litter prevention behaviour at Macquarie university campus is good.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATLPB3: Litter prevention behaviour at Macquarie university campus is pleasant.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATLPB4: Litter prevention behaviour at Macquarie university campus is a wise idea	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ATLPB5: Litter prevention behaviour helps save our environment.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LPI1: I intend to apply litter prevention behaviour at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LPI2: I intend to apply litter prevention behaviour in littered locations at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LPI3: I intend to apply litter prevention behaviour in clean locations at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LPB1: I have used litter prevention behaviour at Macquarie university campus.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
LPB3: I will continue using litter prevention behaviour at Macquarie university campus.							

## Appendix 7. Post-Questionnaire

How much do you think that using the following softwares have helped change your behavioural intention?

	A great deal	A lot	A moderate amount	A little	None at all
EVA V1 Standard Mobile App (without AR)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
EVA V2(AR) App	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
EVA V3(AR Game)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

How much do you think that you have changed your littering behavioural intention after using the following softwares?

	A great deal	A lot	A moderate amount	A little	None at all
EVA V1 Standard Mobile App (without AR)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
EVA V2(AR) App	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
EVA V3(AR Game)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

How effective would you say the following litter prevention approaches in changing your littering behavioural intention?

	Extremely effective	Very effective	Moderately effective	Slightly effective	Not effective at all
Videos	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Images	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
AR Videos	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
AR Images	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
AR Game	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

How do you describe the environment (in term of littering status) in each of the following tasks locations during your visit?

	Minimal or No Litter	Slightly Littered	Littered	I haven't been there
EVA V1 Task	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
EVA V2 Task	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
EVA V3 Task	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Did you complete the following tasks, if yes how many times did you visit the tasks' locations?

	Task Completion		Number of Visit
	Yes	No	(Number)
EVA V1 Task	<input type="radio"/>	<input type="radio"/>	
EVA V2 Task	<input type="radio"/>	<input type="radio"/>	



EVA V3 Task	<input type="radio"/>	<input type="radio"/>	
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Roughly, how many times did you drop litter during the experiment?

☐ I dropped \_\_\_\_\_

☐ Prefer not to answer

If you did drop litter during the experiment, what motivated you to do that?

### Big5

How well do the following statements describe your personality?

I see myself as someone who....

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
... is reserved	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... generally trusting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... tends to be lazy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is relaxed, handles stress well	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... has few artistic interests	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... is outgoing, sociable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... tends to find fault with others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... does a thorough job	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... gets nervous easily	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
... has an active imagination	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## Appendix 8. Cross Cultural Initial Analysis

*Table A8.1 Post-V3 data means by country*

Country		N	Mean	Std. Deviation	Std. Error Mean
V3 APP PEOU	Australia	44	5.53	1.53	0.23
	Saudi Arabia	46	5.48	1.28	0.19
V3 APP PU	Australia	44	5.21	1.53	0.23
	Saudi Arabia	46	5.61	1.25	0.18
V3 APP PE	Australia	44	5.11	1.64	0.25
	Saudi Arabia	46	5.79	1.30	0.19
V3 APP ATU	Australia	44	5.22	1.49	0.22
	Saudi Arabia	46	5.78	1.29	0.19
V3 APP UI	Australia	44	5.34	1.42	0.21
	Saudi Arabia	46	5.90	1.27	0.19
V3 APP UB	Australia	44	5.27	1.53	0.23
	Saudi Arabia	46	4.82	1.67	0.25
V3 APP SN	Australia	44	4.82	1.95	0.29
	Saudi Arabia	46	5.17	1.60	0.24
V3 APP PBC	Australia	44	5.30	1.41	0.21
	Saudi Arabia	46	5.47	1.27	0.19
V3 Littering PE	Australia	44	5.56	1.36	0.21
	Saudi Arabia	46	5.57	1.31	0.19
V3 Littering SN	Australia	44	5.95	1.31	0.20
	Saudi Arabia	46	5.33	1.50	0.22
V3 Littering PBC	Australia	44	5.91	1.38	0.21
	Saudi Arabia	46	5.28	1.41	0.21
V3 Littering ATU	Australia	44	6.09	1.15	0.17
	Saudi Arabia	46	5.86	1.05	0.16
V3 Littering BI	Australia	44	5.95	1.21	0.18
	Saudi Arabia	46	4.90	1.86	0.27
V3 Littering LB	Australia	44	5.98	1.18	0.18
	Saudi Arabia	46	5.00	1.81	0.27

