applied sciences

MDPI

Article

Assessment of a Location-Based Mobile Augmented-Reality Game by Adult Users with the ARCS Model

Konstantina Sdravopoulou *, Juan Manuel Muñoz González and María Dolores Hidalgo-Ariza

Department of Education, University of Cordoba, C\San Alberto Magno, S/N 14071 Cordoba, Spain; juan.manuel@uco.es (J.M.M.G.); lola.hidalgo@uco.es (M.D.H.-A.)
* Correspondence: z82sdsdk@uco.es

Abstract: In mobile augmented reality (MAR) games, learning by doing is important to supplement the theoretical knowledge with practical exercise in order to maximize the learning outcome. However, in many fields, the users are not able to apply their knowledge in practical ways, despite having achieved a good understanding of the theoretical fundamentals and this is even more important to adult learners. The aim of this research is to examine young, middle-aged and elderly adults' opinions about the location-based MAR game Ingress, by applying John Keller's "ARCS learning motivation model" (Attention, Relevance, Confidence and Satisfaction). The users' responses to closed questions related to Ingress were collected from 45 adult players aged 20–60 from Greece and were subsequently analyzed by means of pre- and post-quantitative measures of the four ARCS factors. The results show that: (a) game training improves all the factors of ARCS, primarily attention and satisfaction; (b) the responses of young people (20–35) agree more with those of elderly adults (>52) than with those of the intermediate age group of 36–51. Our findings, therefore, highlight the potential and the applicability of the ARCS model in MAR games.

Keywords: mobile augmented reality (MAR); augmented reality; adult education; MAR games; ARCS model; augmented reality in education

Citation: Sdravopoulou, K.; González, J.M.M.; Hidalgo-Ariza, M.D. Assessment of a Location-Based Mobile Augmented-Reality Game by Adult Users with the ARCS Model. *Appl. Sci.* **2021**, *11*, 6448. https://doi.org/10.3390/app11146448

Academic Editor: Diana Urbano

Received: 16 June 2021
Accepted: 9 July 2021
Published: 13 July 2021

1. Introduction

Augmented reality (AR) is a term that refers to the enhancement of the real-life physical world with computer-generated software and hardware that enable the user to function in the real and the virtual space simultaneously. It is also widely acknowledged that AR is real-time interactive and recorded in three dimensions [1].

Games are widely regarded as the most effective domains of AR applications and are well-known for popularizing modern technologies and the gaming industry is a vast and rapidly growing industry that attracts a large number of customers [2]. As a result, the vast part of the effort put in both AR research and industrial production is centred on game development.

Innovations using mobile technologies have expanded into all market categories over the past few years [3], and their pervasive impact on our activities in urban environments causes a profound shift in culture and practice [4–6]. Users are stimulated by augmented-reality games to satisfy their needs [7], and location-based mobile games (LBMGs) or hybrid-reality games (HRG) are forms of digital games that have arisen as a result of technological advances in both software and hardware. Under the hybrid realities theoretical paradigm, such games use augmented reality as their main technical feature [7,8]. The spatiality of digital games has advanced from simplistic two-dimensional worlds to complex three-dimensional worlds [9], and now even to complex (relational) hybrid multi-dimensional spaces [10]. A hybrid space can be described as a space that exists between the physical and virtual worlds [11]. The LBMGs are distinguished by their use of embedded GIS and have a profound effect on how people play, communicate and experience a city, by fusing urban and virtual spaces into so-called “hybrid realities” [12,13]. These games incorporate player position (which is transmitted via GPS signals) into the gameplay, as well as the user’s speed, heading, and orientation [14]. The geographical location of a player’s avatar in the map-based virtual world corresponds to a precise physical location, allowing for unique interaction possibilities b using the player’s mobile phone.

Game environments have high potential for facilitating immersive learning. The act, method, or experience of acquiring information or ability to play the game is referred to as “learning”. Learners need encouragement to participate in the act of learning information or abilities [15] and adult learners probably more so. According to Chan and Ahern [16], when people are fundamentally inspired to learn, they not only learn more, but they also have a more positive experience.

To inspire a potential user of one of such AR games means to “offer an opportunity” and the tutor must give them a reason to participate in the process of learning [15]. Motivation is often considered a preliminary phase in the instructional process in conventional instructional design practice [16]. Although such a practice usually focuses on a less integrated approach, the aim of education has always been to cultivate life-long learners who are intrinsically motivated, exhibit intellectual curiosity, enjoy learning, and continue pursuing information after their formal instruction has ended [17].

The sum of effort spent during the learning process can be used to determine whether or not the students were motivated. However, in order for ‘effort’ to take place, two conditions must be met [15]: the task must be valuable to the individual and the person must believe they can complete the task successfully. In any given instructional scenario, the learning assignment must be delivered in a way that is both stimulating and meaningful to the student, as well as one that fosters constructive expectations for meeting learning objectives [17]. The ARCS Model of Motivational Design, created by John M. Keller of Florida State University, with hundreds of research studies and applications, can help us understand motivation in teaching [18]. For motivating guidance, the ARCS Model recognizes four basic strategy factors: «*Attention*» strategies for arousing and sustaining curiosity and interest, curiosity and interest-arousing-and-maintaining attention tactics. As the instructional design stimulates curiosity and interest in the content or learning background, learners are more inspired. The «*Relevance*» factor refers to all those techniques that connect to the needs, desires, and motivations of the students. When goals are clearly established and aligned with the needs of learners, they are more driven. The «*Confidence*» factor examines the techniques that assist students in developing a realistic expectation of success, considering that learners are more inspired when the task is balanced in such a way that the learning process is neither too straightforward nor too challenging for the learner to succeed. Finally, the «*Satisfaction*» factor of ARCS examines the techniques that reward commitment with both extrinsic and intrinsic rewards, considering that when there are incentives for correctly performed acts, learners are more inspired. Each one of these factors comprises a number of components (not all components apply to all research applications).

