Comparing the Effects of Immersive Information Modes on Agricultural Technology Acceptance

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Abstract

Since agricultural technology is slowly being accepted and adopted it was assessed which role immersive information modes have in facilitating technology acceptance. 128 Participants explored either a video or a game and filled out an online survey. Participants were compared in their self-reported measurements of affective responses, uncertainty, risk and benefit perception, and intention to accept an agricultural technology. Results show that despite varying immersiveness levels, the information modes indicate no difference in eliciting behavioural beliefs and intentions. The results confirmed the importance of attitudes on behavioural intention but cannot confirm that immersiveness causes changes in technology acceptance or other behavioural beliefs.

Keywords: technology acceptance, behavioural intention, immersiveness, behavioural beliefs, information technology

Comparing the Effects of Immersive Information Modes on Agricultural Technology Acceptance

Established socio-technological regimes are generally resistant to change (Geels & Schot, 2007). Technological change is a process of incremental emergence, improvement, and distribution over time. Theoretical models propose that technological innovations follow a multiple stage adoption process (e.g. Gartner Inc., n.d.) and feature a big surrounding landscape of influences (Multilevel Perspective, Geels & Schot 2007) which make change a complex process. Information communication technologies and the media landscape can play a big role in distribution of information and can act as an influencing factor on the adoption of technologies and the change of regimes. Through a sense of interactivity and increased telepresence ('immersiveness') they can influence how people process information (Slater & Wilbur, 1997, as cited by Cummings & Bailenson, 2016). This is especially the case for 3D environments that surpass the traditional 2D screens (Huang, Backman, Backman, & Chang, 2015).

The agricultural sector faces these slow changes (e.g. Fuglie & Kascak, 2001; or Long, Blok, Coninx, 2015), despite the climate and food crises requiring a change in food practices (e.g. De Haan & van Dijk, 2013). Understanding technology acceptance might mitigate the time needed for change to establish itself. Making communication channels as effective as possible could be essential to change consumer behaviours. An important question is what determines the acceptance of technologies in the agricultural domain. Specifically, if and to what extent this has to do with the immersiveness of ICTs with which innovations are presented.

Theoretical Framework

Technology Acceptance

Technology acceptance is conceptualized as people's support instead of resistance against the use of a given technology (Huijts, Molin, and Steg, 2012). Supporting a technology can have two distinct levels. People can be *tolerant*, meaning they passively accept a technology, or they can be *supportive* which presupposes active supporting behaviour (e.g. advertising or purchase). Technology acceptance is both needed for citizens (‘placement of a technological object in or close to one’s home, which is decided about, managed or owned by others’, Huijts et al., 2012, p. 526) as well as consumers (‘behavioral responses to the availability of technological innovations, that is, the purchase and use of such products’, p. 526). For a technology to be adopted successfully, it is defined that citizens need to be supportive of the technology existing in their environment as well as showing active and supportive consumer behaviour (based on Wüstenhagen, Wolsink, Bürer, 2007; Schweizer-Ries, 2008).

The agricultural context of innovations may be especially important. The history of genetically modified foods shows that people can react to changes in their food systems with seriousness and skepticism. Genetically modified foods were met with confusion and connivance and even with open resistance (Brossard, Shanahan & Nesbitt, 2007). This shows the importance of technology acceptance in both citizens and consumers, as support is needed from both groups for technological changes to have success.

Theory of Planned Behaviour

The Theory of Planned Behaviour (Ajzen, 1991) is a dominant approach in health-related behaviour research and finds successful application in advertisement, healthcare (including food decisions (e.g. Conner, Kirk, Cade, Barrett, 2003).) and environmental psychology (including the agricultural domain, e.g. Burton, 2004; Fielding, Terry, Masser, & Hogg, 2008; Hansson, Ferguson, & Olofsson, 2012). While other models such as the Technology Acceptance Model (TAM; Davis, 1989) and the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesch et al. 2003) also focus on technology acceptance, the models focus on technology usage behaviour, specifically (e.g. ease of use, voluntariness of use, use behaviour). However, usage of the technology is not as relevant here as people do not decide about using the technology directly but instead the willingness to accept its product (livestock), or the technology's existence in their environment. This is characterized as non-volitional behavior which is accounted for in the TPB. The framework includes measuring attitudes and behavioural intention and is extended by adding specific behavioural beliefs (risk and benefit perception, affect, uncertainty), as well as the predictors, trust in science, and trust in technology. Sociodemographic factors are added to the TPB, such as age, gender, and education (based on Huijts et al., 2012).

Behavioural Intentions. According to the TPB, the intent to do a desired action is likely a precursor for actual behaviour. The formulation of intent is determined by people's *attitudes*, the perceived social pressure to behave (*subjective norm),* and their *perceived behavioural control*. A desirable intended behaviour is defined as the willingness to actively buy or recommend a presented agricultural technology. An emphasis is put on people's attitudes as they pose a strong predictor of behavioural intentions. Attitudes are influenced by the beliefs about the consequences of a behaviour and the corresponding positive or negative judgements about each consequence.

Risk and Benefit Perception. Behavioural beliefs are beliefs about the consequences of a specific behaviour. Important attitudes are thought to be determined by a sense of risk perception (Huijts et al., 2012; Lobb, Mazzocchi, & Traill, 2007). Risks and benefits have an inverse relationship, meaning that the more benefits are perceived, the lower the risk perception and vice versa (Alhakami & Slovic, 1994). Attempts to include factors such as risk perception into the TPB framework indicate that it affects behavioural intention (e.g. SPARTA; Lobb et al., 2007). Lobb et al., found that risk perception influences behaviour indirectly by negatively affecting attitudes which in turn affect behaviour.

Health Risks and Benefits. As found by Miles and Frewer (2001), consumer concerns relating to health issues are common to all perceived hazards, which also includes concerns for food related changes. Mooney and Walbourn (2001) showed the importance of health benefits by pointing out that held health values serve as primary influences on food selection. Mooney and Walbourn define health values to include disease avoidance and feelings of wellbeing. These can for example aid in accepting healthy foods and engaging in health promoting behaviour, including food selection and food rejection. On the societal level, health benefits may include having access to healthier and more nutritious foods (Rollin, Kennedy, & Wills, 2011).

Environmental Risks and Benefits. As found by Butz et al. (2003; as cited by Bruhn, 2007), environmental friendliness was one of the most important factors to determine people's intended consumer behaviour. Overall, multiple studies conform environmental concern to be a determinant for food acceptance and related innovations (e.g. Frewer et al., 2011; Lusk, 2004). Huijts et al. (2012) define environmental aspects of importance to be among others, air pollution, noise pollution, climate change, loss of biodiversity, as well as scarcity of energy sources and increasing energy costs which affect safety and well-being.

Uncertainty. While some people make up certain opinions on whether to promote or oppose a technology, it is also possible that people hold uncertainty about which attitudes to hold or that they hold both positive and negative attitudes at once (ambivalent; Brossard et al., 2007). Ronteltap, van Tijp, Renes, and Frewer (2007) write that uncertainty arises in ambiguous, complex, unpredictable, or probabilistic situations where information provision might not be accessible or incoherent. Uncertainty can apply when people feel insecure (see Brossard et al., 2007) but uncertainty also applies when people hold two opposing opinions at the same time not knowing which weighs more. This is the case when people experience a lack of information and perceive a higher risk as a consequence (Clark, 2013), or, despite having enough knowledge about a topic, feel both negative and positive opinions at the same time. The states of holding two opposing opinions at once or being unsure about adopting either will be referred to as 'uncertainty'.

Affect. Affective responses can influence both attitudes and behavior. Affect may directly influence attitudes, and indirectly intention to behave (Huijts et al., 2012). There is positive affect (pride, happiness, satisfaction) and negative affect (fear, worries, anger) which independently predict attitudes (Huijts et al., 2012). Affect and uncertainty are connected. When holding uncertainty, "affect heuristic" apply to guide judgement and decision-making (Finucane et al., 2000, as cited by Townsend, Clarke, & Travis, 2004).

Trust in Science and Technology. Trust is defined as a "psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another" (Rousseau, Sitkin, Burt, & Camerer, 1998, p. 395). Risk perception decreases when trusting people or institutions involved (Featherman & Pavlou, 2002; Gefen et al., 2002; as cited by Horst, Kuttschreuter, & Gutteling, 2007; Siegrist, 1999, 2000; Siegrist, Gutscher, & Earle, 2005). Lobb et al. (2007) confirm the inverse relationship and connect trust to more favourable attitudes.

Two types of trust can be argued to be especially important. Without elaborate knowledge about a technology, people can instead trust other people's expertise, such as scientists (Siegrist et al., 2005). Hendriks, Kienhues, and Bromme, (2016) find that for trust in science, the public's general appreciation of science, general trust in science, trust in science in the context of a specific topic are important to consider here. Similar, trust in technology means believing that a technology can help achieve one's goals despite any uncertainty and vulnerability (Lee and See, 2004, as cited by Xu et al., 2014).

Communication Models

In addition to the theory about accepting the technology and its products, the presentation and communication media of this technology can influence technology acceptance. This notion is supported by the Theory of Multimedia Learning which argues that people achieve a higher ability to learn from multiple sensory representations of information ("technology-rich learning", Mayer & Mayer, 2005, p. 640). Learning occurs more effectively if information cues are processed via different cognitive channels (dual coding theory). This can reduce the cognitive load of the learner and ease the learning process. In addition, the Interest Theory support the effect of using a novel technology such as VR to enhance situational interest and increase learning. Immersiveness may be one aspect which can pique interest in people to learn about a technology more effectively and can, consequently, help in attitude formation (Parong, & Mayer, 2018).

Immersiveness. Being immersed means that a person engages and interacts with a given environment. Virtual immersive environments provide a realistic, high-quality environment where products can be introduced while maintaining user engagement. A specific conceptualization of immersiveness is derived by Norman (2010). An immersive environment must have the following characteristics; *Visual Presence* (concerning graphic realism), *Auditory Presence* (realistic 3D surround sound output), *Sensory Engagement* (engaging the senses of a user), and *Sense of Control* (feeling of being in control of views and actions). Two factors negatively impact immersion: *Awareness of the Interface* (thinking actively about an interface and how to operate it) and *Awareness of the Real World* (being distracted from the environment).