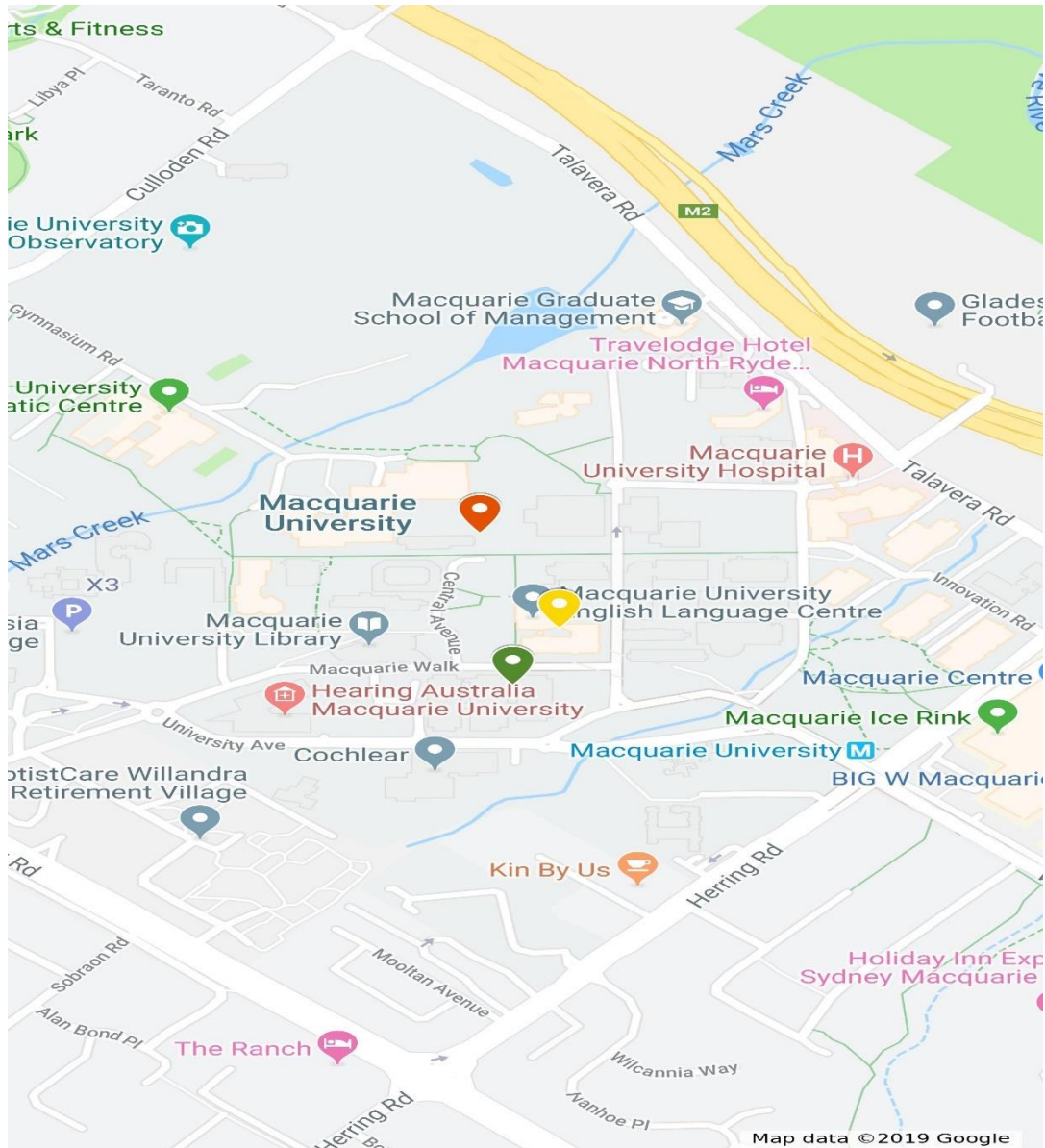
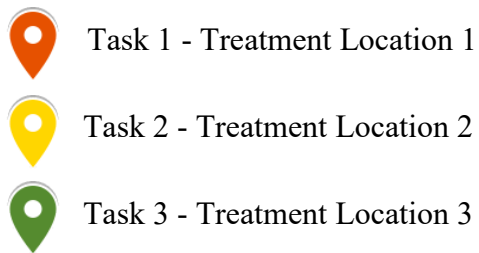
*Table A8.2 Post-V3 data means by country - Independent sample t-test results*

	t-test for Equality of Means					
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference
						Lower Upper
V3 APP PEOU	0.15	83.88	0.88	0.04	0.30	-0.55 0.64
V3 APP PU	-1.35	82.95	0.18	-0.40	0.29	-0.98 0.19
V3 APP PE	-2.15	82.08	0.06	-0.67	0.31	-1.30 -0.05
V3 APP ATU	-1.91	84.93	0.06	-0.56	0.29	-1.15 0.02

V3 APP UI	-1.96	86.02	0.05	-0.56	0.28	-1.12	0.01
V3 APP UB	1.36	87.85	0.18	0.46	0.34	-0.21	1.13
V3 APP SN	-0.94	83.32	0.35	-0.36	0.38	-1.11	0.39
V3 APP PBC	-0.59	86.06	0.56	-0.17	0.28	-0.73	0.40
V3 Littering PE	-0.03	87.34	0.98	-0.01	0.28	-0.57	0.55
V3 Littering SN	2.07	87.36	0.07	0.61	0.30	0.02	1.20
V3 Littering PBC	2.16	87.97	0.06	0.63	0.29	0.05	1.22
V3 Littering ATU	0.99	86.52	0.33	0.23	0.23	-0.23	0.69
V3 Littering BI	3.21	77.57	0.09	1.06	0.33	0.40	1.71
V3 Littering LB	3.05	77.65	0.08	0.98	0.32	0.34	1.62




## Appendix 9. Maps of Treatment Locations

# Macquarie University Campus Map



**Figure A9.1 Treatment Locations Map of Macquarie University Campus**

## Aljouf University Main Campus Map

-  Task 1 - Treatment Location 1
-  Task 2 - Treatment Location 2
-  Task 3 - Treatment Location 3



*Figure A9.2 Treatment Locations Map of Aljouf University Main Campus*