Chang et al. [18] presented a mobile augmented-reality (MAR) application supporting teaching activities in interior design. Lin et al. [19] studied a board game assimilating AR into health education and they found that learning motivation was improved by the integration of AR into the health education board game. Kaur et al. [20] studied the use of augmented reality as a tool for interactive learning in various fields of engineering education and its contribution towards student motivation in classroom scenarios with the ARCS model. Hamzah et al. [21] proposed an enhanced ARCS model for gamification of learning called “ARCS + G”. Schmidt [22], Di Serio et al. [23], Gómez-Galán et al. [24] and Gutierrez & Fernandez [25] suggested the utilization of augmented reality for enhancing student motivation by improving the visualization of course material for better understanding. However, how adult users assess mobile augmented-reality games with ARCS model has hitherto never been examined or explored, and neither learning how to play location-based MAR games has been examined in terms of the ARCS framework. This research uses the MAR game “Ingress”, which was developed and published by “Niantic” (one of the spinoff companies of "Google"), in 2014. The company was the same that created yet another very popular MAR game, the "Pokémon Go", but while the latter is mainly intended for young players, "Ingress" can also be played by adults.

The key concept of "Ingress" is that there are two factions of players: the "Enlightenment" and the "Resistance", and players need to choose only one of them to identify themselves with. Both factions need to expand their influence in the virtual space and this is achieved conquering in the virtual space specific locations of the real space named "portals" that are dispersed in various locations, mainly in urban areas [26].

By locating a marker called "resonator" at a portal, users can leave a personal mark (through their mobile phone) in the game's virtual space on behalf of their faction and so the portal changes colour to either green for the faction of "Enlightened" ones or blue for the "Resistance". If players come across portals that they have already been conquered by the opposite team, they can displace the opponents by using virtual "weaponry" provided by the system. As the aim of each one of the two virtual factions is to expand their influence in virtual space (by conquering portals), a further procedure provided by the game is to connect portals to create triangles which, in turn, define "fields" and establish a stronger control in space for the faction that has created them.

Thus, this study addresses these research gaps by concentrating on the following research issues: Based on the ARCS model, how do adult learners assess a location-based MAR game? Which factors of the ARCS model affect more the training in location-based MAR games?

2. Materials and Methods

To achieve the aim and objectives of the project, quantitative research methods were applied for data collection in order to assess the educational activity that was carried out and was focused on the location-based MAR game Ingress. With the training session, participants familiarized themselves with the game menu, learned to follow the vocal instructions, to recognize symbols and icons of the game and learned the game's (most commonly used) procedures (selecting weapons, recognizing triangles, conquering portals, etc.).

The educational research project involved 45 users in Greece, aged 20 to 60 years old. The participants were chosen on the basis of four characteristics: (a) they had been using an Android smartphone already, (b) they understood written and spoken English, (c) they could understand written or oral instructions the game provides them and (d) they were not familiar with Ingress at all. Of the participants, 12 were graduates of secondary education, 4 university students, 18 university graduates, 9 held a Master's degree and 2 held a doctoral degree. The participants were divided into three age groups: 20–35, 36–51 and >52 (Table 1) with 15 persons per age group, and they were trained to learn the basics of Ingress for two hours and then played Ingress for about one hour.

Table 1. Statistical description of participant age groups.

Age Group	20–35	36–51	52–60	20–60
n	15	15	15	45
mean	28.6	44.4	56	43
s.d.	4.71	4.54	2.14	11.93
median	30	44	56	44

Before and after playing the game, a questionnaire-based survey was conducted using the ARCS model to find out the level of learners' motivation in relation to the parameters measuring attention (A), relevance (R), confidence (C) and satisfaction (S) of the participants for playing Ingress. The survey questionnaire was composed of 31 closed questions, and was developed specifically for this research, allowing for answers based on a 5-point

Likert scale (with 1 being strong disagreement and 5 strong agreement). Each question corresponds to a certain category of Keller's ARCS model, as shown in Table 2.

Table 2. Questionnaire to investigate participant motivation with MAR game (Ingress), and correspondence of each question to Keller's motivation components in the ARCS model.