An immersive interaction leads to a successful online presentation of products due to a higher enjoyment, which ultimately affects behavioural intentions (Huang, Backman, Backman, & Chang, 2015). Suh and Lee (2005) confirm that immersive environments can lead people to adopt positive attitudinal and behavioural outcomes. When encountering novel objects, people engage in exploration behaviour to learn. Immersive environments show considerable success in providing learning opportunities by introducing realistic learning environments and a rich feedback. These environments provide flexibility and personalization, as well as learner control, and interaction with tools or tasks that reflect real world experiences (Mayer & Mayer, 2005 p. 634). A better learning experience helps in the process of forming favourable attitudes.

Information modes and role function. While the exploration and learning behaviour has a vital connection to attitude formation and technology acceptance, the role assigned to a consumer can make a difference. Interaction and participation of consumers is a vital element when attempting to create immersiveness. This is based on the assumption that there are different levels of engagement when being a mere observer or being a participant (Laurel, 1993, as cited by Jennings, 2000). The different roles also lead to different experiences. For example, James et al. (2002) found that object recognition and perceptual learning is affected by an active vs passive role. From this follows that for the introduction of new technologies, immersiveness is strengthened when engaging users in an active way instead of assigning them an observer role. The notion of task engagement is supported by the Self-efficacy theory where motivation and performance are enhanced by interesting communication channels utilizing an active task and a rich feedback environment, such as VR (Schunk & DiBenedetto, 2016, as cited by Parong, & Mayer, 2018).

The information mode in which to present new technologies can assign different roles to consumers. More dynamic techniques developed to ensure people have a more immersed experience, some being more immersive than others. These techniques include introducing technology through animations or videos, or even (serious) games. Because of their feasibility in required resources and promise of interactivity, videos receive great attention in marketing and product development (Parise & Guinan, 2008). Similarly, virtual reality present another approach to communicate ideas, concepts, or products in the marketing sector (Burke, 2017; Ruppert, 2011) However, there may still be a difference in immersiveness depending on the role a person is assigned while exploring the new technologies. It is assumed that being an active participant while playing a game is eliciting more immersiveness than being a passive observer of a video.

The Agricultural Regime

The agricultural regime is not sustainable and there is a need of replacing the traditional technologies of livestock production (Friedmann, 2005, Tanner and Wölfing Kast (2003). Change in this regime is difficult to achieve for multiple stakeholders are a part of a shift (Geels & Schot, 2007). The agricultural landscape includes politicians and policy makers, agriculturalists, the supply chain and retail, as well as consumers that can initiate pressure on the established system to change. For example, policy makers could introduce regulations in favor of a green shift, while agriculturalists could optimize their plant cultivation performance. At the same time, the supply chain and the retail business could support changes in terms of availability, and customers can change their consumer behaviour. While new technologies face various stakeholders, in the end, it is the consumers that decide about the implementation of agricultural innovations by their behavioural choices as an act of coevolution which would not be possible without their cooperation (e.g. Bree, …, Kramer 2010; Geels, 2012).

New technologies such as soilless systems are developing which pose a feasible alternative to traditional agriculture (Garrett, Alexander, Robinson, Bragg, 2016). Most crops can be grown in these controlled environments while at the same time offering great environmental arguments in terms of crop productivity, use of water, fertilizer, and pesticides (National Institute of Food and Agriculture, n.d.), and logistical problems. Crops in soilless systems have no dependence on fossil fuels, they reduce greenhouse gas emissions, they relieve the degradation of soil, and the destruction of biodiversity (Bernstein, 2015). However, regardless of the advantages, the agricultural sector generally adapts slowly (Long, Blok, & Coninx, 2016). Possible psychological barriers to technology adaptation can be when there is conflict with traditional methods, overly complex functionality, difficult to observe results, or negatively presumed assumptions (Long et al., 2016).

This Study

This study aims to provide an understanding of public acceptance attitudes towards new agricultural technologies such as soilless systems, especially in the Netherlands and Germany. Specifically, what difference the role of information modes plays in eliciting different levels of immersiveness. The levels of immersiveness and behavioural intention are compared between two information modes (video vs game). It is of interest to understand how and to what extent participants determine to be willing to accept and adopt new technological developments when exposed to different levels of immersive media presentation. Presenting new technologies has been the focus of marketing strategies for a long time, however, whether showing videos or virtual reality games show differences in introducing agricultural technologies in terms of gaining support or acceptance remains unanswered.

Hypotheses.

H1: Participants experience a significantly higher level of *Immersiveness* when presented with a different ICT condition. A game will introduce higher levels of immersiveness than a video.

H2: The presentation of technology via video vs game will elicit a difference in levels of behavioural beliefs (*Risk and Benefit Environment, Risk and Benefit Health, Affect Positive, Affect Negative*, and *Uncertainty*) compared to the video group to be more favourable of the technology.

H3: Participants in the high immersiveness game condition will have significantly more positive *Behavioural Intention* to support the technology.

H4: The relationship between the manipulation and *Behavioural Intention* is moderated by *Trust in Science* and *Trust in Technology*. At low trust levels, the manipulation-*Behavioural Intention* association is comparatively weak, while at high trust levels the manipulation-*Behavioural Intention* association is significantly stronger.

Figure 1 provides an overview of the hypotheses in the theoretical framework.

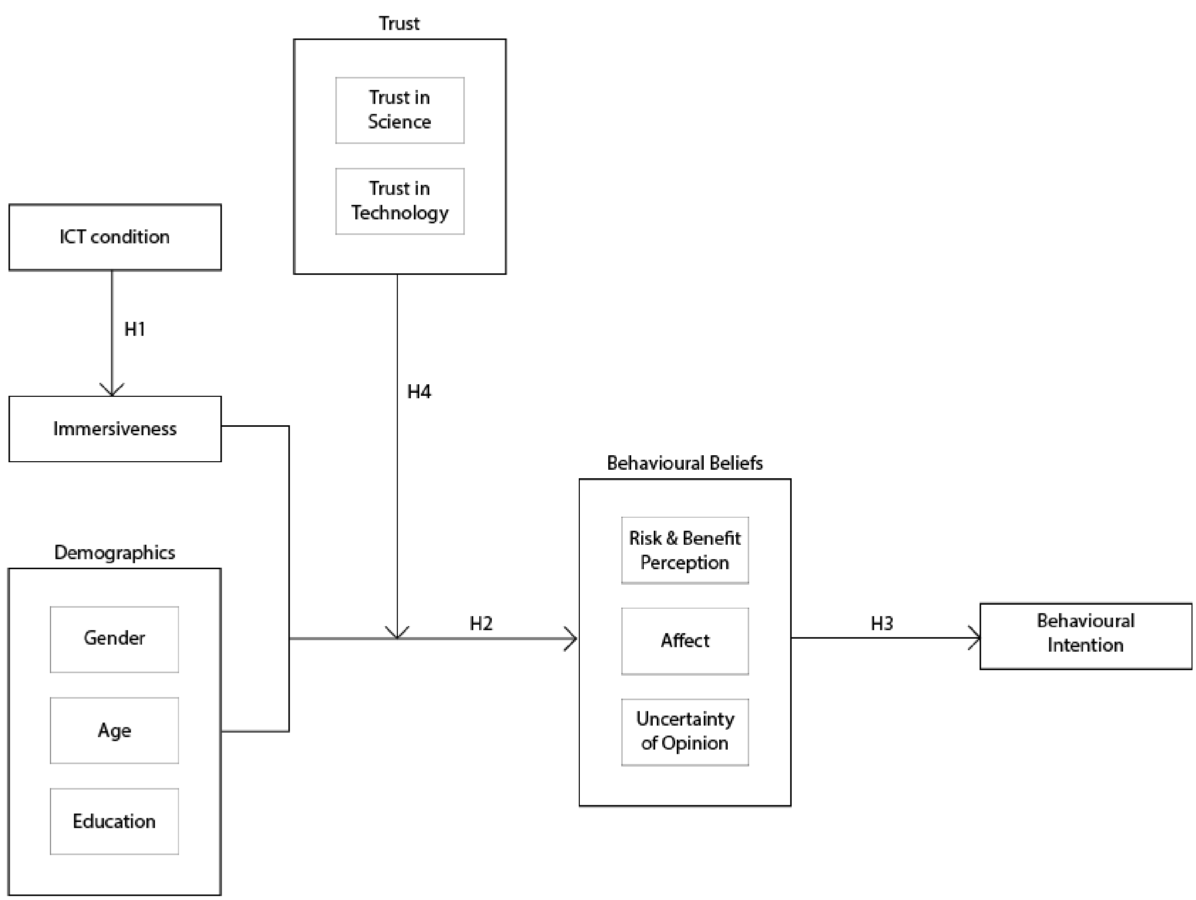

Figure 1. A diagram representing the theoretical framework, illustrating the determinants of behavioural intention to accept a given agricultural technology. The hypotheses are marked correspondingly.

Methods

Participants.

A total of 128 participants were recruited by convenience sampling in the time frame of 29. July until 28. September 2020. Participants were actively recruited via Sona Systems, Facebook, LinkedIn, SurveySwap, and MTurk in exchange for credit points, survey exchange, monetary compensation (1.50€, on MTurk), or on a voluntary basis. Participants took part in a virtual experience of a hydroponic greenhouse and filled out an online survey via Qualtrics. Ages ranged between 19-64 (M = 32.96, Median = 28.0). When removing a possible outlier according to the IQR 3 rule (participants age = 100), the range of age was 19-64 (M = 32.05). Data of 3 participants in regard to age was missing. Most participants (53.3%) belonged in the age group 18-29 with a spike around 22- 24. The education level was overrepresented in university education (55.4%). Table 1 summarizes the demographics variables.

Participants were randomly sampled into two conditions: game vs video. The game condition included 37 participants (45.9% female, 54.1% male) and the video condition 46 participants (56.5% female, 41.3% male, 2.2% other). Data of N = 40 participants were excluded due to not completing the study and N = 5 participants were excluded due to indicating on a control question that they have not engaged with the stimuli, leaving a total of N = 83 participants. When controlling for computer problems, 23 participants were excluded from analysis, leaving N = 60 participants. Figure 2 provides an overview of the participants flow through the selection and distribution process into groups.

