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AUGMENTED REALITY FOR NUDGING GREEN BEHAVIOR: DESIGN, EVALUATION AND IMPLEMENTATION

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Research Paper

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Abstract

This article reports findings from a Design Science Research study that introduced an augmented reality (AR) artifact for nudging green behavior. The artifact illustrated the consequences of environmental problems through AR experiences and was evaluated through focus groups with end users. We found that the use of AR in environmental communication has great potential to motivate green behavior thanks to its information, social, and technical aspects. End users prefer to interact with AR through already familiar services (e.g., social networks) and believe that such content can lead to collective green movements. However, environmental communicators should not rely solely on AR to achieve long-term behavior change, as behavior also depends on many other internal and external factors. By applying rigorous guidelines for conducting qualitative research, this study has provided new theoretical, methodological, and practical contributions that may be applicable in the broader context of designing artifacts to digitally nudge behavior change.

Keywords: environmental communication, pro-environmental behavior, augmented reality (AR), green information systems (Green IS), Design Science Research (DSR)

1 Introduction

Our planet is currently facing the consequences of unsustainable production, overconsumption, and inadequate waste management of plastic products (United Nations Environment Programme [UNEP], 2021). Scientists estimate that about 8 million metric tons of plastic waste end up in the oceans every year (Jambeck et al., 2015), and if these movements continue, about 12,000 tons of plastic could end up in nature by 2050 and remain there forever in the form of microplastics, permanently transforming the Earth's surface (Geyer et al., 2017).

At the same time, environmental communicators face a great challenge: we rarely directly observe the consequences of environmental threats, so we barely understand their causes and feel a lack of responsibility for them (Uzzell, 2000). Research shows that direct experiences enhance risk awareness (Akerlof et al., 2013), so one possible solution for increasing engagement around environmental pollution would be to bring people to far-away beaches to expose them to sea animals entangled in plastic litter. However, this could be complicated, costly and even dangerous.

The Information Systems (IS) community is expected to tackle these challenges and use information technology to address environmental issues at individual, organizational, governmental and societal levels (Elliot, 2011; Elliot & Webster, 2017). However, while researchers from other disciplines have pointed out that immersive technologies such as augmented reality (AR) and virtual reality (VR) can

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revolutionize environmental communication and motivate environmentally friendly behaviors (Ahn et al., 2016; Nelson et al., 2020), such studies are still lacking in the main IS literature (Buljat, 2021).

This paper proposes a novel green artifact that demonstrates the consequences of plastic pollution through AR experiences: by using a smartphone, users can directly observe real-sized animals fighting with plastic litter, augmented in their immediate real surroundings in a form of a digital hologram. Such an experience might impact their risk perception, awareness, and behavior. The world's leaders in environmental communication have already recognised the potential of AR for raising awareness about important global issues such as plastic pollution and have used it in their campaigns (UNEP, 2019; World Wildlife Fund [WWF], 2017; Vasey, 2021).

Our study is guided by the following research question: *How to implement digital nudges into AR artifacts to induce pro-environmental behavioral change?* To address this research question, we conducted a Design Science Research (DSR) study (Hevner et al., 2004; Gregor & Hevner, 2013).

Following guidelines that ensure scientific rigor and credibility (Gioia et al., 2013), we inductively analyzed data collected from six focus groups, during which we introduced and demonstrated the prototype of the artifact to focus group participants to obtain their feedback. This approach resulted in novel findings on emerging phenomena and helped identify the design, development and evaluation requirements of a green IT artifact, as well as contributing to the development of new IS theories.

This study responds to an urgent call for research on Green IS (Elliot & Webster, 2017), and makes three major contributions: methodological, theoretical, and practical. Firstly, we provided an example of the DSR evaluation strategy in the design of (1) an artifact with an environmental dimension and (2) a AR artifact in its conceptual phase. Secondly, inductive analysis of our data led to a grounded theory model that informs the design and implementation of a green AR artifact, which generated the theory type IV (Theory for Explaining and Predicting) and the V (Theory for Design and Action) (Gregor, 2006). Thirdly, the practical implications for policy makers, communication experts, and environmental organizations include specific guidelines for implementing AR -based behavior change interventions for nudging pro-environmental behavior in practice. We hope that this study can also contribute to the understanding of how a broader class of behavior-changing artifacts might be designed, evaluated and applied in practice.

This paper is organized as follows. In the second section, we provide a background of relevant literature and kernel theories that informed the artifact's design. Then, we provide details about the DSR methodology we adopted for this study. We present and demonstrate the artifat in section 4, and in section 5 we explain the DSR evaluation process. In section 6, we present and discuss the main findings, and provide guidelines for developing a pro-environmental AR-based behavior-change communication strategy. Lastly, in the section 7, we point out the limitations of this study, suggest some further steps, and conclude with final remarks.

2 Theoretical Background

The world produces more than 300 million tons of plastic per year (United Nations [UN], 2019), and most of it ends up in our oceans, mainly due to human activities on land (Jambeck et al., 2015). Similar to many other environmental problems, the challenge in communicating about plastic pollution is that the consequences are not immediately visible-they occur "somewhere else," far away in space and time, and are therefore seen as "psychologically distant" and irrelevant (van der Linden et al., 2015; Trope & Liberman, 2010).

Studies suggest that direct experience with environmental threats appears to be an effective motivator for pro-environmental behavior (Akerlof et al., 2013). For example, people who had experienced flooding reported greater concern and willingness to take action on climate change (Spence et al., 2011). However, putting people under water to experience the unpleasant consequences of plastic pollution may not be a good idea. Instead, we should find a way to simulate such experiences. In this context, IS researchers should turn to the design and development of Green IS (Elliot & Webster,

2017; Melville, 2010)-technological solutions designed to encourage people to behave in a more environmentally friendly way (Seidel et al., 2018; Mirsch et al., 2018).