No	No.	Question	Keller's Motivation Component
1	A_1	The application contributes to sharpening decision making and problem-solving skills.	A.5.2
2	A_2	Your attention was attracted already at the beginning of the game.	A.2.1
3	A_3	You feel "immersed" while playing the game.	A.6.1
4	A_4	The visual characteristics of the application are attractive to you.	A.3.3
5	A_5	The user interface of the application is efficient.	A.5.3
6	A_6	The visual complexity of the shapes shown by the game affects the learning process.	A.5.1
7	A_7	The range of colors shown by the game affects the learning process.	A.5.1
8	A_8	The ordering and sequencing of shapes, forms and sounds of the game affects the learning process.	A.5.1
9	R_1	The application allows you to develop friendly interactions with other users	R.4.2
10	R_2	The contents of the game are relevant to your interests and everyday life.	R.1.3
11	R_3	You would prefer to get acquainted with AR with the aid of this particular game instead of any other application.	R.3.1
12	R_4	The particular game is suitable to teach AR.	R.5.3
13	R_5	The software allows you to take a break and continue later.	R.5.2
14	R_6	The game relates to your own future goals.	R.3.2
15	R_7	The application offers a combination of your mental and physical skills.	R.1.1
16	R_8	You intend to recommend the application to others.	R.3.2
17	C_1	You use correct terms while referring to the application.	C.1.1
18	C_2	You have the impression (at first sight) that this would be an easy game to play.	C.3.1
19	C_3	The application presents surprises.	C.2.1
20	C_4	The game presents new challenges at the right pace.	C.2.1
21	C_5	The game contributed to you some concepts of geography.	C.3.2
22	C_6	The application is simple to use.	C.5.3
23	C_7	The instructions to the user are properly written/expressed.	C.1.1
24	C_8	The application can quickly be learnt by the user.	C.3.2
25	S_1	The procedures of the application motivate the user.	S.3.4
26	S_2	The application is entertaining to the user.	S.5.1
27	S_3	The application presents adequate reinforcements.	S.5.3
28	S_4	The user is rewarded by a sense of accomplishment when winning the game.	S.2.1
29	S_5	The user feels satisfied from playing the game.	S.1.1
30	S_6	The application enhances the user's skills during the game.	S.5.1
31	S_7	The use of AR made the user feel uneasiness, anxiety or other discomfort.	S.4.1

Data analysis employed quantitative approaches. The purpose of the quantitative data analysis was to measure how training of the game effects participants' learning motivation across the ARCS factors. To better visualize the relationships among statistical means and standard deviations by ARCS factor, by age, standard deviation balls were used. The radius of each ball is equal to the standard deviation.

3. Results

The questionnaire was designed with 31 items with an acceptable reliability score of 0.97 (Cronbach alpha).

The mean value of participants' responses per question for each one of the A,R,C,S factors was calculated by dividing the sum of the Likert scores (ranging from 1 to 5) for each question by the total number of participants.

The mean value of participants' responses per question for each one of the A,R,C,S factors was calculated by dividing the sum of the Likert scores (ranging from 1 to 5) for each question by the total number of participants (Table 3 and Figure 1).

Table 3. Standard deviations of the participants' answers per ARCS factor and per question of the ARCS model, before training (b.t.) and after training (a.t.).

	A				R				C				S			
Question Number	**b.t.**		**a.t.**		**b.t.**		**a.t.**		**b.t.**		**a.t.**		**b.t.**		**a.t.**	
	M	**sd**	**M**	**sd**	**M**	**sd**	**M**	**sd**	**M**	**sd**	**M**	**sd**	**M**	**sd**	**M**	**sd**
1	2.04	0.63	3.04	1.15	2.78	0.51	3.53	0.91	3.09	0.55	3.64	0.76	2.49	0.69	3.33	0.7
2	2.27	0.57	3.89	1.02	2.4	0.74	2.62	0.97	2.89	0.85	3.58	0.83	2.73	0.44	3.93	0.44
3	2.20	0.58	3.29	0.98	2.38	0.79	2.58	0.86	2.56	0.83	2.96	0.92	2.38	0.71	3.27	0.72
4	2.36	0.60	3.53	0.96	3.38	0.64	4.00	0.52	2.60	0.88	3.00	0.92	2.18	0.64	3.07	0.88
5	2.47	0.65	3.62	0.74	3.24	0.73	3.87	0.72	3.42	0.58	4.22	0.42	2.71	0.45	4.09	0.51
6	2.22	0.63	3.36	1.08	2.33	0.89	2.58	1.02	3.13	0.72	3.89	0.67	2.42	0.65	3.36	1.00
7	2.24	0.64	3.35	1.76	3.47	0.62	4.2	0.58	2.82	0.74	3.22	0.87	1.93	0.95	1.93	0.90
8	2.24	0.63	3.31	1.15	3.25	0.63	3.91	0.81	3.00	0.67	3.69	0.69	-	-	-	-