Randomization of groups was tested by the administration of a one-tailed independent samples t-test. The conditions did not significantly differ in their means regarding age (Game: M

= 1.54, *SD* = .74, Video: *M* = 1.67, *SD* = .77), *t*(78) = -.73, *p* =.24. Groups also did not significantly differ in their means regarding gender (Game: *M* = 1.92, *SD* = 1.26, Video: *M* = 2.15, *SD* = 1.52), *t*(80.93) = -.77, *p* =.45, nor in education (Game: *M* = 1.54, *SD* = .51, Video: *M* = 1.61, *SD* = .54), *t*(81) = -.59, *p* =.55.

A correlation matrix shows the relationship between the demographic variables and the dependent variables. Education shows a weak positive correlation to Age [*r*(83) = .32, *p* = .004], and a weak negative correlation with *Immersiveness* [*r*(83) = -.25, *p* = .03]. Gender has a weak positive correlation with *Affect Positive* [*r*(83) = .27, *p* = .02], *Risk and Benefit Environment* [*r*(83) = .27, *p* = .01], *Affect Negative* [*r*(83) = .29, *p* = .01], and *Affect Positive* [*r*(83) = .27, *p* = .02]. Age has a weak positive correlation with *Trust in Science* [*r*(83) = .31, *p* = .01] and *Trust in Technology* [*r*(83) = .25, *p* = .02]. Table 2 (see Appendix B) provides an overview of the correlations.

Table 1.
Demographics of Study Sample

	Total Sample	Game	Video
Age			
n	75	37 (missing 2)	46 (missing 1)
% 18-29	53.3	56.8	47.8
% 30-49	32.0	24.3	37.0
% 50-64	13.3	13.5	10.9
% 65+	1.3	94.6	2.2
Gender			
n	78	45.9	46
% Female	41.0	54.1	41.3
% Male	57.7	0	56.5
% Other	1.3		2.2

Education			
n	78	37	46
% WO	56.4	54.1	56.5
% HBO	12.8	18.9	8.7
% VWO/ HAVO/	12.8	16.2	10.9
WMBO	7.7	2.7	10.9
% None	10.3	8.1	13.0
% Other			

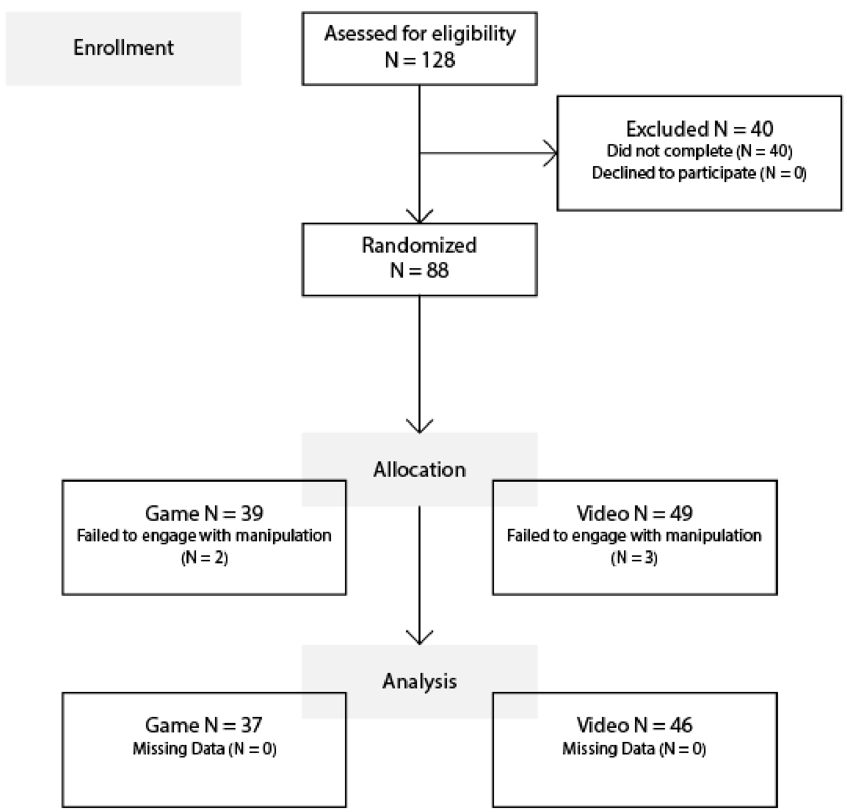

Figure 2. Sampling and Flow of Subjects Through a Randomized Allocation.

Design.

A quantitative research design was used to assess behavioural intentions of participants given that different electronic media outlets present an innovative agricultural technology. Data collection was original. A between-groups design with 2 groups of randomly assigned participants was used. The independent variable was *Immersiveness* of the presented information that was either a digital Game or a Video. Two potential moderator variables were *Trust in Science* and *Trust in Technology*. As a dependent variable, *Behavioural Intention* was measured to assess the acceptance of a given technology in terms of promotion intentions. Other dependent variables were *Risk and Benefit Environment, Risk and Benefit Health, Affect Positive, Affect Negative,* and *Uncertainty*.

Materials

Stimuli. The stimuli used for the study encompasses an immersive 3D digital environment created by the Unity software version 2019.3.5f1. This digital environment encompassed a warehouse space where 28 soilless plant cultivation systems were arranged with basil or strawberry plants (Figure 3 & 4, see Appendix B). In addition, 3D models were included to represent electricity, water, nutrients, ventilators, and software necessary to run the cultivation systems. Participants were provided information in the form of information cards with the function to introduce various details and the functionality of the greenhouse (Figure 5, see Appendix B). A total of 9 information cards were introduced, including hydroponics, irrigation, fruits, herbs and vegetables, nutrients, ventilation, software, electricity, light. Both groups of participants were presented the same information and depictions. A card counter helped participants to keep track of the information cards encountered and to keep track of their progress and when to end the game. To make the 3D environment as immersive as possible, the settings in Unity included a naturalistic motion blur, included the sound of footsteps, water, electricity, and ventilators, utilized a first-person camera, an ambient occlusion (which predicts natural shadows and enables more realistic light graphics), and a focus distance of 2 meters.

The environment served as a space where participants walked around using their mouse or computer keyboard to explore the system in a 360-degree view, or, alternatively, observe someone walking around in a prerecorded video. Instructions were given at the beginning of both stimuli types to turn on the sound, as well as the instruction that the goal of the exploration is to discover all information cards (see Figure 6). To avoid participants being confused about the controls in the game condition, instructions were given after starting the game, including how to walk, how to use the camera, how to end the game. In the video condition, instructions on how to navigate the environment were omitted.

To check whether the manipulation was successful, the two different manipulation groups were compared in their levels of *Immersiveness*, as defined in the Instruments section. The 37 participants who received the game manipulation (M = 3.85, SD = .84) compared to the 46 participants in the video group (M = 3.31, SD = .77) demonstrated significantly higher scores on immersiveness, $t(81) = 3.08$, p =.002. From this it can be concluded that the manipulation indeed was successful in eliciting higher levels of immersiveness in the game group than in the video group.

Instruments. A self-administered questionnaire was given to the participants (Table 3, see Appendix A). The dependent variable *Behavioural Intention* was measured using three items (5-point Likert scale; Definitely yes - Definitely no) which assess the level of people's willingness to actively support the technology (e.g. ‘If my supermarket would offer food that was grown from the system I just saw, I would buy it'). The scale for *Behavioural Intention* provided an acceptable reliability (*a* = .78). An additional item assessed people's willingness to tolerate the technology ('I would tolerate the technology to exist in my environment'). Items were recorded where a score of 1 = 'definitely no', 5 = 'definitely yes', meaning a higher score on the scale a higher score on behavioural intention.

Risk and benefit perception was measured using a total of 6 items (5-point Likert scale; Not at all - Very much). The scale *Risk and Benefit Environment* included three items (e.g. 'I am concerned about the potential negative impact of the technology on the environment.'), and the scale *Risk and Benefit Health* included three items (e.g. 'I believe the new technology could have useful medical benefits.'). Questions asked both for risk and benefit of the individual or the society. Cronbach's Alpha shows a reliability of *a* = .65 for the scale *Risk and Benefit Environment*, and an *a* = .75 for *Risk and Benefit Health*, respectively. Items were recoded so that a higher score on the scale a higher perception of risk and lower perception of benefits (1 = 'not at all', 5 = 'very much').

People's *Uncertainty* in their attitudes was measured using four items (7-point Likert scale; Strongly agree - Strongly disagree, based on Brossard et al., 2007). The four items asked whether participants think they are uncertain due to either missing knowledge, or because they think the technology holds both positive and negative aspects. The scale for *Uncertainty* shows an acceptable reliability (a = .71). In the *Uncertainty* scale, items were recoded to indicate that a higher score on the scale was a higher score in levels of uncertainty (1 = 'strongly disagree', 7 = 'strongly agree'.) An additional two items (7-point Likert scale; Strongly agree - Strongly disagree) were included to ask whether participants have certain attitudes about whether the technology should be opposed or supported. Items were recoded so that a higher score means a higher certainty (1= ‘strongly disagree’, 7 = 'strongly agree’).

Participants were asked to indicate their levels of affect divided into positive (pride, happiness, satisfaction) and negative (fear, worry, anger) feelings toward the technology (5-point Likert scale; A great deal - None at all). Each scale contained three items. Cronbach’s alpha shows good to excellent reliability with .87 (*Affect Positive*) and .92 (*Affect Negative*). Items were recoded so that a higher score on the scale means a higher score of positive/ negative feelings (1 = ’none at all’, 5 = ’a great deal’).

The independent variable *Immersiveness* was measured using six items (5-point Likert scale; Not at all - very much, based on Norman, 2010). Two items measured perceived sensory engagement, and one item the participant’s perceived sense of control. Additionally, one item for each awareness of the real world, and enjoyment were included. Items are coded to indicate that a higher score on the scale means a higher score in immersiveness levels (1 = ‘not at all’, 5 = ‘very much’). The reliability shows good reliability for the *Immersiveness* scale in the game condition (*a* = .86) and acceptable reliability in the video condition (*a* = .77). Table 4 provides an overview of the items used to assess *Immersiveness*.

Table 4.

A list of the items included for the Immersiveness scale classified by their respective subconcepts of Immersiveness.

Subconcept of Immersiveness	**Video Condition**	**Game Condition**
Sensory engagement	My senses were actively engaged while exploring the warehouse.	My senses were actively engaged while exploring the warehouse.