Recently, the attention of environmental communicators has turned to immersive technologies. Augmented and virtual reality can provide vivid, interactive, computer-simulated experiences that influence our cognitive and emotional information processing and create a sense of presence (Innocenti, 2017). While VR is fully immersive and requires a headset that blocks the user's view, AR embeds three-dimensional virtual elements in real time on a screen or semi-transparent smart glasses and creates the illusion that these objects are part of the user's real environment (Azuma, 1997).

Today, we are witnessing widespread adoption of AR, largely thanks to the rapid development of mobile devices, the Internet, and social media (Slater, 2019; Wingfield & Isaac, 2016). The world's leading environmental communicators have begun to incorporate AR into their campaigns: UNEP's AR #Cleanseas campaign (UNEP, 2019), and WWF's "Take a photo with a leopard" contest recently resulted in a viral campaign that reached thousands of people on social media (WWF, 2017).

Although there is still a lack of relevant studies on this topic in the leading IS literature (Buljat, 2021), researchers from other disciplines point out that people treat virtual experiences as real, so attitudes and behaviors adopted in such computer simulations are often transferred to the real world. For example, people reduced their paper consumption after cutting down a tree in virtual reality (Ahn et al., 2014), felt more connected to nature after virtually embodying animals (Ahn et al., 2016), and donated more money to marine conservation charity after diving into coral reefs with VR (Nelson et al., 2020).

This article proposes AR -based green artifact to communicate the problem of plastic pollution and nudge behavior change. By "experiencing" the impacts of plastic pollution on the most endangered marine species, this innovative mode of communication could psychologically bring the environmental issue closer, raise environmental awareness, and increase environmental engagement. Our design solution relied mainly on three kernel theories (Gregor & Hevner, 2013), each focusing on one of the three design aspects of a DSR artifact: the information aspect, the social aspect, and the technology aspect (De Leoz et al., 2018). These theories are briefly introduced below.

Information aspect: Construal Level Theory.

According to Construal Level Theory (CLT), psychological distance is a subjective perception of how far away an object or event is from the here and now - when, where, to whom, and whether an event occurs. When we do not directly experience something, we perceive such an event as psychologically distant (Trope & Liberman, 2010). Unfortunately, people who pollute do not necessarily see or suffer the consequences, and pollution is not easily observable because it occurs in remote locations or deep in the oceans. Based on Construal-Level Theory, we can assume that those who do not have the opportunity to experience the consequences of plastic pollution consider it unlikely that they will be affected in the near future, or unlikely that it will happen at all (Trope & Liberman, 2010).

Manipulating psychological distance may be a promising method to motivate pro-environmental behaviors (Spence et al., 2012; Ahn et al., 2016; Ahn et al., 2014). Immersive virtual experiences allow people to experience future scenarios in the present. These experiences can reduce the time gap between the cause (one's behavior) and the effect (the negative impact on the environment). For example, one study has shown that an immersive experience is able to convince users of the consequences of irresponsible paper consumption and change their behavior (Ahn et al., 2014).

Social aspect: Theory of planned behavior.

A recent study warns that techno-centric approach to DSR processes may ignore important social interactions, structures, or relationships that a IS may influence. A social aspect implies not only social interactions, but also changes in social behavior as a direct or indirect consequence of using an artifact in a particular context (De Leoz et al., 2018). This is consistent with the Theory of Planned Behavior,

which states that subjective norm is an important predictor of one's behavior (it refers to social pressure to perform or not perform a particular behavior) (Ajzen, 1991).

A AR artifact has a social component because it can enable social interactions between (1) users and (2) users and the artifact itself. First, mobile AR experiences can be shared with friends on social networks, opening doors for social influence-a powerful tool that has recently gained attention as an environmental policy tool (Farrow et al., 2017). Second, if a computer has certain physical or psychological characteristics, it can trigger the same instincts as humans and create relationships. One of the first examples of emotional relationships with computers is Tamagotchi, a virtual pet embodied by a pocket device (Fogg, 2003). It is human nature to respond in certain ways in social situations. Thus, if the object AR is interactive and appears sufficiently real, a user may feel empathy and a social connection to it. These social connections should allow the user to change their behavior in a more environmentally friendly way.

Technology aspect: Persuasion.

In early 2000, BJ Fogg, a founder of the Behavior Design Lab (formerly the Persuasive Technology Lab) at Stanford University, introduced the term persuasive technology. He described it as any interactive computer system that aims to persuade the user to voluntarily change his or her attitude and/or behavior without using coercion or deception (Fogg, 2003). Interactive technologies can influence behavior in different ways depending on the role they play - computers can be used as a tool, as a medium, or as a social actor, or a combination of all three. A computer can be used as a medium that provides an experience, and immersive technologies are particularly powerful in this area because they enable interactive, sensory-rich computer simulations (Fogg, 2003).

Therefore, immersive computer simulations may be the most promising weapon of persuasive technology: they can serve as a shortcut to vividly and immediately experience the results of various inputs (Fogg, 2003), reduce psychological distance, and promote understanding of the cause-and-effect relationship of environmental issues (Breves & Schramm, 2021, Ahn et al., 2014). When people receive feedback immediately after performing a particular behavior, they are likely to improve their performance. However, this is usually not the case for long-term processes where feedback is delayed, as is the case with environmental behaviors. Nudges can work even when there is no feedback (Thaler & Sunstein, 2008), and immersive simulation could be a possible solution to overcome this barrier.