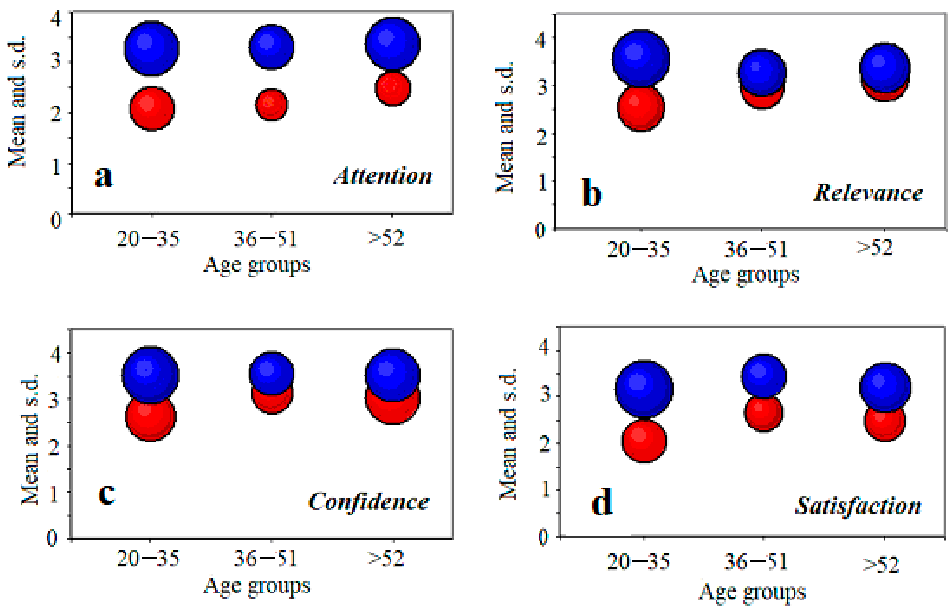

Figure 1. Average mean score and standard deviation of responses by all participants for the 31 questions per factor of the ARCS model, before training (lower row) and after training (upper row) per age group (ball sizes are proportional to standard deviation): Attention (**a**), Relevance (**b**), Confidence (**c**), Satisfaction (**d**).

Figure 1a shows the average mean score (on the Likert scale) and the standard deviation of all participants for the eight questions that belong to the Attention factor, before training (lower row) and after training (upper row) with the diameter of each ball being proportional to the standard deviation. The factor of Attention improved for all the questions after training in the game. Additionally, the standard deviation of the answers is higher after game training, indicating that there was greater heterogeneity and variability in the values of participants' answers after training. These results show that participants were highly satisfied with the training of the game. The largest statistically significant difference observed in the questions contained in the factor of attention was between the age groups 20–35 and 52–60 (the test statistic was -2.4879, with *p*-value 0.006306, which was statistically significant ($p < 0.01$)).

In questions R_1, R_2, R_3, and R_6, answers before and after training are highly similar, while in questions R_4, R_5, R_7, R_8, they are less similar (Figure 1b). Considering also that there is no noticeable difference in the standard deviation of the answers before and after the game training, it follows that the training did not affect participants significantly in terms of Relevance of the ARCS model.

Further, from the responses to questions C_1, C_3, C_4, and C_7, it can be seen (Figure 1c) that there is a great overlap of answers before and after training while in questions C_2, C_5, C_6, C_8, there is less overlap of participant answers. Additionally, as the standard deviation of question C_5 is smaller there was smaller heterogeneity and variability in the values of participants' answers after the training. These results show that training did not affect participants in terms of the factor of Confidence from the ARCS model.

Figure 1d shows the average mean score and the standard deviation of all participants for the seven questions that belong to the category of satisfaction before training (lower row) and after training (upper row). We can see that the factor of satisfaction was improved for all the questions after the game training. Additionally, the standard deviation of the answers is about the same after training of the game. These results indicate participants were highly satisfied with the training of the game pointing to the fact that training improved their "satisfaction" in the ARCS model. The largest statistically significant difference observed in the questions contained in the factor of satisfaction was between the age groups 20–35 and 36–51 (test statistic -1.90892, with *p*-value = 0.01956, which was statistically significant at the level of statistical significance ($p < 0.05$)).

The response from the post-test feedback shows that there were high levels of motivation in terms of Attention (A) with mean score 3.42, Relevance (R) with mean score 3.41, Confidence (C) with mean score 3.52 and Satisfaction (S) with mean score 3.28.

Concerning all four factors of the ARCS model, we see that responses to questions A_5, R_7, C_5 and S_2 yielded the highest differences before and after game training.

An interesting picture is revealed with respect to age differences (Table 4, Figure 1). The scores for the factor of Attention were higher for the age groups 20–35 and 36–51 after the training session, so the participants' Attention (as measured by questions corresponding to the ARCS model) improved after the training. As for the factor of Relevance, higher scores were reported for the age group 20–35 after training, as were for the factor of Confidence (while in the other age groups there was an overlap of the answers before and after the game training of the factor Confidence). However, the factor of Satisfaction improved after training for all age groups. The statistical comparisons among age groups and ARCS factors were carried out by means of the Learner's *t*-test.

From Figure 2a, it follows that scores for all ARCS factors improved after training. Additionally, the standard deviations are all greater after the training of the game, which means higher heterogeneity in the assessments after training. Additionally, the participants of age group 20–35 were highly satisfied with the training of the game by reporting that training improved their Attention, Relevance, Confidence and Satisfaction. The highest statistically significant differences were observed in the age group 20–35 and were between Attention and Confidence (test statistic: -1.6478, *p*-value = 0.0497, $p < 0.05$) and between Attention and Relevance (test statistic: -1.82747, *p*-value = 0.03636, $p < 0.05$).

Table 4. Standard deviations of the participants' answers per ARCS factor and per age group, before training (b.t.) and after training (a.t.).