	My attention was focused on the video.	My attention was focused on the application.
Sense of control	I had control over the exploration of the warehouse.	I had control over the exploration of the warehouse.
Awareness of the Real World	I was able to concentrate without outside interruptions.	I was able to concentrate without outside interruptions.
	I felt drawn into the greenhouse scenario.	I felt drawn into the greenhouse scenario.
Enjoyment	I enjoyed watching the video.	I enjoyed playing the game.

Two additional items were included for the video condition, and three items were included in the game condition to assess whether participants experienced computer problems regarding navigating (awareness of the interface: "I knew how to navigate through the warehouse.") or experiencing the manipulation (visual presence: The graphics were realistic.", "The video ran smoothly on my computer."; 5-point Likert scale; Not at all - Very much, based on Norman, 2010). Items are coded to indicate that a higher score on the scale means a higher score in experiencing problem levels (1 = 'very much', 5 = 'not at all'). When controlling for computer problems, participants were excluded from analysis when answering 'not at all' or 'not really' on the identified control items, while participants that answered 'undecided', 'somewhat', and 'very much' were included.

The potential moderator variable of trust was assessed by creating a scale for *Trust in Science*, and *Trust in Technology*. *Trust in Science* was administered using 13 items with a 7-point Likert scale (Strongly agree - Strongly disagree) to assess general appreciation of science (e.g. 'I trust scientists to make a valuable contribution to society'), general trust in science (e.g. 'Science is more harmful than beneficial'), and trust in science in the context of agriculture (e.g.

'I trust in science's positive effect in the context of food', based on Hendriks, Kienhues, & Bromme, 2016). *Trust in Science and the Science of Trust. Trust and Communication in a Digitized World*, 143–159. doi:10.1007/978-3-319-28059-2_8). *Trust in Technology* was measured using three items (7-point Likert scale from strongly agree to strongly disagree) to assess levels of trust in technology in general (e.g. 'Technological devices and machines in general function properly.'), and trust in agricultural technology specifically ('I think agricultural technologies are dangerous.'; based on Xu, Le, Deitermann, & Montague, 2014). The *Trust in Science* scale shows a good reliability (a = .82) while *Trust in Technology* shows a questionable reliability (a = .62). In both scales, items are coded to indicate that a higher score on the scale means a higher score in trust levels (1 = 'strongly disagree', 7 = 'strongly agree').

Sociodemographic details were collected using one item each for age, gender, and educational level.

Assumptions for parametric tests. To test normality, the Shapiro-Wilk test in addition with a z-score test using skewness and kurtosis are applied. In accord with Kim (2013), a medium sample ($50 < n < 300$) should assume a normal distribution when the absolute z-value was between -3.29 and +3.29 (alpha level 0.05). Table 5 (see Appendix B) provides descriptive statistics, including skewness and kurtosis and their respective z-scores, as well as the results of the Shapiro-Wilk test of normality and the Levene's test of homogeneity of variance for all measured variables. All scales prove to be normally distributed as well as showing homogeneity of variance. One exception is the scale *Affect Negative* which holds a non-normal distribution according to the Shapiro-Wilk (game: p < .001; video: p < .001) as well as according to the z-score test.

The data overall showed no heteroscedasticity problem. Also, multicollinearity was not found between the predicting variables, a correlation matrix showed that there were no strong correlations between predicting variables. Also, no outliers were detected (IQR rule 3). In conclusion, data analysis resumes under the assumption that the data fulfils assumptions for parametric tests.

Procedure

After reading an information sheet and signing the consent form, participants were given a questionnaire survey to fill out using a computer or a laptop. The questionnaire first asked about their sociodemographic factors, then about their opinions regarding *Trust in Science*, and *Trust in Technology*. Then, the participants were provided a link that would forward them to either a game or a video to watch. Both participant groups have as much time as needed to explore the 3D simulation either through navigating the game or watching the video. Participants were instructed to loosely follow a certain task of reading information cards positioned throughout the 3D environment; however, they could do so in their own pace and order. Only the group with the game was provided a short introduction on how to navigate the game while this information was omitted for the video group. After the participants were finished with exploring the materials, they were asked to return to the questionnaire. After completing the questionnaire, the participants were thanked and debriefed. This study was reviewed and approved by the Ethics Committee of the University of Twente in Enschede, Overijssel.

Data Analysis

For statistical analysis of the administered questionnaire, the software IBM SPSS Statistics 24 was used. Data was omitted when participants did not complete the study or indicated to not have engaged with the manipulation. Demographics and frequencies for sample indications were calculated. To test whether the manipulation had been successful, the conditions were compared using a one-sided independent samples *t*-test. Scales were recoded, and Cronbach's Alpha was used to assess the reliability of each scale. Assumptions for parametric tests were assessed using the Shapiro-Wilk test and QQ plots, as well as, skewness, kurtosis, and respective z-scores according to Kim (2013). Levene's test of homogeneity of variance was administered and it was checked for outliers using boxplots (IQR rule 3), a one-way ANOVA to assess heteroscedasticity, and bivariate correlations to assess multicollinearity.

Statistical characteristics of the scales *Trust in Science, Trust in Technology, Risk and Benefit Environment, and Risk and Benefit Health,* as well as *Technology Acceptance,* and *Immersiveness* were assessed and means, frequencies, and correlations were calculated. To test the hypotheses, dependent variables were analyzed for differences between conditions using one-sided independent samples *t*-tests (a = .05). Moderator analyses were performed testing *Trust in Science* and *Trust in Technology* as potential moderators on the main effect of the manipulation on the dependent variable *Behavioural Intention.* This was done using z-scores and multiple linear regression. Null hypotheses were rejected if $p \leq 0.05$.

Results

Means and Correlations.

Means. Means in the combined sample are analyzed in all measured entities. *Behavioural Intention* (to promote) scores (range of 1 to 5) show a moderate mean (*M* = 3.48; *SD* = .83). *Behavioural to Intention to Tolerate* scores (range of 1 to 5) show a moderate mean (*M* = 4. 08; *SD* = .83). *Risk and Benefit Health* scores (range of 1 to 5) show a low to moderate mean (*M* = 2.54; *SD* = .74). *Risk and Benefit Environment* scores (range of 1 to 5) show a low to moderate mean (*M* = 2.76; *SD* = .56). A*ffect Positive scores* (range of 1 to 5) show a moderate mean (*M* = 3.08; *SD* = 1.05). *Affect Negative* scores (range of 1 to 5) show a low mean (*M* = 1.87; *SD* = 1.02). *Uncertainty* scores (range of 1 to 7) show a medium to high mean (*M* = 4.72; *SD* = 1.13). *Opposition* scores (range of 1 to 7) show a low to moderate mean (*M* = 2.90; *SD* = 1.62). *Promotion* scores (range of 1 to 7) show a high mean (*M* = 5.01; *SD* = 1.36). *Trust in Science* scores (range of 1 to 7) show a high mean (*M* = 5.23; *SD* = .71). T*rust in Technology scores* (range of 1 to 7) show a high mean (*M* = 5.04; *SD* = .96). *Immersiveness* scores (range of 1 to 5) shows a moderate mean (*M* = 3.55; *SD* = .84). Figure 7 shows an overview of means in a bar chart.

Correlations. *Behavioural Intention* was found to have a weak negative correlation with *Uncertainty* [*r*(83) = -.26, p = .02], *Risk and Benefit Environment* [*r*(83) = -.27, *p* = .01], and medium strong negative correlations with *Risk and Benefit Health* [*r*(83) = -.43, *p* < .001], and *Affect Negative* [*r*(83) = -.54, *p* < .001]. Medium strong positive correlations were found with *Affect Positive* [*r*(83) = .50, *p* < .001], *Trust in Science* [*r*(83) = .44, *p* < .001] and *Trust in Technology* [*r*(83) = .48, *p* < .001]. A medium strong positive correlation exists between *Affect*

Negative and *Risk and Benefit Environment* [$r(83) = .51$, $p < .001$]. *And a* weak positive correlation with *Risk and Benefit Health* [$r(83) = .23$, $p = .04$]. *Affect Positive* shows a weak negative correlation with *Uncertainty* [$r(83) = -.32$, $p = .003$]. A weak negative correlation exists between *Risk and Benefit Health* and *Uncertainty* [$r(83) = -.25$, $p = .02$].

Trust in Science and *Trust in Technology* are moderately positive correlated, [$r(83) = .49$, $p < .001$]. *Trust in Science* weakly correlates with *Affect Negative* [$r(83) = -.37$, $p = .001$] while *Trust in Technology* shows multiple weaker correlations to *Risk and Benefit Environment* [$r(83) = -.20$, $p = .03$] and *Risk and Benefit Health* [$r(83) = -.24$, $p = .03$], *Affect Positive* [$\mathrm{r}(83) = .28$, $p = .01$] and a moderately strong correlation with *Affect Negative* [$r(83) = -.51$, $p < .001$]. *Immersiveness* shows a weak positive correlation with *Affect Positive* [$r(83) = .25$, $p = .02$] and weak negative correlation with *Risk and Benefit Health* [$r(83) = -.29$, $p = .01$]. Table 6 shows an overview of the correlations ($r \geq .2$).