The following table (Table 1) provides an overview of the key design principles on which the artifact was built. It is governed by three kernel theories (Gregor & Hevner, 2013) that informed the information, social, and technological aspects of the artifact (De Leoz et al., 2018). This theoretical background contributes to the debate on how to design an information system that encourages individuals to behave in an environmentally friendly manner by simulating the usually unobservable long-term negative consequences of environmental threats.

DESIGN ASPECT	KERNEL THEORY	DESIGN PRINCIPLES
Information	*Construal Level Theory (Trope & Liberman, 2010)*	To minimize the psychological distance between an observer and the event, the abstract mental construal of "plastic pollution" should be transformed into a more concrete counterpart such as "animal caught in plastic waste." AR Artifact should therefore reduce the abstractness of the phenomena by simulating the real experience of the consequences of plastic pollution and reduce the psychological (temporal, spatial, hypothetical) distance between a user and the event.
Social	*Theory of planned behavior (Ajzen, 1991)*	The artifact AR should enable social interactions between users. These social interactions are possible thanks to social networks that allow sharing AR experiences with friends. The artifact should also enable the establishment of a social relationship between users and IS itself by representing a living being in an empathic situation.
Technology	*Persuasion (Fogg, 2003)*	The artifact should provide a vivid, interactive simulation of the long-term consequences of an environmental problem. The AR artifact should convince users of the risks and promote understanding of the cause-and-effect relationship of plastic pollution. In addition, the AR experience should be available on a smartphone to make it accessible to a wide audience.

Table 1. Overview of design principles of the green AR artifact.

3 Methodology

This paper presents one iteration of a design process of a DSR study (Hevner et al., 2004; Gregor & Hevner, 2013) in which the aim was to design and evaluate a novel IT artifact with an environmental impact (Seidel et al., 2018). The outcome of a DSR study should be an artifact in the form of a construct, a model, a method, or an instantiation, that is intended to solve a relevant real-world problem (Hevner et al., 2004). During the study process, we followed guidelines for conducting and reporting qualitative research that ensure research rigor, rely on data, lead to development of new concepts, and generate a grounded theory (Glaser & Strauss, 1967; Strauss & Corbin, 1990; Gioia et al., 2013). Following the steps (Peffers et al., 2008) and guidelines to meet the requirements of an effective DSR study (Henver et al., 2004), our research approach resulted in concrete outcomes, as presented in Figure 1.

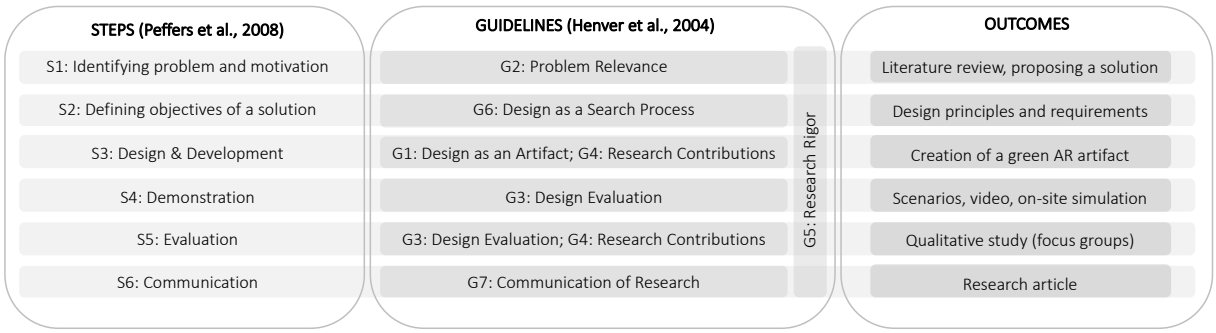

Figure 1. Our DSR research approach.

Besides design itself, evidence-based artifact evaluation is a crucial step of the DSR process (Hevner et al., 2004). The evaluation pathway was established based on FEDS (a Framework for Evaluation in Design), and it combines two strategies: The Human Risk & Effectiveness evaluation strategy and The Technical Risk & Efficacy evaluation strategy. In both strategies, the dominant paradigm implies artificial evaluation using simulations and scenarios, with the intention of determining whether the artifact is technically adequate, and whether it is likely to provide usefulness and fitness in real situations and over the longer period of time (Venable et al., 2018).

4 Artifact Description

Built on predefined design principles presented in Table 1, in this study we introduce a novel AR-based Green IT artifact – a mobile application that demonstrates consequences of plastic pollution through AR experiences, which can be consumed through the lenses of mobile device such as smartphone or tablet[1]. The experiences consist of various scenes of plastic pollution crisis: real-sized tridimensional high-poly models of the most endangered animals suffering from plastic pollution: a seal, a sea turtle, a bird, a dolphin and a whale (Senko et al., 2020), presented in a form of a digital tridimensional hologram in user's immediate surrounding.

There was a methodological challenge to overcome in this study. Especially in the early design phase, it is difficult to show and evaluate a AR artifact with other media such as photo or video because AR needs to be experienced. Therefore, for the purpose of this study, we built the artifact prototype in the open source software Spark AR. The AR scene depicts a seal caught in plastic garbage and trying to escape from it. In the current version, users cannot influence the outcome of the scenario. The animated 10-second scene of a moving three-dimensional object plays in an infinite loop[2].