	A		**R**		**C**		**S**	
Age Group	**b.t.**	**a.t.**	**b.t.**	**a.t.**	**b.t.**	**a.t.**	**b.t.**	**a.t.**
20–35	0.82	1.18	0.79	1.23	0.78	1.02	0.74	1.19
36–51	0.39	0.83	0.73	0.88	0.56	0.66	0.58	0.70
>52	0.52	1.16	0.86	0.98	0.88	0.91	0.68	1.02

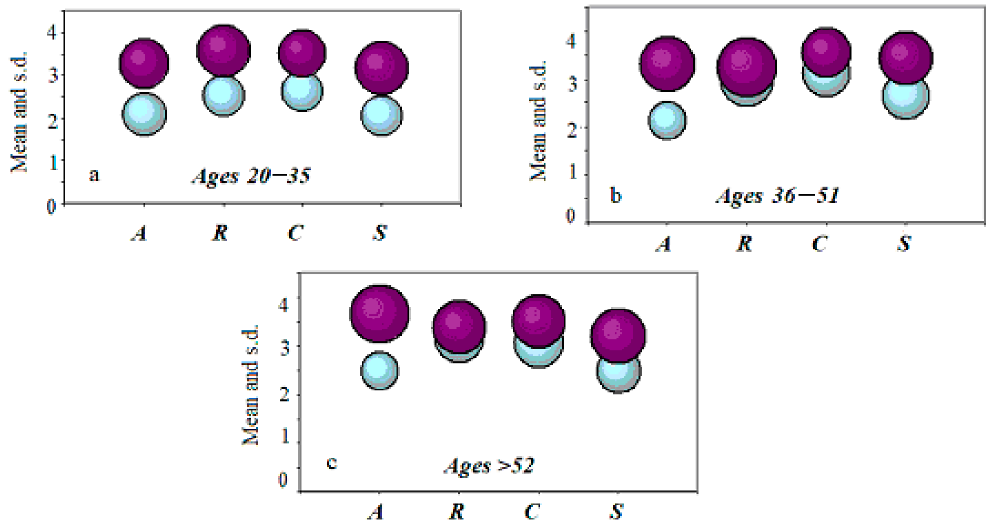

Figure 2. Mean score and the standard deviations per age group, for all questions, for the factors of Attention (A), Relevance (R), Confidence (C) and Satisfaction (S) of the ARCS model, before training (lower row) and after training (upper row). The diameter of each ball is proportional to the standard deviation: 20–35 (**a**), 36–51 (**b**), >52 (**c**).

Figure 2b displays how the factors of Attention and Satisfaction improved after training, while there was an overlap of scores related to the factors of Relevance and Confidence after training. Additionally, the standard deviation is greater after the training for the factors of Attention and Satisfaction. These results indicate that the participants of age group 36–51 were highly satisfied with the training of the game by agreeing to the fact that training improved their Attention and Satisfaction, while the factors of Relevance and Confidence remained relatively unaffected. The highest statistically significant differences observed in the age group 36–51 were between Attention–Confidence (test statistic: -2.43016, p-value = 0.007546, $p < 0.05$), between Attention and Relevance (test statistic: -0.453267, with p-value = 0.6618, $p < 0.05$) and between Relevance and Satisfaction (test statistic: -1.75794, p-value = 0,03975, $p < 0.05$).

From Figure 2c it follows that the scores for the factors Attention and Satisfaction also improved after training, while there was similarity of responses to the factors of Relevance and Confidence after the training of the game. It also follows that the participants of age group >52 were highly satisfied with the training of the game by agreeing to the fact that training raised their Attention and Satisfaction scores, while the factors of Relevance and Confidence remained relatively stable.

The correlation among the ARCS factors was calculated before and after training with the Pearson r index (Table 5): the lowest correlation and the least significant one was for Attention, meaning that the highest impact made by training was for the factor Attention, while the impact of training was least significant in the factors of Confidence and Relevance.

Table 5. Pearson r for ARCS before and after training for each factor of the ARCS model (Attention, Relevance, Confidence, Satisfaction).

	Pearson r	p-Value	Significant at
A	0.7064	0.050157	$p < 0.10$
R	0.9841	0.00001	$p < 0.01$
C	0.9784	0.000025	$p < 0.01$
S	0.8399	0.018036	$p < 0.05$

The effect of training per ARCS factor and per age group was calculated by means of Cohen's d effect measure [27] and its interpretation by Sawilowsky [28] as shown in Table 6.

Table 6. Values of Cohen's d measure of effect, per ARCS factor and per age group: the highest effect of training was for the age 20–35 and, for all ages, for the factors A and S.

	ARCS Factors			
	A	R	C	S
Age groups				
20–35	1.183	1.007	1.005	1.174
36–51	1.365	0.363	0.685	1.219
52–60	1.047	0.233	0.511	0.847

4. Discussion

The ARCS model provides a useful method for diagnosing students' motivational issues and educational results, and is particularly suited for research with adult learners. Researchers may recognize key motivational problems and understand how these evolve over time by comparing pre- and post-training outcomes. Additionally, researchers can look at the interactions between all four ARCS factors and decide how they can improve the guidance and their instruction to achieve the desired motivational outcome [29]. Interpreting ARCS findings can be difficult due to the complexities involved in learning motivation, since several variables must be considered while carrying out research in learning motivation and the reverse: no single cause results in a motivational problem. Consequently, when it comes to diagnosing motivational problems, researchers must take an eclectic approach [29].

Studies indicate that the ARCS model may be well adopted to computer-based or web-based instructional environment [30], although it was originally designed for developing motivating instructional materials in traditional instructional settings (face-to-face, classroom-based). Several concepts about learning motivation are incorporated into the ARCS model, but the central idea is to include a well-systematized approach to instructional and learning designs. As a result, teaching materials are more in line with participatory learning designs and provide interactivity to motivate students and this makes the ARCS model particularly attractive to carry out research with adult learners. The design of teaching material is a major factor in attracting students' attention and keeping them engaged in the learning process. Learning results could be unsatisfactory if students are not paying attention and are not interested in the learning material or methods [18].