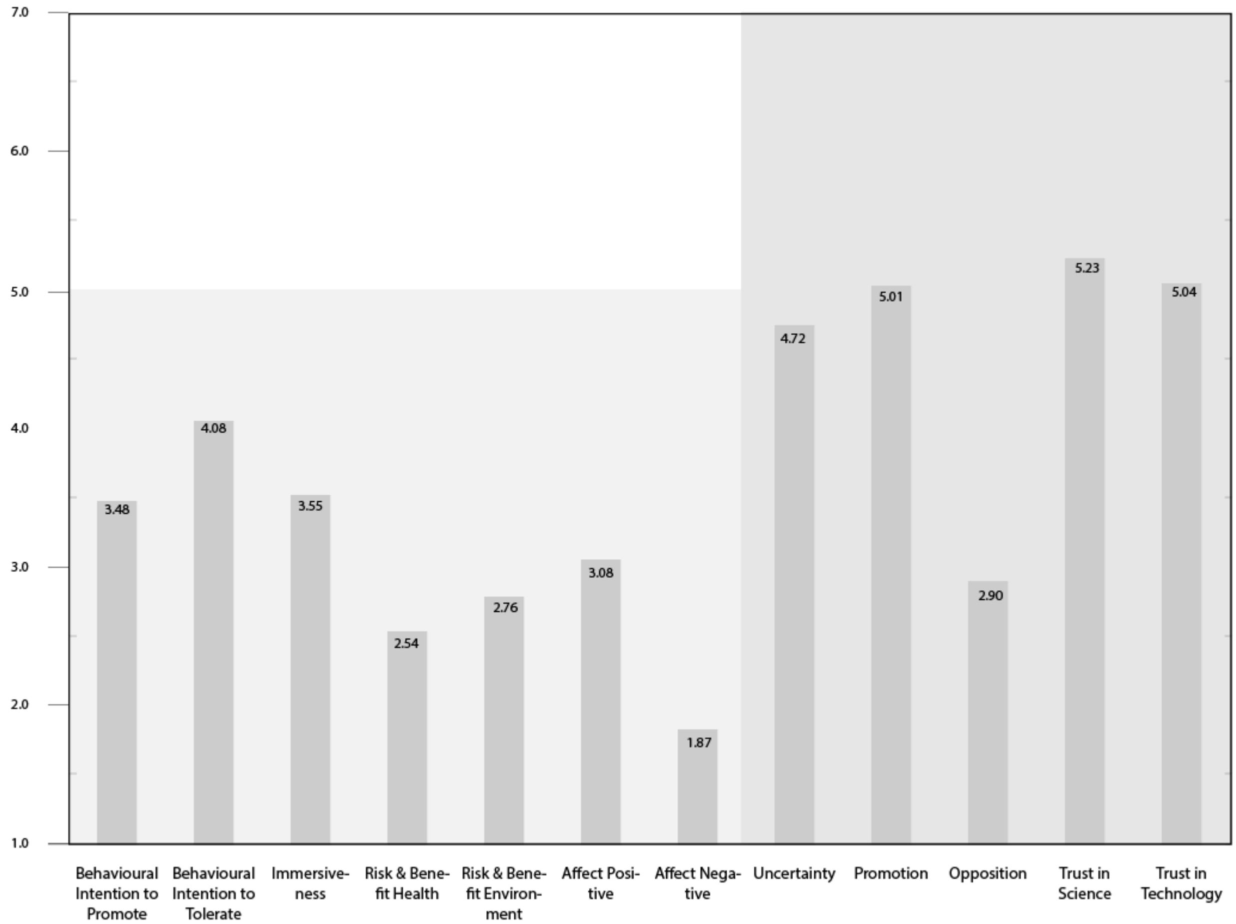

Figure 7. An overview of means in the combined sample. The gray backgrounds indicates a reference to the range in which the scores fall (light gray: scale from 1 to 5; dark gray: scale from 1 to 7).

Table 6.
Correlation Matrix between the variables Immersiveness, Behavioural Intention, Affect Positive, Affect Negative, Risk and Benefit Environment and Risk and Benefit Health, as well as Uncertainty.

		I	BI	A-	A+	RBE	RBH	U	TS	TT
Immersiveness (I)	R	1	.20	-.03	.25*	.14	-.29**	-.05	.05	-.04
Behavioural Intention (BI)	R		1	-.54**	.50**	-.27*	-.43**	-.26*	.44**	.48**
Affect Negative (A-)	R			1	-.07	.51**	.23*	-.08	-.37**	-.51**
Affect (A+)	R				1	.13	-.47**	-.32**	.28*	.28*
Risk and Benefit Environment (RBE)	R					1	.07	-.11	.04	-.24*
Risk and Benefit Health (RBH)	R						1	.25*	-.39**	-.20
Uncertainty (U)	R							1	-.15	-.03
Trust in Science (TS)	R								1	.49**
Trust in Technology (TT)	R									1

*$p < .05$, **$p < .01$, *** $p < .001$

Hypothesis testing.

Manipulation and Immersiveness Levels (H1). As noted above, a one-sided independent samples *t*-test has shown that the game and video conditions experience different levels of *Immersiveness* depending on the manipulation presented. Correlations show that group affiliation and *Immersiveness* levels are negatively correlated [$r(83) = -.32$, $p = .00$], which indicates that being sorted into the game manipulation is associated with higher levels of immersiveness and being sorted into the video group was correlated with lower scores on *Immersiveness*. Hypothesis 1 was therefore supported by the results. Participants experience significantly higher level of immersiveness when presented with a game than when presented with a video.

Manipulation and Behavioural Beliefs (H2). To test whether the manipulation impacts behavioural beliefs to be more favourable, one-tailed independent samples *t*-tests were conducted to compare the groups in their levels of *Risk and Benefit Environment, Risk and Benefit Health, Affect Positive, Affect Negative,* and *Uncertainty*. Table 7 provides an overview of the results. No behavioural belief showed any significant difference in scores between the game and the video condition. While immersiveness and the manipulation are correlated, neither shows strong correlations with the behavioural beliefs. Hypothesis 2 was not supported by the results.

Behavioural Intention (H3). It can be seen that *Behavioural Intention* shows a lower mean in the game than in the video group. To test whether the levels of *Behavioural Intention* differ between groups in a significant level, a one-tailed independent samples *t*-test was administered. Results showed that groups do not significantly differ. The 37 participants in the game group ($M = 3.45$, $SD = .81$) compared to the 46 participants in the video group ($M = 3.51$, $SD = .85$) demonstrated no significantly different level of *Behavioural Intention*; $t(81) = -.35$, $p = .36$. Hypothesis 3 is not supported by the results.

Table 7.

Group Statistics and the comparison between groups in their levels of Behavioural Intention, Risk and Benefit Environmental, Risk and Benefit Health, Affect Positive, Affect Negative, and Uncertainty using a one-tailed independent samples t-test.

	Grouping Variable	**N**	**Mean**	**Std. Deviation**	**t**	**df**	**Sig. (1-tailed)**
Behavioural Intention	Game	37	3.45	.81	-.35	81	.36
	Video	46	3.51	.85			
Risk and Benefit Environment~~al~~	Game	37	2.81	.58	.82	81	.21
	Video	46	2.71	.54			
Risk and Benefit Health	Game	37	2.42	.73	-1.27	81	.10
	Video	46	2.63	.74			
Affect Positive	Game	37	3.15	1.07	.53	81	.30
	Video	46	3.03	1.05			
Affect Negative	Game	37	1.77	.95	-.74	81	.23
	Video	46	1.94	1.08			
Uncertainty	Game	37	4.78	1.06	.48	81	.32
	Video	46	4.66	1.20			

Moderation Analysis (H4). *Trust in Science* and *Trust in Technology* were examined as a moderator of the relation between the manipulation and *Behavioural Intention*. *Trust in Science* and the manipulation variable were entered in the first step of the regression analysis, $R^2 = .18$, $F(2, 80) = 10.65$, $p < .001$. In the second step of the regression analysis, the interaction term between *Trust in Science* and the manipulation variable was added, $F(3, 79) = 6.84$, $p < .001$, $R^2 = .18$. In both models, *Trust in Science* was found to be a unique contributor to the regression equation (Model 1: $\beta = .45$, $t(79) = 4.48$, $p < .001$; Model 2: $\beta = .45$, $t(79) = 4.50$, $p < .001$). This means a higher *Trust in Science* is associated with a higher level of *Behavioural Intention*. However, the moderation variable was not found to account for a unique variance, $\beta = -.07$, $t(79) = -.68$, $p = .50$. Adding the moderator variable was not found to explain a significant increase in variance in *Behavioural Intention*, $\Delta R^2 = .01$, $p = .50$. Thus, *Trust in Science* was not a significant moderator of the relationship between the moderation and *Behavioural Intention*. The moderation model would decrease previous explained variance of $R^2 = 18.2\%$ to 17.6%. Table 8-10 (see Appendix B) provide a more detailed statistical output.

Trust in Technology and the manipulation variable were entered in the first step of the regression analysis, $R^2 = .23$, $F(2, 80) = 11.72$, $p < .001$. In the second step of the regression analysis, the interaction term between *Trust in Technology* and the manipulation variable was added, $R^2 = .23$, $F(3, 79) = 7.97$, $p < .001$. In both models, *Trust in Technology* was found to be a unique contributor to the regression equation (Model 1: $\beta = .48$, $t(79) = 4.83$, $p < .001$; Model 2: $\beta = .45$, $t(79) = 4.28$, $p < .001$). This means a higher *Trust in Technology* is associated with a higher level of *Behavioural Intention*. However, the moderation variable was not found to account for a unique variance, $\beta = .08$, $t(79) = .77$, $p = .44$. Adding the moderator variable was not found to explain a significant increase in variance in *Behavioural Intention*, $\Delta R^2 = .01$, $p =$

.44. Thus, *Trust in Technology* was not a significant moderator of the relationship between the moderation and *Behavioural Intention*. The moderation model would increase previous explained variance of R^2 = 22.7% to 23.2%. Table 11-13 (see Appendix B) provide a more detailed statistical output. Hypothesis 4 was therefore not supported by the results.

Additional Analyses.

Computer Problems. The data evidently shows that some participants experienced computer problems. To analyze whether possible computer problems distorted the results, an additional analysis was performed. When controlling for computer problems, as described in the Methods section, results of a one-sided independent samples *t*-test confirm that groups do not significantly differ in their levels of *Behavioural Intention*. The 24 participants in the game group (M = 5.42, SD = 1.34) compared to the 36 participants in the video group (M = 5.54, SD = 1.26) demonstrated no significantly different level of *Behavioural Intention*, $t(58) = -.367$, p = .72. This analysis confirms that computer problems were no confounding variable in the analysis of the results above.