The purpose of the artifact is to enhance traditional environmental communication by supplementing it with engaging, immersive and sensory-rich media forms. Not only is such experience more engaging than photo or video, but recent wide adoption of AR camera effects on social networks enables easy sharing among its users, which could lead to campaign virality (Vasey, 2021). Basically, a campaign creator doesn't create the final product – the final product is created by users themselves, and each experience is unique and personalized. The experiences can be marketed in three different forms: (1) as a camera effect on social networks such as Facebook, Instagram, Snapchat, TikTok; (2) as a smartphone application; (3) as an interactive service integrated into a website, that is accessible through an Internet browser that supports AR. The following figure (Figure 2) demonstrates the artifact's AR scenes in different environments.

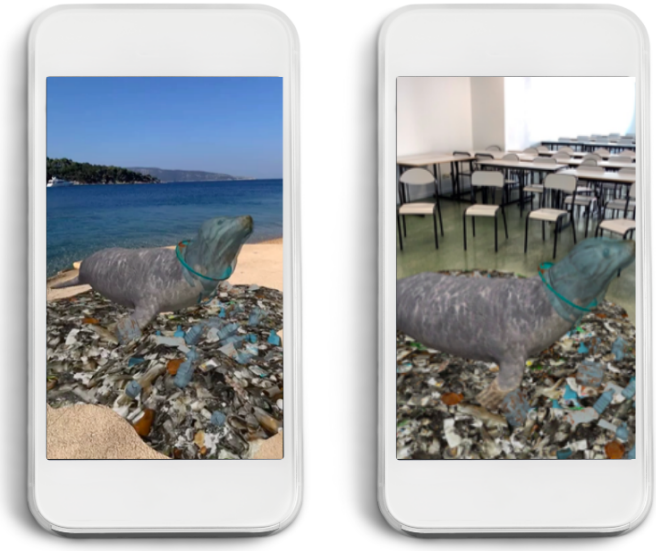

Figure 2. Examples of AR scenes of a seal suffering from plastic pollution

[1] Here are the three reasons why we choose the smartphone as a device for the AR experience: (1) because mobile-based AR is more democratized than AR glasses (Statista, 2001); (2) because mobile phones are giving suggestions at the oportuistic moments (Fogg, 2003) and (3) make green content "available at everybody's fingertips" (Pitt et al., 2011).

[2]The AR scene contains an unpleasant scene – the suffering animal. Because the literature on fear appeals and negative imagery is not consistent (O'Neill & Nicholson-Cole, 2009), we decided to investigate this matter during the focus group.

5 Evaluation

Guided by our research question, we evaluated the artifact through six focus groups with end users. Focus groups are especially suitable for investigating novel technologies, where theoretical background is still limited. Although time-consuming and challenging, this approach often generates new ideas and concepts, and results in the greater understanding of an emerging phenomenon (Sutton & Arnold, 2011; Morgan, 1988; Tremblay et al., 2010).

For the purposes of our research, we combined two types of focus groups, namely: exploratory and confirmatory (Tremblay et al., 2010). In the exploratory phase, we aimed to understand which environmental communication approach and campaign elements work best in general; in the confirmatory phase, we evaluated the design of the artifact and tested its utility in a hypothetical field use through on-site simulation and scenarios. Additionally, in order to increase the credibility of our findings, we accessed participants' confirmatory opinions in a more anonymous manner through two questionnaires conducted before and after each focus group discussions.

Focus groups were conducted in university's facilities, in controlled conditions, in the period between September and December 2020, among master's students[3] at two European universities. Our sample (N=73, Female=56, Average age= 22.7 years) represents typical social networks users – people between 18 and 29 years old (Pew Research Center, 2021). On average, participants indicated moderate to high level of concern about plastic pollution (M 5.41/7), and moderate familiarity with AR (M 3.41/7). Six focus groups resulted in 5 hours of recordings and 111 pages of transcription. Sessions ranged between 60 and 90 minutes in length, and were recorded using a voice recorder or a smartphone. All participants signed a written consent to participate in the study.

The discussion aimed at obtaining participants' feedback on the artifact, specifically, its social, information and technology aspects (De Leoz et al., 2018). Since the artifact was being evaluated in the context of nudging environmentally sustainable behavior, we also inspected participants' "green" attitudes and investigated whether there were any contextual barriers that would possibly impact the effectiveness of the artifact and its adoption. The artifact was introduced with a scenario, a one-minute video (available on demand) and an on-site demonstration using a smartphone iPhone X (focus group settings are displayed in Figure 2, right image). A detailed focus group guide is available on request.

6 Results and discussion

Focus group recordings were transcribed by an independent person, and, if necessary, translated into English. In order to ensure anonymity, pseudonyms are used in place of participants' names. At this stage, 3 major themes and 24 sub-themes emerged after coding transcription (see Appendix A for the Codebook). The first-order thematic analysis revealed key elements of a successful environmental campaigns, internal and external factors that influence pro-environmental behaviors, and techical and design requirements of an AR artifact.

Since there is very little existing research about AR as a pro-environmental communication tool, we let the data speak for itself and built a theory from the ground up (Strauss & Corbin, 1990). The insights from the study also informs kernel theories on which the artifact's design was built, which is the theoretical contribution of the study. Next, we applied a more systematic inductive approach in order to move from specific observations to broad generalizations, and to draw conclusions from the collected data (Gioia et al., 2013). The figure below (Figure 3) summarizes the second-order analysis, and graphically represents the process of transforming the raw data into more abstract themes and aggregate dimensions (Gioia et al., 2013).

[3]Alhough we can not generalize our results to all population of social networks users, results from many studies that used students as a sample are robust and informative (Frechette, 2011).