Our study had some limitations. First, we conducted this research with people who had never played a mobile AR game before. In other words, variations in constructs were discovered among non-users but not among users and hence, future research into the factors that drive general interest in these games is still required. Second, it's likely that some of the results of this study are skewed by the study's spatial settings (i.e., cityscapes within the same city) or the demographics of the participants, pointing to the need for further studies, under different conditions and with different participants. Third, different findings might be obtained if the three age groups were classified differently. Fourth, restrictions in the number of participants per age group may affect the research finding that the age group 20–35 has more similarities with the age group >52.

This research highlighted the effects of integrating the ARCS model into the learning phase of a MAR game and the influence of this new implementation model on participants' motivation. Specifically, it is shown here that:

(i) Using the ARCS model enabled the classification of users' responses with respect to their interaction with the game and was therefore useful for education with MAR game.
(ii) The players' responses did not change linearly with their age.
(iii) The training has had different impact on each age group of learners.
(iv) The training increased the scores of the factors of ARCS model.
(v) Our statistical results verified that teaching a MAR game to adults has had a positive effect on ARCS factors of their attitudes and perceptions of the game Ingress and, finally.
(vi) While Keller's motivational instructional design ideas are indeed applicable to emerging interactive learning platforms such as MAR [19], our research presented evidence that Keller's framework can be coupled with the use of cutting-edge digital technology in outdoors education.

Ingress combines a powerful collection of creative mechanisms based on a wide variety of LBMG possibilities. Its hybrid spatiality, which colocates material and virtual elements in the city, blurs the game space and the space of urban activities, causing them to become intertwined and entangled, as de Souza e Silva [9] and Montola [31] suggested. The city is viewed through a dynamic "digital skin" [32], which generates (re)readings of territory and related activities. The opportunity for players to suggest game elements and have them supported by providing knowledge about physical spaces in the city creates a bottom-up mechanism for Volunteered Geographic Information (VGI) [33] that involves players who try to re-define the geographical information available over the game board. The flow of knowledge between the digital and physical worlds is gradually aligning them, blurring the lines and incorporating them into a hybridized space. This aids in city exploration and discovery by providing players with new and additional knowledge about known and unknown locations [34]. The tools for player communication and cooperation open up a whole new world of strategic and spatial possibilities for engaging with fellow citizens. Ingress "interlaces" with urban life in various ways [35] and, due to its pervasiveness, users may play it in between other activities unrelated to the game (shopping, promenading etc.). Indeed, the game can be played on the spur of the moment, depending on the player's position in the city and the need to respond to changing game conditions.

Previous research has found that younger adults (18–35 years) are more comfortable with videogames than older ones [36–39]. In contrast, Madrigal-Pana et al. [40] suggested that game exposure and practice rather than age, may be the causes of any negative attitudes toward games. Additionally, recent research indicates that once older adults understand and play videogames, their negative attitudes begin to fade [41,42]. In contrast to these findings, our research with Ingress research shows that the adult users of the 52 > age group can have a positive attitude toward it. Indeed, Przybylski's [43] study, which found a connection between negative attitudes toward video games and generational issues, backs this up. Evidence also suggests that older adults now embrace and use technology, and that their acceptance and use is influenced by their personality, behaviour, education, income, and age, among other factors [44,45]. In conclusion, although age has consistently been found to be an indicator of negative attitudes toward videogame use in the general population and among academics [42,43,46], once older adults understand the material and play the videogames, they no longer report negative attitudes [42]. This supports the argument that, at least in part, concerns about such games may stem from a general ignorance about this kind of games.

5. Conclusions

Keller (1987) emphasized [47] that the application of ARCS motivation model A, R, C, S four factors are interlinked, and the positive direction of each link will definitely make the student's learning a virtuous circle. This is of particular relevance for users of MAR games, as they need to be aware about the rules of the specific game. Thus, training in the game before play endows users is a worthwhile effort.

This study revealed that the ARCS motivation model can provide users of MAR games with design strategies for identifying and understanding their motivational needs to promote learning motivation and effectively improve user learning and performance. Our results demonstrated the applicability of the ARCS model in MAR games, that goes beyond the range of its hitherto known applications: ARCS can be a useful model for evaluating education with augmented reality (AR).

By applying pre- and post-quantitative measures of the four ARCS factors for the users' responses to closed questions related to Ingress, it was found that game training improved all the factors of ARCS and primarily "attention" and "satisfaction". It was also found that the responses of young people agreed more with those of elderly adults than with those of the intermediate age group. Additionally, we found that training affected positively all the domains of participants' involvement in terms of user learning, user engagement, user behavior and user feedback.