Discussion

Summary

This study investigated what the impact is of presenting an agricultural technology in differently immersive information modes on the intention to accept the technology. A total of 83 participants filled out an online questionnaire to assess whether the immersiveness of ICT channels and levels of trust affect people’s risk and benefit perception in terms of the environment and health, their emotional reaction, and their uncertainty, as well as ultimately behavioural intention to adopt the new technology. The technology was presented in either a game or video condition and the two conditions were compared. The two information modes showed varying levels of immersiveness with the game being more immersive than the video. Nonetheless, the video group showed a high level of immersiveness. Despite this difference, results cannot confirm that people decide significantly different upon their behavioural intention to adopt a technology. Both groups experienced similarly high levels in their intention to tolerate and to promote the presented technology, in fact, both groups displayed similar behavioural beliefs. The two groups did not significantly differ in their risk and benefit perception in terms of the environment and health, their emotional reaction, and their uncertainty. Combined means indicated that participants, regardless of information mode and immersiveness, experienced medium levels of risk perception and experienced more positive than negative emotions toward the technology. While participants in general showed a high level of promotion opinion and a lower level of opposition opinion, it should be noted, that participants showed a high mean of uncertainty as well.

Hypothesis 1 stated that participants experience a significantly higher level of immersiveness when presented with a game than when presented with a video due to a more engaging and active task at hand. Hypothesis one was supported by the results. As mentioned in the introduction, literature indicated that being a passive observer or active participant leads to differences in user experience. Being an active participant supposedly made a user experience more positive due to being engaged. Some alternative explanations remain that are discussed in the limitations.

Hypothesis 2 stated that due to a higher immersiveness level, the game condition experiences significantly more positive behavioural beliefs (*Risk and Benefit Environment, Risk and Benefit Health, Affect Positive, Affect Negative,* and *Uncertainty*). There was no confirmation that the different manipulation conditions caused different levels of behavioural beliefs. The conditions did not differ in their levels of behavioural beliefs. Despite the groups experiencing significantly different levels of immersiveness, neither the manipulation nor the immersiveness levels showed strong correlations to any behavior belief. Hypothesis two was therefore not confirmed.

Hypothesis 3 was that participants in the high immersiveness game condition have significantly more positive behavioural intentions to support the technology. This study did not confirm this hypothesis. Despite the manipulation eliciting different levels of immersiveness, groups did not differ in their levels of behavioural intentions. A correlation between Immersiveness and Behavioural Intention did not exist. Hypothesis three was therefore not confirmed.

Hypothesis 4 was that the relationship between group conditions and *Behavioural Intention* is moderated by *Trust in Science* and *Trust in Technology* and that high levels of trust result in more favourable behavioural intentions. There was no indication that trust had a moderating effect on the relationship between the manipulation conditions and behavioural intention. Levels of trust and immersiveness were not correlated, while with behavioural intention they were. This showed that trust levels play a role in determining Behavioural Intention, however there was no moderation effect on the main effect between immersiveness and behavioural intention. Hypothesis four was therefore not confirmed.

Theoretical Implications

The results confirm that information gathering, and opinion-forming processes are complex and informed by multiple cues. These cues do not only include the content of information but also additional cognitive cues that affect the intention to actively accept a technology. This confirms the theoretical framework of the Theory of Planned Behaviour, that shows that attitudes are a determining part of information seeking and processing that includes the intent to behave.

Extending the Theory of Planned Behaviour to include socio-demographic factors, risk and benefit perception, affect and uncertainty showed valuable insights into the decision-making process of the participants. For example, socio-demographic factors indicated that female participants responded more affective (both positive and negative) as well as perceived a higher environmental risk perception. Also, as age increased, trust levels in both technology and science increased. Interestingly, a higher education indicated higher immersiveness levels. Measuring specific behavioural beliefs had the advantage of discovering that, on average, people hold more favourable beliefs of the presented technology. Their affect levels were more positive than negative, and their risk perception showed medium levels. However, despite participants revealing that their opinions to promote a technology is rather high, their uncertainty levels were high, as well. Including the uncertainty variable introduced the possibility that despite having favourable behavioural intention, the opinions formed are not yet certain and may be susceptible to change over time. Measuring specific behavioural beliefs, especially uncertainty, is of great value for future theoretical efforts. Measuring only generally favourable or unfavourable attitudes may not provide enough information on people's beliefs and subsequent attitudes.

While it was found that attitudes are connected to behavioral intention, there is no confirmation that having an active vs passive role in information gathering via ICT channels is a determinant for different behavioural intentions. Despite the presented manipulation being considerably successful in eliciting higher levels of immersiveness in both groups, the role of immersiveness is not yet clear enough to conclude its specific role. Since there is no previous literature on this topic, this is a first finding which needs confirmation in future research. Alternative explanations to the findings are further analyzed in the following sections.

The Theory of Planned Behaviour recommends measuring attitudes in addition to *Subjective Norm* and *Perceived Behavioural Control*. More research into technology acceptance in relation to these concepts and its connection to immersiveness and information modes may inform on how ICT channel can be most effective, and whether immersiveness matters in technology acceptance at all. This study strengthened the impression that for future design efforts, the idea of immersiveness and information modes might be of interest to take into account when introducing new technologies on the web, yet future research is yet to complete the picture of the complex process of the formation of behavioural intent.

Strengths and Limitations

This study was a first attempt to assess an issue not many other studies pay attention to. It is very common to present a product or new technology online where two of the most widely known strategies are videos or websites. However, the comparison to other channels of communication (such as games) and whether one of them is more successful in evoking technology acceptance is a new research angle. In accord with the definition by Norman (2010), new insights are given into how to scale and measure immersiveness, which shows a good reliability (a = .86). Also, the Behavioural Intention scale achieved a good reliability with low amounts of items (a = .78). In general, this study showed that people have rather optimistic and favourable attitudes toward science and technology, however, the sample is overrepresented by young, highly educated participants, which may affect this result. In addition, a possible indication is that, regardless of manipulation, people show quite high levels of favourable attitudes and behavioural intentions to accept the technology, yet also that there was a high level of uncertainty among participants.

Some shortcomings and open questions are to be determined. For one, the methodological choices were constrained by the low sample size, the skewed sample toward highly educated, young participants, the nature of the study being online, and the frame of attention of the participants. The methodology also showed some shortcomings into detecting levels of immersiveness. Results may represent the fact that levels of immersiveness differ between participants but not influence behavioural intent. However, there are three alternative explanations. The way by which immersive environments were set up in the two conditions may not have been optimal in eliciting immersiveness levels high enough to influence behavioural intention in in both groups. While the video may have elicited more immersiveness levels than intended, it is possible that the game condition elicited less immersiveness than expected which lead both information modes to not lead to optimal levels of immersiveness. Another explanation could be that the self-reported measurement of immersiveness may have not been sufficient to assess levels of immersiveness. A third explanation is that other confounding variables were not sufficiently assessed.

The first alternative explanation incudes the fact that the video condition featured a video that gave the participants an illusion of being an active participant. Since the video features a very active game play to observe, this may have the consequence that the participants had the illusion of being active, while being an observer. This result is less surprising when considering the trend of e-sports and game streaming, which found that people favour watching professional players over playing themselves (Kaytoue, Silva, Cerf, Meira, Raïssi, 2012). This may indicate that video games are changing the meaning of being active and passive due to the engaging material (Smith, Obrist, & Wright, 2013). Consequently, this study's immersiveness levels of the video condition may increase and come closer to the game condition's immersiveness levels. This may be especially the case because participants received a video recorded while playing the game on a high-end computer with the highest quality settings, which leaves graphics very sharp and no quality reduction was observed over the streaming platform. If participants were truly feeling like being an active participants and this was coupled with the fact that there were no computer problems due to high processing power as it would with the game, participants may have a good foundation of feeling more immersed.

At the same time, the game condition may have been not immersive enough due to experienced computer problems and more unrealistic graphics. This may be caused by the Immersiveness vs Functionality tradeoff. To run the simulation smoothly, the 3D environment was designed in a way that takes a set-back from a real-world scenario. First, the amount of hydroponic systems displayed was reduced to avoid a heavy processing load. In total, 28 hydroponic systems represent the idea of a larger scale growing operation. The game ultimately was altered to ensure a more efficient rendering by altering every more distant 3D object to become simpler in their object meshes. Consequently, the graphics were reduced to ensure that most laptops or computers with average processing power can have a smoother experience (Figure 8, see Appendix B). This was still no guarantee that participants had a smooth experience which may have affected the levels of immersiveness experienced. This strengthens the argument above that the video condition likely received higher quality graphics than the game condition and may experience a higher immersiveness.

The immersiveness vs functionality tradeoff also leads to the second alternative explanation. The measurement of immersiveness may have not been sufficient to assess levels of immersiveness. Measuring immersiveness objectively remained difficult in online studies. Self-report questionnaires are not an optimal way to measure immersiveness. More objective measurements would also need the information about the actual quality of the game and its consistency to make a comparison between groups more reliable. Optimally, a faster computer and a laboratory station would be good alternatives for future efforts to make sure people have a more consistent computer experience. However, one should take into account the criticism by Sun and Zhang, (2006) that there should be caution with laboratory studies even with higher explanatory power overall, there is still the influence of the artificial environment that may alter participants perceptions and physiological responses.

A third possible alternative explanation could be confounding variables not being assessed properly. For one, there are the above-mentioned computer problems that should be controlled for in a more accurate manner. In addition to quality issues, the game may have had a long loading time which would affect participants perception of immersion. Another possible influence for the game group could be that some people were not as experienced in gaming which affects motor and navigation skills and possibly lead to less immersion. Despite the criticism by Sun and Zhang (2006), measuring physical responses of participants could enable a more objective measurement of immersion such as heart rate and skin resistance (Wiederhold, Jang, Kaneda, Cabral, Lurie, May, ... & Kim, 2001). Other measurements such as eye movement tracking (e.g. where did the participant look first or the most, which elements attracted attention), time (e.g. how much time was spend in total, or at each information card), and path tracking (e.g. in which sequence and how many information card did the participant explore the environment, how far and how much distance was covered) could enable data on possible confounding variables of immersion. This is especially the case when comparing the game experience with a video condition where the above-mentioned variables are fixed.

The generalizability of the results remains questionable and no claims outside of game and video technologies can be made. This is especially the case because according to the conceptualization of immersiveness, different information modes are likely to evoke different levels of immersiveness. For example, in virtual reality an actual 3D environment can be presented instead of a 3D environment presented on a 2D screen. Testing the same hypotheses with a VR setup might show different results due to a higher immersiveness.