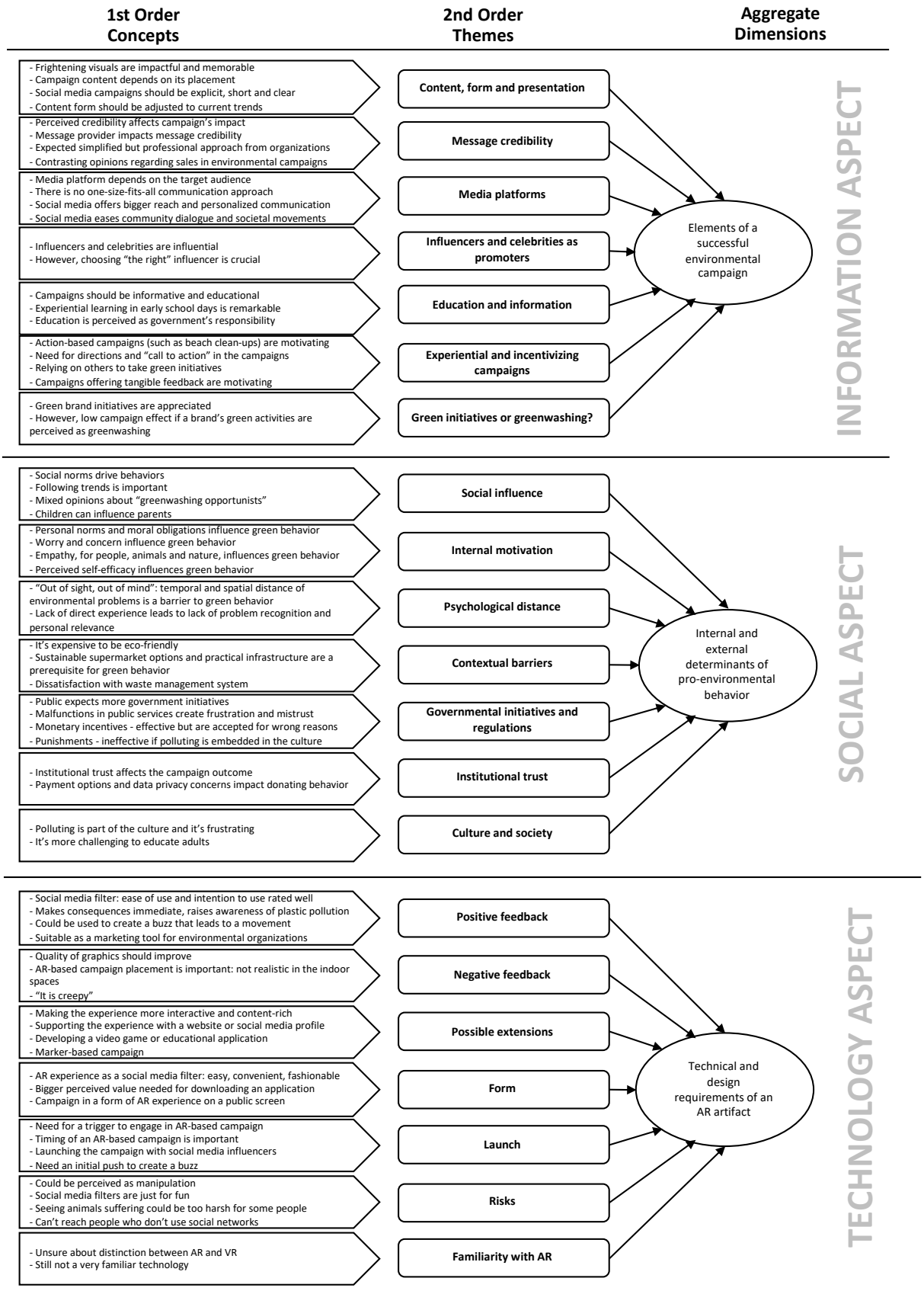

Figure 3. Data structure.

After in-depth analysis of our findings, we used the static data structure to generate a dynamic inductive data-driven grounded theory model (Strauss & Corbin, 1990) which represents interrelations between emergent concepts of the phenomenon (Gioia et al., 2013). The model represents the process of introducing AR for enhancing environmental-behavior-change nudges (Figure 4).

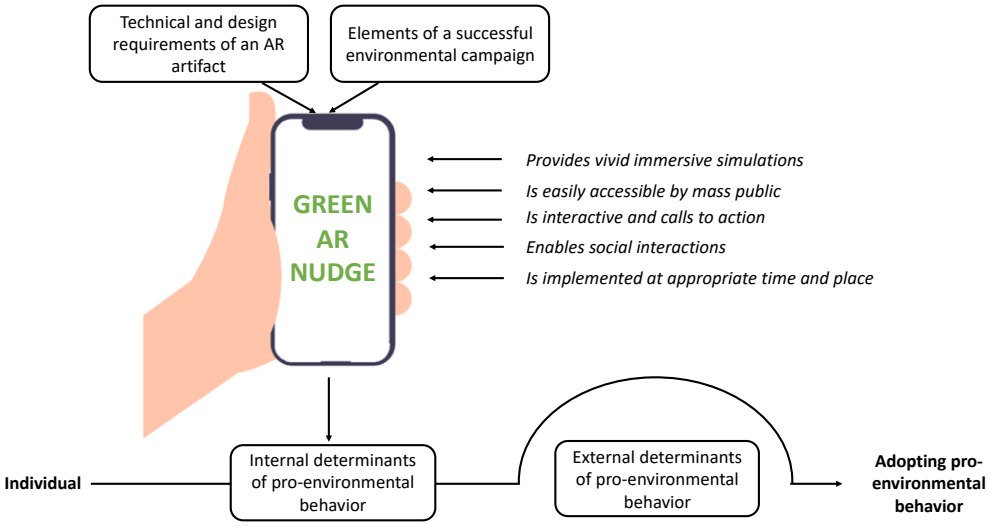

Figure 4. Theoretical model: The process of introducing AR for enhancing pro-environmental behavior-change nudges.