Author Contributions: Conceptualization, K.S.; methodology, K.S.; formal analysis, K.S.; investigation, K.S.; data curation, K.S.; writing—original draft preparation, K.S.; writing—review and editing, K.S.; visualization, K.S.; supervision, J.M.M.G. and M.D.H.-A.; project administration, K.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Ethical review and approval were waived for this study, due to the fact that all participants were adults and participated by their own will.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Azuma, R.T. A survey of augmented reality. *Presence: Teleoperators Virtual Environ.* **1997**, *6*, 355–385. [CrossRef]
2. Anderson, N. Video gaming to be twice as big as music by 2011. *Ars Tech.* **2007**, *30*, 17–34.
3. Ash, J. *The Interface Envelope: Gaming, Technology, Power*; Bloomsbury Publishing: London, UK, 2015.
4. Castells, M. The space of flows. *Rise Netw. Soc.* **1996**, *1*, 376–482.
5. Fernández-Enríquez, R.; Delgado-Martín, L. Augmented Reality as a Didactic Resource for Teaching Mathematics. *Appl. Sci.* **2020**, *10*, 2560. [CrossRef]
6. Bueno, S.; Gallego, M.D.; Noyes, J. Uses and Gratifications on Augmented Reality Games: An Examination of Pokemon Go. *Appl. Sci.* **2020**, *10*, 1644. [CrossRef]
7. De Souza e Silva, A.; Sheller, M. (Eds.) *Mobility and Locative Media: Mobile Communication in Hybrid Spaces*; Routledge: London, UK, 2014.
8. De Roo, G.; Yamu, A. New ways of conditioning space and place in the dynamic and transformative environments: Liaising between the worlds of matter and the virtual. In *The Virtual and the Real in Planning and Urban Design: Perspectives, Practices and Applications*; Yamu, C., Poplin, A., Devisch, O., de Roo, G., Eds.; Routledge: London, UK, 2017; pp. 11–39.
9. De Souza e Silva, A. Hybrid reality and location-based gaming: Redefining mobility and game spaces in urban environments. *Simul. Gaming* **2009**, *40*, 404–424. [CrossRef]
10. De Souza e Silva, A.; Hjorth, L. Playful urban spaces: A historical approach to mobile games. *Simul. Gaming* **2009**, *40*, 602–625. [CrossRef]
11. Winter, S.; Richter, K.F.; Baldwin, T.; Cavedon, L.; Stirling, L.; Duckham, M.; Kealy, A.; Rajabifard, A. Location-based mobile games for spatial knowledge acquisition. *CEUR Workshop Proc.* **2011**, *780*, 1–8.
12. Colley, A.; Thebault-Spieker, J.; Lin, A.Y.; Degraen, D.; Fischman, B.; Häkkilä, J.; Kuehl, K.; Nisi, V.; Nunes, N.J.; Wenig, N.; et al. The geography of Pokémon GO: Beneficial and problematic effects on places and movement. In Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems, Denver, CO, USA, 6–11 May 2017; pp. 1179–1192.
13. Hjorth, L.; Richardson, I. Pokémon GO: Mobile media play, place-making, and the digital wayfarer. *Mob. Media Commun.* **2017**, *5*, 3–14. [CrossRef]