Some caution must also be accounted for the reliability of the scale for *Risk and Benefit Environment (a* = .65). The questions asked perhaps were very general. Future research should be adapted to ask questions specifically targeted at environmental aspects such as air pollution, noise pollution, climate change, loss of biodiversity, or scarcity of energy sources. However, the participant's attention limits the number of added items. Rather it might be of more value to test scale reliability previously in a pretest. In fact, this would improve scale validity and reliability for most constructs measured. This also counts for the scales of trust which were indicated to be rather complex by literature. This study included 13 items for the scale *Trust in Science* and achieved a good reliability (a = .82) while *Trust in Technology* shows a questionable reliability (a = .62) with only three representing items. Trust in Science may be optimized in its number of items, as well as Trust in Technology which was as well not optimally represented and could be improved in future studies.

Implications

This study informs about technology acceptance and implementation efforts of soilless systems which have the potential to bring changes into the life cycle of food production, trade, and consumption. Informing stakeholder's technological efforts to be more effective in its communication channels is a crucial step to place innovation in its place. Introducing technologies effectively is a crucial step in the quest for sustainable agricultural development. Reforming agricultural technologies also helps to meet climate change goals, one of them being to cut emissions in agriculture and horticulture. Implementing innovations effectively can have wide ranging advantages and help to bring less work intensive jobs into the agricultural sector, less water waste, less nutrient and pesticide usage, a release of the pressure on depleting soil, and savings of growing space. This is done by defining and detailing possible behavioural or psychological barriers in technology acceptance, and to study how stakeholders make consumer choices with either 2D or 3D presented material about the technology. This study contributed to the understanding which determinants lead to behavioural intention to adopt technology in the sense of consumer behaviour (buying or recommending). This information can be valuable information for various programs, start-ups, or companies that develop niche technology to eventually be adopted into the existing market regime, however some follow up confirmation is necessary. Changing the way by which technology is introduced one can change the debate, the eventual decision making, and course finding of agricultural success.

Recommendations

Polarized and political issues, such as environmental change and agricultural innovation affect a vast array of people. Technologies develop quickly and are introduced to an audience who might not necessarily be ready to accept it. Determinants of technology acceptance are inevitable as a knowledge base to design communication efforts introducing new technologies to maximize their success and implementation. It is recommended to consider the complex nature of decision-making that is yet to be fully understood in contextual differences. The nature of this study shows with some caution that video and game introductions of new innovations are meeting a rather trustful audience that uses multiple contextual cues to determine their opinions and behaviours, including risk perception and affect. However, as results show people can also hold uncertainty about new technology This also means that people can hold negative as well as positive opinions about a technology. For people to realize the positive aspects about a given technology, it is clear that as much assuring information should be given about its advantages, best done by providing enough clear and understandable information to enable a reduction of uncertainty as much as possible. Yet, in addition, it is important that the presence of positive attitudes should not be misinterpreted as the absence of negative attitudes. When evaluating how successful a technology acceptance is, one should consider that negative and positive attitudes are in fact no opposing forces but can coexist. Embracing the fact that people hold uncertainty can help to inform how and which information should be distributed. This includes not only presenting positive attitudes but also disputing or disarming perceived disadvantages.

Based on the results and its limitations, no specific recommendation can be made whether to favour a video or game mode. Too many factors remain unanswered in a complex formula of technology acceptance and the role of immersiveness. Instead, future research is needed.

Further Research

Future research can provide valuable benefits in exploring the complex nature of people's decision making and behavioural intention, which can be informed by measuring specific behavioural beliefs, especially uncertainty. Research concerning the influence of immersiveness of different ICT channels should focus on providing their participants with real-life scenarios to determine influencing factors. However, it should not be disregarded that people's real-life experiences often will not include a technology introduction in high functioning lab environments. The influence of suboptimal technological circumstances may be an interesting influence. When attempting to use this study's methodology it should be considered that scale reliability and validity can be improved, as well as efforts to increase generalizability are recommended. An interesting angle to research may be to include a virtual reality setting including a headset to possibly evoke higher levels if immersiveness and to assess whether findings confirm the role that immersiveness plays in determining behavioural intention. While being less feasible for online websites to introduce innovation through a VR headset, it is assumed to be an even more immersive medium because of the equipment's impact. An attribute of VR is that it introduced more and more depth for sensory cues, especially visual (Klein 2003, as cited by Suh & Lee, 2005). But beyond visual cues, VR also provides auditory, and kinaesthetic, enabling users to perceive realistic representation of the environment it portrays (Slater and Usoh 1993, as cited by Tussyadiah, Wang, Jung, & Dieck, 2018). It has been demonstrated that 3D advertising environments such as provided by VR lead to a better learning and more positive attitude than presenting information in a 2D manner (Li et al. 2001, 2002, 2003, as cited by Suh & Lee, 2005). Suh and Lee (2005) found that the impact of a VR environment increases perceived product knowledge, product attitudes, and purchase intention than if they were presented with a static 2D virtual environment such as presented on store websites.

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Appendix A: Questionnaire

Table 3.
Questions included in the questionnaire sorted by their measured and affiliated constructs, as well as the scale with which they were measured.

Construct	Subconstruct	Question	Answer
Socio-Demographics	Age	What is your age?	Slider: 18 - 100
	Gender	What is your gender?	MC: Male, Female, Other
	Education	What is the highest degree or level of school you have completed?	MC: VMBO-T, HAVO, VWO, WO Bachelor, WO Master. HBO, HBO Master, Other (text entry), None of the above
Immersiveness	Sensory engagement	I actively participated in the exploration of the 3D environment.	Likert-scale 1 to 5: Not at all - Very much
		My attention was focused on the game/video.	
	Sense of control	I felt a sense of control over the exploration of the 3D environment.	
		I was able to concentrate on the task of exploring the 3D environment.	
	Awareness of the Real World	I explored the game without outside interruptions.	

	Enjoyment	I enjoyed playing the game/ watching the video.	
Control Questions	Visual presence	The graphics in the game/ video were realistic.	Likert-scale 1 to 5: Not at all - Very much
		The game/video ran smoothly on my computer.	
	Awareness of the interface	I knew how to navigate through the warehouse.	
	-	Have you explored the warehouse/ watched the video?	MC: Yes/No
Trust	In Science	I trust scientists to make a valuable contribution to society.	Likert-scale 1 to 7: Strongly Agree – Strongly Disagree
		I trust that science has a positive influence on society.	
		I trust that scientists work for the good of humanity	
		I trust that scientists work on things that will make life better for the average person	
		Generally, science is more harmful than beneficial	
		I think generally scientists have good intentions.	

		Scientists are generally qualified to give explanations about the impact of scientific and technological developments on society. In general, I think scientists have integrity and make truthful claims Application of science and technology can generally threaten human rights Generally, scientists produce reliable information of good quality. I trust in science’s positive effect in the context of food When it comes to the food I eat, I trust science to improve my safety. Food decisions should be made by scientists instead of governmental representatives	
Trust	In Technology	Technological devices function properly I think agricultural technologies are dangerous I trust that the food produced by agricultural technologies are safe to eat	Likert-scale 1 to 7: Strongly Agree – Strongly Disagree

Risk and Benefit Perception of Agricultural Technology	Environmental	I am concerned about the potential negative impact of the technology on the environment. I believe that the new technology could benefit the environment by requiring less damaging ingredients (such as fertilizer). The environment around where I live can be positively affected by the new technology.	Likert-scale 1 to 5: Not At All – Very Much
	Health	I believe the new technology could have useful medical benefits. I think the new technology can uplift the health levels in many countries. Eating food produced by the new technology will make me healthier.	Likert-scale 1 to 5: Not At All – Very Much
	Uncertainty	The new technology should be opposed. The new technology should be promoted. I am not sure whether the new technology should be promoted or opposed. I don't think I know enough about the long term effects of this new technology.	Likert-Scale 1 to 7: Strongly Agree - Strongly Disagree

		This new technology holds both positive and negative consequences. The consequences of the technology are not yet clear.	
	Affect	If the technology would be employed in my city, to what extent would I feel: proud happy satisfaction fear worries anger	Likert-scale 1 to 5: A Great Deal – None At all
Behavioural Intention (Technology Acceptance)		If my supermarket would offer food that was grown from the system I just saw, I would buy it I would recommend this new technology to a friend. (I would tolerate the technology to exist in my environment) If my supermarket would sell food only from this hydroponic system, I would express opposition.	Likert-scale 1 to 5: Definitely Yes – Definitely No

Appendix B

Table 2
Correlation Matrix between demographic variables and measured variables.

		Age	Education	Gender	I	BI	RBH	RBE	A-	A+	U	TS	TT
Age	R	1	.32**	.03	-.16	-.13	.20	-.08	.06	-.07	-.15	-.31**	-.25**
Education	R		1	-.01	-.25*	.07	.05	-.18	-.14	-.05	-.11	.00	.05
Gender	R			1	.10	.04	-.21	.27*	.29*	.27*	-.11	-.02	-.09

*p < .05, **p < .01, *** p < .001
Immersiveness (I), Behavioural Intention (BI), Affect Positive (A+), Affect Negative (A-), Risk and Benefit Environment (RBE) and Risk and Benefit Health (RBH), Uncertainty (U), Trust in Science (TS) and Trust in Technology (TT).

Table 5.
Descriptive statistics, including skewness, kurtosis, respective z-scores, the Shapiro-Wilk test of normality, the Levene's Test of homogeneity of variance for all measured variables.