Our findings suggest that green AR nudges have great potential to enhance traditional pro-environmental behavior- change interventions, especially if they are immersive, interactive, accessible to a wide audience, enable social interactions, encourage users to take concrete actions, and are launched at the right time and place so that users can easily consume AR content. By optimizing the technical and design requirements of a AR artifact and incorporating effective elements for a successful environmental campaign, such strategically designed green AR behavior-changing nudge may affect individuals' internal determinants of pro-environmental behavior that lead to action. However, the outcome of a campaign may also depend on external factors (e.g., contextual, cultural, and social barriers) that must be overcome to achieve the adoption of pro-environmental behavior.

The form of an AR nudge is important. The acceptance of the artifact is likely to be the highest in the form of a social media camera effect, as in UNEP's campaign #CleanSeas (UNEP, 2019). Comparing to a stand-alone application or an AR experience within a website, this form is the easiest to use, but also attractive, engaging, and capable of becoming viral and creating a "buzz". In order to be attractive for users, a standalone mobile application should provide more added value (entertainment or education).

- FG1 P1: "It's very easy to use, everyone can do it, that's the capacity, well, the big advantage is the ease of use..."
- FG1 P3: "This is really the advantage, it's the hyper-practical side, the practicality, that's the advantage."
- Moderator: "And if you see this from some kind of environmental agency, or UN for Environment... this type of filter, would it make you curious to see who is behind it? Would you click? Would it catch your attention?"
- FG4 P2: "I think yes."
- FG4 P7: "Yes, I think it would because it's not usual to see those kinds of things on social media, so..."

In order to be convincing and cause social reaction and empathy, the simulation has to be realistic. The biggest criticisms of the artifact were the quality of graphics of the tridimensional model, and also the context of use: participants find it weird to see an animal in the classroom. Thus, some campaigns may require marker-based AR experiences, which limit the exposure only to locations where the

augmentation of the models makes sense (for example, limiting a campaign featuring sea animals to seaside locations only).

However, a campaign's outcome greatly depends on other elements as well, such as content and media platform. Although metaphorical visuals may better suit mass campaigns, it seems that shocking and negative imagery makes a pro-environmental campaign attractive and memorable, causing emotions that lead to engagement with issues and a personal connection, as stated in Leiserowitz (2006). Explicit, short and visual content may be more effective than textual, especially when there is a need to explain and present complex environmental data to lay people (Corner et al., 2018).

- FG3 P2: "(...) I think it's very important to have an emotional impact, yes, that's the main reason of marketing campaigns, to trigger something in you, and develop a need in you, but this (impact on animals) is kind of harsh to some people."
- FG3 P1: "Yes, but this is the point."
- FG3 P8: "Yes, I think that is the point because this is the harsh reality."
- FG3 P1: "Yes."
- FG3 P8: "You can collect the plastic in the field. When people see that, yeah, we can collect it. But you cannot bring animals back after they die! Like, this is the worst consequence, not the pollution in a field, you know…"
- FG3 P4: "I think this has more effect, compared to the other. Because this clearly… When somebody sees this, they would be like "Oh my God, I'm not going to do this. I'm not going to pollute the environment. I'll keep the plastics somewhere." So, this actually brings out the reality."

Furthermore, it is important to follow communication principles and trends relevant to target audience (Steg & Vlek, 2009). Social media may be the most suitable platform for green AR campaigns, as it can contribute to collective green movements (Ballew et al., 2015; Vasey, 2021). Not only it can use customized communication and reach more people than traditional media, but it may serve as a powerful weapon to gather similar individuals and put pressure on brands and corporations to act in a more eco-responsible way, as seen in a campaign by Greenpeace (2010).

- FG3 P1: "As she said, different target groups. That's why advertising on social media and generally on computers where everything is strictly personalized, to me, it's easier than putting it on the buildings. On a building, everybody from 0 to 99 years, they can see it. So you don't know who is going to see it, you cannot customize it. It has to be for everyone. On social media it's personalized to you – because you accept cookies, you agree with this, you agree with that, you give all your information, they know everything about you, they know if this picture, or that picture is going to work for you."

When a campaign is designed, attention should be put into planning its launch. AR campaigns may require a call-to-action (e.g. a poster or a social media post) as an invitation for users to join the experience. AR campaigns are specific because users cannot simply be exposed to them, they have to decide to engage with them. Therefore, a campaign creator must pay attention to the appropriate time and place when users may be able to engage with it. For example, a billboard on the highway wouldn't work in this case.

Although providing information is a crucial part of a campaign, it is often not enough (Kollmuss & Agyeman, 2002). Therefore, it is expected that governments and environmental organizations will supplement informational campaigns with experiential activities such as beach clean-ups, as well as directives for further steps. In addition, virtual experiences should be frequently updated with new features, if long-term artifact use is desired.

Also, since credibility determines the success of a persuasion attempt (Fogg, 2003), message providers – preferably social media influencers or celebrities – should be carefully selected, so that their lifestyle reflects the values of the campaign. Environmental organizations should think twice before selling a product, as well as brands who claim to be green without clear evidence; the campaign may be counter-effective if the public perceive it as greenwashing.