14. Paras, B.; Bizzocchi, J. Game, Motivation, and Effective Learning: An Integrated Model for Educational Game Design. In Proceedings of the DiGRA 2005 Conference: Changing Views Worlds in Play, Vancouver, BC, Canada, 16–20 June 2005.
15. Chan, T.S.; Ahern, T.C. Targeting motivation—adapting flow theory to instructional design. *J. Educ. Comput. Res.* **1999**, *21*, 151–163. [CrossRef]
16. Small, R.V. *Motivation in Instructional Design. ERIC Digest*; ERIC Clearinghouse on Information and Technology: Syracuse, NY, USA, 1997.
17. Keller, J.M. Motivational design of instruction. *Instr. Des. Theor. Models Overv. Curr. Status* **1983**, *1*, 383–434.
18. Chang, Y.S.; Hu, K.J.; Chiang, C.W.; Lugmayr, A. Applying Mobile Augmented Reality (AR) to teach Interior Design students in layout plans: Evaluation of learning effectiveness based on the ARCS Model of learning motivation theory. *Sensors* **2020**, *20*, 105. [CrossRef]
19. Lin, H.C.K.; Lin, Y.H.; Wang, T.H.; Su, L.K.; Huang, Y.M. Effects of Incorporating Augmented Reality into a Board Game for High School Students' Learning Motivation and Acceptance in Health Education. *Sustainability* **2021**, *13*, 3333. [CrossRef]
20. Kaur, D.P.; Mantri, A.; Horan, B. Enhancing Student Motivation with use of Augmented Reality for Interactive Learning in Engineering Education. *Procedia Comput. Sci.* **2020**, *172*, 881–885. [CrossRef]
21. Hamzah, W.A.F.W.; Ali, N.H.; Saman, M.Y.M.; Yusoff, M.H.; Yacob, A. Enhancement of the ARCS model for gamification of learning. In Proceedings of the 2014 3rd International Conference on User Science and Engineering (i-USEr), Shah Alam, Malaysia, 2–5 September 2014; pp. 287–291.
22. Schmidt, J.T. Preparing Students for Success in Blended Learning Environments: Future Oriented Motivation and Self-Regulation. Ph.D. Thesis, Ludwig Maximilian University of Munich, München, Germany, 2007; pp. 301–302.
23. Di Serio, Á.; Ibáñez, M.B.; Kloos, C.D. Impact of an augmented reality system on students' motivation for a visual art course. *Comput. Educ.* **2013**, *68*, 586–596. [CrossRef]
24. Gómez-Galán, J.; Vázquez-Cano, E.; Luque de la Rosa, A.; López-Meneses, E. Socio-educational impact of Augmented Reality (AR) in sustainable learning ecologies: A semantic modeling approach. *Sustainability* **2020**, *12*, 9116. [CrossRef]
25. Gutiérrez, J.M.; Fernández, M.D.M. Applying augmented reality in engineering education to improve academic performance & student motivation. *Int. J. Eng. Educ.* **2014**, *30*, 625–635.
26. Karpashevich, P.; Hornecker, E.; Dankwa, N.K.; Hanafy, M.; Fietkau, J. Blurring boundaries between everyday life and pervasive gaming: An interview study of ingress. In Proceedings of the 15th International Conference on Mobile and Ubiquitous Multimedia, Rovaniemi, FL, USA, 12–15 December 2016; pp. 217–228.
27. Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*; Routledge: London, UK, 1988.
28. Sawilowsky, S. New effect size rules of thumb. *J. Mod. Appl. Stat. Methods* **2009**, *82*, 467–474. [CrossRef]
29. Huang, D.W.; Diefes-Dux, H.; Imbrie, P.K.; Daku, B.; Kallimani, J.G. Learning motivation evaluation for a computer-based instructional tutorial using ARCS model of motivational design. In Proceedings of the 34th Annual Frontiers in Education, FIE 2004, Savannah, GA, USA, 20–23 October; 2004; p. T1E-30.
30. Keller, J.M. Motivation in cyber learning environments. *Int. J. Educ. Telecommun.* **1995**, *1*, 7–30.
31. Montola, M. Exploring the edge of the magic circle: Defining pervasive games. In Proceedings of the DAC, Shanghai, China, 18–21 January 2005; Volume 1966, p. 103.
32. Rabari, C.; Storper, M. The digital skin of cities: Urban theory and research in the age of the sensored and metered city, ubiquitous computing and big data. *Camb. J. Reg. Econ. Soc.* **2015**, *8*, 27–42. [CrossRef]
33. Goodchild, M.F. Citizens as sensors: The world of volunteered geography. *GeoJournal* **2007**, *69*, 211–221. [CrossRef]
34. Sengupta, U.; Tantoush, M.; Bassanino, M.; Cheung, E. The Hybrid Space of Collaborative Location-Based Mobile Games and the City: A Case Study of Ingress. *Urban Plan.* **2020**, *5*, 358–370. [CrossRef]
35. Fragoso, S.; Reis, B.M.S. Ludic Re-enchantment and the power of locative games: A case study of the game Ingress. In Proceedings of the International Conference on Culture, Technology, and Communication, London, UK, 15–17 June 2016; pp. 131–148.
36. Malik, A.; Hiekkanen, K.; Dhir, A.; Nieminen, M. Impact of privacy, trust and user activity on intentions to share Facebook photos. *J. Inf. Commun. Ethics Soc.* **2016**, *14*, 364–382. [CrossRef]
37. Malik, A.; Hiekkanen, K.; Hussain, Z.; Hamari, J.; Johri, A. How players across gender and age experience Pokémon Go? *Univers. Access Inf. Soc.* **2019**, *19*, 799–812. [CrossRef]
38. Taddicken, M. The 'privacy paradox'in the social web: The impact of privacy concerns, individual characteristics, and the perceived social relevance on different forms of self-disclosure. *J. Comput. Mediat. Commun.* **2014**, *19*, 248–273. [CrossRef]
39. Peleg-Adler, R.; Lanir, J.; Korman, M. The effects of aging on the use of handheld augmented reality in a route planning task. *Comput. Hum. Behav.* **2018**, *81*, 52–62. [CrossRef]
40. Madrigal-Pana, J.; Gómez-Figueroa, J.; Moncada-Jiménez, J. Adult perception toward videogames and physical activity using Pokémon Go. *Games Health J.* **2019**, *8*, 227–235. [CrossRef]
41. Ivory, J.D.; Kalyanaraman, S. Video games make people violent—Well, maybe not that game: Effects of content and person abstraction on perceptions of violent video games' effects and support of censorship. *Commun. Rep.* **2009**, *22*, 1–12. [CrossRef]
42. Ferguson, C.J.; Donnellan, M.B. Are associations between "sexist" video games and decreased empathy toward women robust? A reanalysis of Gabbiadini et al. 2016. *J. Youth Adolesc.* **2017**, *46*, 2446–2459. [CrossRef]
43. Przybylski, A.K. Electronic gaming and psychosocial adjustment. *Pediatrics* **2014**, *134*, 716–722. [CrossRef]

44. Vroman, K.G.; Arthanat, S.; Lysack, C. "Who over 65 is online?" Older adults' dispositions toward information communication technology. *Comput. Hum. Behav.* **2015**, *43*, 156–166. [CrossRef]
45. Hargittai, E.; Dobransky, K. Old Dogs, New Clicks: Digital Inequality in Skills and Uses among Older Adults. *Can. J. Commun.* **2017**, *42*, 195–212. [CrossRef]
46. Ferguson, C.J.; Colwell, J. Understanding why scholars hold different views on the influences of video games on public health. *J. Commun.* **2017**, *67*, 305–327. [CrossRef]
47. Keller, J.M. Development and use of the ARCS model of instructional design. *J. Instr. Dev.* **1987**, *10*, 2–10. [CrossRef]