		Mean (Std. Error)	**SD**	**Skewness (Std. Error)**		**Kurtosis (Std. Error)**		**Shapiro-Wilk**			**Levene's Test**	
					Z		**Z**	**Statistic**	**df**	**Sign.**	**Statistic (df1 = 1, df2 = 81)**	**Sign.**
Behavioural Intention	Game	3.45 (.13)	1.27	-.39 (.39)	-1.00	.05 (.76)	.07	.95	37	.07	.00	.95
	Video	3.51 (.13)	1.29	-.60 (.35)	-1.71	.16 (.69)	.23	.93	46	.006		
Risk and Benefit Environment	Game	2.81 (.10)	.58	-.58 (.39)	-1.49	1.30 (.76)	1.71	.94	37	.04	.26	.61
	Video	2.71 (.08)	.54	.11 (.35)	0.31	-.34 (.69)	-.50	.96	46	.16		

Risk and Benefit Health	Game	2.42 (.12)	.73	-.45 (.39)	-1.15	-.60 (.76)	-.79	.94	37	.06	.09	.77
	Video	2.63 (.11)	.74	.44 (.35)	1.26	1.19 (.69)	1.72	.95	46	.06		
Affect Positive	Game	3.15 (.18)	1.07	-.52 (.39)	-1.3	-.35 (.76)	-.46	.94	37	.04	.12	.73
	Video	3.03 (.16)	1.05	-.37 (.35)	-1.06	-.37 (.69)	-.54	.95	46	.04		
Affect Negative	Game	1.77 (.16)	.95	1.65 (.39)	4.23	2.72 (.76)	3.58	.79	37	< .001	2.83	.10
	Video	1.94 (.16)	1.08	1.06 (.35)	3.03	.71 (.69)	1.03	.82	46	< .001		
Uncertainty	Game	4.78 (.17)	1.06	-.82 (.39)	-2.10	1.12 (.76)	1.47	.95	37	.10	1.22	.27
	Video	4.66 (.18)	1.20	-.40 (.35)	-1.14	-.48 (.69)	-.70	.96	46	.17		
Immersiveness	Game	3.85 (.14)	1.24	-.73 (.39)	-1.87	-.31 (.76)	-.41	.92	37	.02	.11	.74
	Video	3.31 (.11)	1.17	-.21 (.35)	-.60	-.47 (.69)	-.68	.98	46	.53		
Trust in Science	Game	5.29 (.11)	.67	.20 (.39)	.51	-.85 (.76)	-1.12	.97	37	.44	.18	.68
	Video	5.18 (.11)	.73	-.03 (.35)	-.09	-.60 (.67)	-.90	.99	46	.86		
Trust In Technology	Game	4.99 (.13)	.78	-.161 (.39)	-.41	-.96 (.76)	-1.26	.95	37	.07	2.58	.11
	Video	5.09 (.16)	1.10	-.76 (.35)	-2.17	.17 (.69)	.25	.94	46	.01		

Table 8

Model Summary for the moderation analysis of Trust in Science

Model	R	R Square	Adjusted R Square	Std. Error of the estimate	R Square Change	F change	df1	df2	Sig. F Change
1	.458	.210	.190	1.15	.21	10.65	2	80	< .001
2	.464	.216	.186	1.15	.005	.55	1	79	.46

Table 9

ANOVA Summary for the moderation analysis of Trust in Science

Model		Sum of Squares	df	Mean Square	F	Sig
1	Regression	28.04	2	14.02	10.645	< .001
	Residual	105.37	80	1.32		
	Total	133.42	82			
2	Regression	28.78	4	9.59	7.214	< .001
	Residual	104.64	79	1.33		
	Total	133.42	82			

Table 10
Coefficients Summary for the moderation analysis of Trust in Science

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficient Beta	t	Sig
	(Constant)	.66	1.06		.63	.53
	Trust in Science	.83	.18	.46	4.59	< .001
	Grouping Variable	.20	.25	.08	.80	.43
	(Constant)	.59	1.06		.56	.58
	Trust in Science	.84	.18	.46	4.63	< .001
	Grouping Variable	.21	.26	.08	.82	.42
	Moderator	-.10	.13	-.07	-.74	.46

Table 11
Model Summary for the moderation analysis of Trust in Technology

Model	R	R Square	Adjusted R Square	Std. of the estimate	R Square Change	F change	df1	df2	Sig. F Change
1	.499	.249	.230	1.12	.249	13.275	2	80	< .001
2	.503	.253	.224	1.12	.004	.376	1	79	.541

Table 12
ANOVA Summary for the moderation analysis of Trust in Technology

Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig**
1	Regression	33.25	2	16.62	13.28	< .001
	Residual	100.17	80	1.25		
	Total	133.42	82			
2	Regression	33.72	3	11.24	8.91	< .001
	Residual	99.70	79	1.26		
	Total	133.42	82			

Table 13
Summary for the moderation analysis of Trust in Technology

		Unstandardized Coefficients		**Standardized Coefficient**		
Model		**B**	**Std. Error**	**Beta**	**t**	**Sig**
	(Constant)	1.90	.75		2.54	.01
	Trust in Technology	.66	.13	.50	5.13	< .001
	Grouping Variable	.05	.25	.02	.21	.83
	(Constant)	2.03	.78		2.60	.01
	Trust in Technology	.63	.14	.48	4.61	< .001

	Grouping Variable	.06	.25	.02	.23	.82
	Moderator	.08	.14	.06	.61	.54

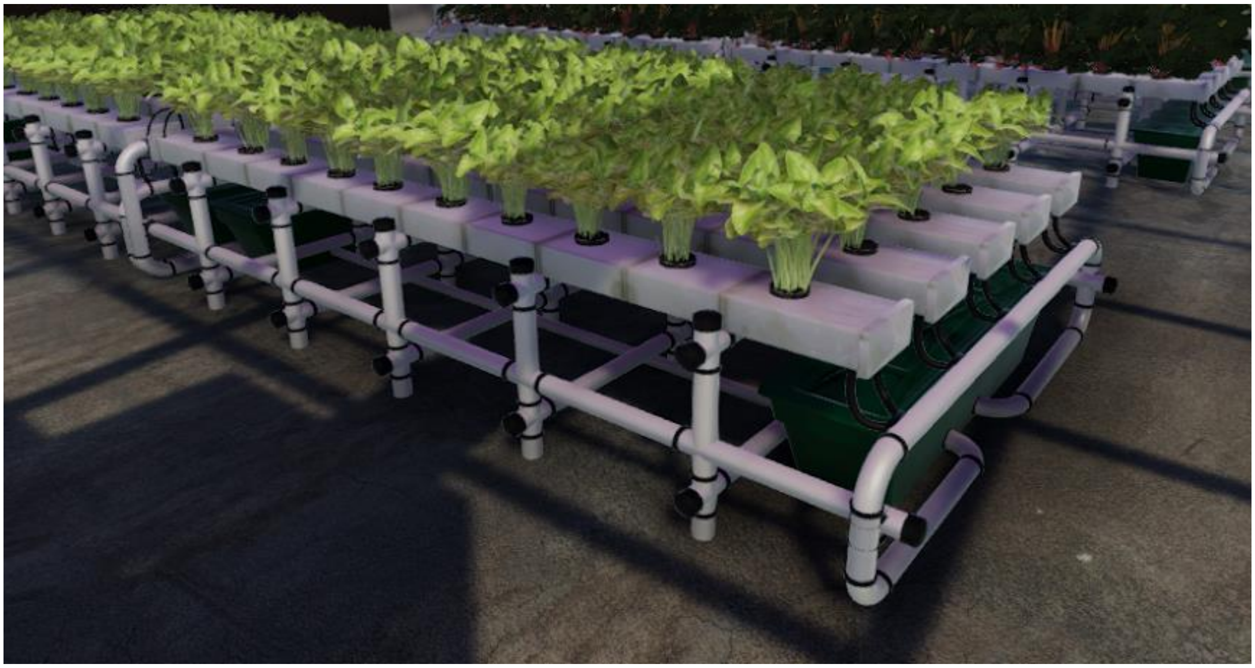

Figure 3. Depiction of the 3D model of a hydroponics growing pod used in the study.

Figure 4. Depiction of the 3D environment as presented in the environment used in the study.

Figure 6. Depiction of the instructions given to the participants in the beginning of the game, including instructions on how to navigate the game and about what to do in the environment.

Figure 5. Depiction of an information card explaining that herbs and vegetables can be grown in hydroponic settings.

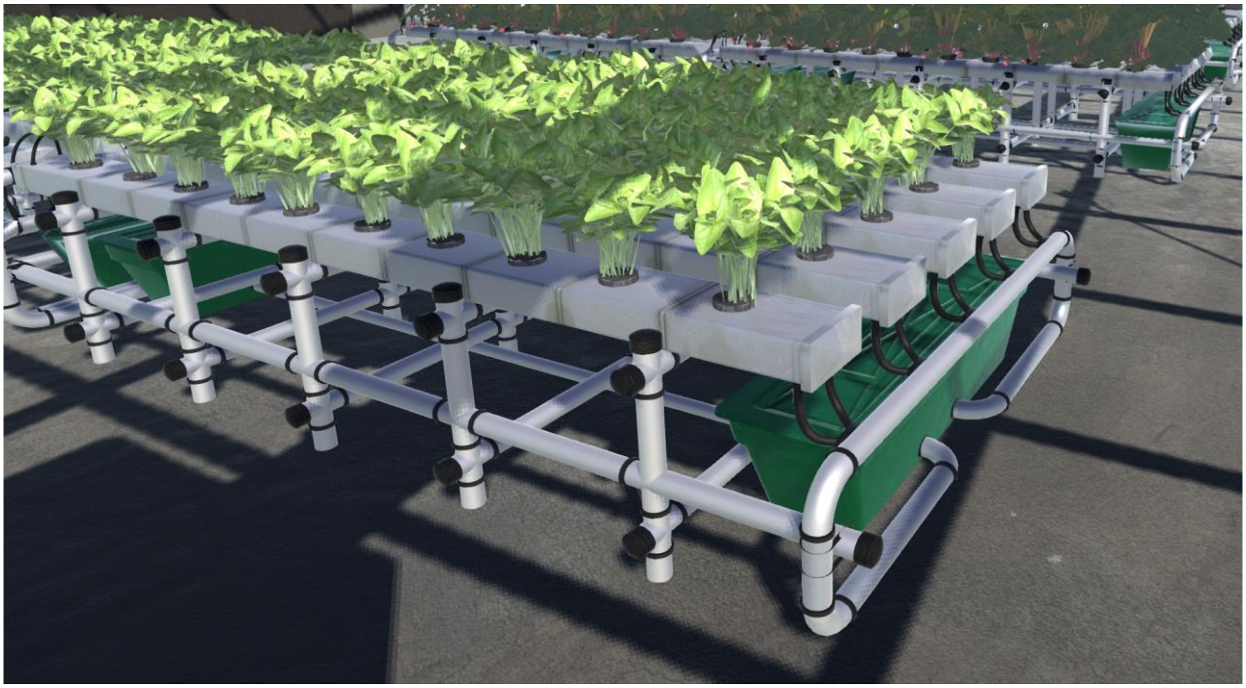

Figure 8. Comparison of the best possible quality available for the game as developed by the researcher (top), the quality as used in the game after optimizing to run more smooth (middle), and an example of how the game was displayed to users (bottom).