A strategically designed environmental campaign enriched with convincing AR experiences may lead to individuals adopting green behavior by affecting their internal determinants, namely: perceived social and personal norms, moral obligations, worry and concern, and psychological distance. This is in line with previous studies (Steg & Vlek, 2009; Wang et al., 2018; McDonald et al., 2014). For example, immersive AR experiences may replace real experiences needed for individuals to personally relate to them and "get psychologically closer" (Carmi & Kimhi, 2015; Spence et al., 2012).

- FG2 P3: "(...) I think the first barrier is what you were saying earlier, you said 'yes but without an iceberg we die', but in reality I don't realize it, you know what I mean? In fact, since I don't have an iceberg near me and my life doesn't depend on an iceberg at the moment, you know, in fact it makes it hard for me to feel concerned because I've been hearing about pollution since I was little but in reality my daily life doesn't change, you know, and I think that's the barrier, it's that as long as I don't feel the impact I have trouble feeling concerned, really committed."
- FG2 P9: "(...) well it's a bit philosophical but generally when we don't feel that our life is in danger, well, we don't feel that we ourselves are going to die if tomorrow there's still plastic, well that's not necessarily going to push us to act, whereas if we really saw the impact in our daily life, well, I think that we'd move more for sure..."

Finally, such behavior-change intervention may work if individuals' way is clear of all the contextual barriers (Steg & Vlek, 2009). For example, mistrust in government and the waste management system may discourage motivated individuals who want to recycle, and few supermarket options may be the reason why some people overconsume plastics, although they would rather not. Moreover, there are certain polluting habits "embedded" in the culture that may be difficult to change.

The following table (Table 2) shows the final evaluation of the artifact, i.e., participants' intention to use it and perceived utility. Participants are most likely to interact with such AR experiences through the services they already use, such as social networks (M 5/7), while downloading an application to their smartphone is obviously not an option (M 2,3/7), unless it brings additional benefits to users (such as entertainment or education). Most importantly, the green AR artifact is generally able to fulfill its main purpose: to make users more concerned about the plastic pollution problem (M 4,49/7).

		Intentions to use					**Perceived utility**
		I would use this system again, if it was available as a free app from the App Store.	*I would use this system again, if it was available as Facebook/Instagram camera filter.*	*I would use this system again, if it was available on a website in Internet browser.*	*I would record my AR experience to share it on my social media.*	*I would recommend this app to my friend.*	*I would say that this app made me more concerned about plastic pollution.*
Focus group ID	*FG1*	1,8 (1,26)	5,4 (1,72)	2,2 (1,47)	4,93 (2,19)	4,26 (2,43)	4,13 (2,03)
	FG2	1,67 (0,9)	4,33 (2,32)	1,73 (1,16)	2,87 (2,2)	3,4 (2,06)	4 (2,04)
	FG3	2,78 (0,97)	5 (1,87)	2,56 (1,81)	3,67 (1,66)	4,22 (1,92)	4 (2,06)
	FG4	2,18 (1,25)	3,18 (2,09)	1,91 (1,04)	2,27 (1,35)	2,73 (1,49)	3,73 (1,42)
	FG5	4 (1,48)	5,75 (2,05)	4 (1,71)	5,17 (1,40)	5,67 (1,23)	6,08 (1,24)
	FG6	1,73 (0,9)	6,18 (1,47)	4,73 (1,79)	4,82 (1,83)	5 (1,61)	5 (1,34)
	Σ	2,3 (1,38)	5 (2,12)	2,84 (1,88)	3,99 (2,1)	4,2 (2,04)	4,49 (1,86)

Table 2. Average marks of participants' evaluation of the artifact on the scale from 1 ("I strongly disagree") to 7 ("I strongly agree"); in the brackets are standard deviations

Based on this discussion, we developed a 6-step guide for creating successful environmental AR-supported campaigns for behavior change (Figure 5). For an intervention to be effective: (1) contextual barriers should be minimized; (2) AR experiences should be based on effective design principles (realistic, informative but emotional AR experiences that, by visualizing the problem, reduce the psychological distance); (3) AR experiences should be embedded in a form that is acceptable and easily accessible by mass public; (4) influential and credible subjects should be hired for its launch; (5) spreading the word on social networks should lead to the "buzz", which is important for activating social pressure, that may finally lead to pro-environmental behavior being adopted. Finally, (6) if an artifact is intended to be used in the long term, frequent updates in its design are needed.

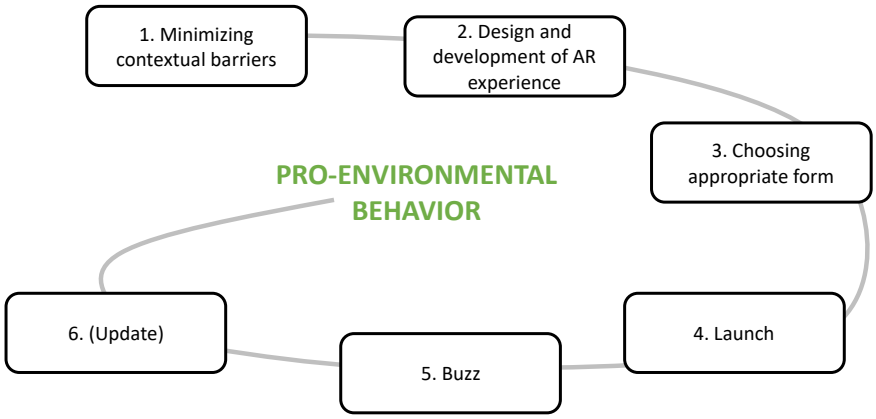

Figure 5. A step by step guide for creating AR-based pro-environmental behavior-change appeals.

7 Conclusion and future directions

Communicating about environmental issues is not an easy task. Aiming to find out how to implement digital nudges in IS to induce pro-environmental behavioral change, we applied a DSR approach to design and evaluate an artifact that demonstrates the consequences of plastic pollution in AR. The findings of six focus groups with end users indicate that AR technology has a great potential to enhance traditional environmental communication, especially if it is vivid, interactive, engaging, and realistic. End users are most likely to consume it through the services they already use such as social networks, which enable social interactions important for motivating behavior change. However, although it may offer a fertile ground for collective green movements, it seems that technology alone is not enough to change individuals' pro-environmental behavior, as this behavior also depends on other internal (such as personal norms and concern) and external (such as contextual and cultural barriers) factors which need to be taken into consideration. We also realize that the context might have influenced the evaluation of the artifact (it simulated the consequences of plastic pollution on the sea animals, it may have appeared unrealistic on the classroom floor), so another focus group settings (outdoor environment) could result in richer findings. Therefore, we can conclude that researchers should be careful about choosing the environment when evaluating an AR artifact. This study has certain limitations, one of them being the difficulty of generalizing conclusions to a larger population. Moreover, in this study we tested the artifact's utility through self-declarative statements. Therefore, conducting a controlled laboratory study might lead to more comprehensive conclusions about the artifact's real influence on pro-environmental behavior. It would be also interesting to evaluate the artifact from other groups of end users, as well as from the suppliers' side, namely, from various subjects who could be interested in using this media in their communication such as governments or nonprofit organizations. Therefore, we propose a set of three research questions that could guide future studies: (1) (How) does AR impact pro-environmental behavior? (2) Are AR experiences able to create a sense of presence? (3) Do professionals support including AR in green campaigns? There are three major contributions made by this study: methodological, theoretical and practical. Firstly, we provided an example for implementation of appropriate DSR evaluation strategy when designing (1) an artifact with environmental dimension and (2) an AR-based artifact in its conception phase. Secondly, our grounded theory model built from inductive analysis of the collected data contributes to the research on Green IS, and provides theoretical support for designing an AR-based artifacts for nudging pro-environmental behavior. Thirdly, we provide concrete guidelines for implementing digital green behavior-change nudges, useful for subjects involved in environmental communication (policy-makers and environmental communicators). Although our study focuses on digitally nudging environmental behavior, these findings could be useful in other domains, for example, in the context of health and pro-social behavior.

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Appendix A

CODEBOOK

THEME	*CODE*	*QUESTION THAT THE CODE ANSWERS*
ENVIRONMENTAL COMMUNICATION *(This theme implies various elements of an environmental campaign. Such elements are under control of a campaign creator, because they can be integrated into a communication strategy.)*	***Experiences and actions***	*How impactful are action-based campaigns (such as clean-up actions, educational field trips, etc.)?*
	Content, form & presentation	*What kind of campaign content is remarkable, rememberable, and shareable? What form of the content presentation (video, photo, billboard...) is the most impactful?*
	Credibility	*Is credibility of a message important in an environmental campaign? What makes a campaign credible? Is the source of the message important?*
	Media platforms	*What media platform is the most promising for environmental campaigns? Which social network is the most effective for environmental messages?*
	Influencers and celebrities	*What is the role of influencers and celebrities in environmental campaigns?*
	Incentive-based campaigns	*How effective are incentive-based campaigns (a type of campaign that offer some kind of reward in return for a green behavior, such as jewelry from recycled material, or planting a tree for a donation)?*
	Education	*How important is environmental education? Is environmental data too complex to understand?*
	Audience	*Is there one-size-fits-all communication solution, or there are different strategies for different target groups?*
	Brand initiatives	*How does public react to green initiatives from commercial brands?*
OTHER FACTORS THAT INFLUENCE PRO-ENVIRONMENTAL BEHAVIOR *(This theme implies elements that are not necessarily a part of an environmental campaign, but positively or negatively influence execution or intention to execute pro-environmental behavior. These elements are usually out of control of a campaign creator)*	***Social influence***	*Does societal pressure and norms play a role in forming environmental attitudes? How important is personal image and following trends?*
	Internal motivation	*What internal motivation influences individual's environmental behavior?*
	Governmental initiatives and regulations	*How effective are government's initiatives? What is the public opinion about monetary regulations?*
	Institutional trust	*Does public have difficulties in trusting institutions?*
	Culture & society	*How does culture and society impact individual's environmental behavior?*
	Psychological distance	*Does psychological (spatial and temporal) distance of environmental problems plays a role in forming environmental behaviors?*
	Context barriers	*What are the contextual barriers (such as supermarket prices and options availability, waste management system, infrastructure) to individual pro-environmental behavior?*
THE ARTIFACT: PRO-ENVIRONMENTAL AR EXPERIENCES *(This theme implies opinions about the proposed novel artifact, possible extensions, launch, downsides etc.)*	***Positive feedback***	*What is well rated about the artifact?*
	Negative feedback	*How should the artifact be improved?*
	Possible extensions	*What are the possible extensions of the artifact?*
	Form	*What is the appropriate form of the artifact?*
	Launch	*How to launch the product on the market?*
	Risks	*What are the risks associated with the artifact?*
	AR in general	*What is the opinion about Augmented Reality in general?*
	Project explanation	*Transcription including project explanations and demonstration*

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