Augmented reality

Recognition of multiple models simultaneously

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Abstract. The problem at hand is to ensure that the perception by means of Augmented Reality (AR) is hence reliable and opinions resulting from a Participatory Design (PD) mediated by this technology could be incorporated into the design solution. This paper presents the evaluation of multiple 3D models recognition in AR, with or without an auxiliary projection. Leisure area designs involve urban equipment of various dimensions that are visualized simultaneously. Therefore, it was necessary to verify if the participants were capable of recognizing them and which would be the best way to visualize: exclusively with the iPad screen or with the iPad associated with an external projection – to verify whether the visualization using an external projection would amplify the visualization area. The results obtained in the evaluation were used to improve the AR application and also, to develop guidelines for the AR use in a PD.

Keywords: Augmented Reality, Recognition, User Experience Evaluation.

1 Introduction

At the social housing Campinas F, in Campinas, SP, Brazil, there is a central area intended to be a leisure area for the neighborhood. However, this area was completely abandoned after the conclusions of the constructions of the buildings in 2006. To plan a suitable leisure area, a Participatory Design (PD)process using Augmented Reality (AR) was proposed. This article presents an evaluation of AR in order to be applied in the design process studied. The evaluation is in terms of user perception with AR, augmenting an abstraction of the real world, that is, a map or a design sheet on tabletop. In [1] mixed realities scale, this study can be characterized as of Augmented Virtuality.

In order to use mobile AR in the intended PD dynamic, the application equipAR! for iPad was developed. The purpose of this application was to enable the visualization and interaction on a tabletop in AR of 3D models of urban equipment for leisure areas. The idea was to use this application in the context of PD, involving

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users of multiple profiles, fromarchitects to users. Users were members of low-income families, who often have little education and do not have familiarity with new technologies.

A leisure area includes multiple equipment; therefore, it was necessary to verify if the participants were capable of recognizing these equipment simultaneously and which form of visualization would be best: exclusively with the iPad screen or with the iPad associated with an external projection. The goal was also to verify if the visualization through the tablet screen presented restrictions of visualization in AR for large areas representing the urban space and whether, in this case, the simultaneous visualization using an external projection would extend the visualization area.

The equipment is visualized and manipulated through AR simultaneously in the PD process. This illustrates the problem at hand, which is to ensure that the perception by means of Augmented Reality (AR) is hence reliable and opinions resulting from a Participatory Design (PD) could be incorporated into the design solution.

2 Related research

Currently there is limited understanding of human experience with mobile AR, especially studies concerning Architectural, Engineering and Construction (AEC) applications. Many authors agree that research in emerging fields, such as AR, cannot base themselves on traditional directives to evaluate the interface with the user [2,3,4, 5]. Little formal research, such as this one, has been performed to evaluate AR interfaces involving users [3], since AR systems differ from *desktop*systems in various aspects; the most crucial is that such systems are produced for being used as a mediator or amplifier of human visualization [2].

One interface of AR includes the *hardware* (e.g. *smartphone; notebook),* the *software* (e.g. Junaio, Layar, Wikitude), the devices for visualization (i.e. HMD, computer screen), the interface elements (e.g. menus, icons), the markers, the interaction format (i.e. rotating the marker, moving the remote control), and the content shown in AR. Depending on device, the tracking form, the interaction technique used, the interface in AR is altered. These factors may justify, in part, the lack of successful methods to evaluate AR interfaces.

According to [3], most AR user evaluations fit into one of the four categories: (i) human perception and cognition; (ii) user task performance; (iii) collaboration between users; (iv) system usability and system design evaluation.Among the research that study human perception and cognition, it is possible to mention afew related to this, as in [6, 7, 8, 11].The research of [6] compares the use of tangible and graphic interfaces. Among the conclusions, the authors state that the understanding of spatial relations of virtual models is improved with the use of tangible interfaces. The research of [7] involved the experiment to verify which mechanism is more appropriate to visualize a virtual model: by the rotation of this model or by the observer's move. The conclusion suggests that the user's move updates the mental representation, producing a positive effect in the performance of virtual models

recognition.

[8, 11]use mobile AR application to support public participation in urban planning. [8] developed a prototype smartphone AR system that superimposes virtual 3D models over an existing building and allows users to provide feedback based on their personal preference of the proposed designs. Their objective included the study of the public reaction to this technology, focusing on mobile device familiarity, system ease of use, and the system utility to participate in the urban planning project.The system was considered useful to participate in the urban planning project, suggesting that the system did not require a high level of technological familiarity to understand its purpose and utility.

[11] performed a user evaluation on the usefulness of a mobile AR system to visualize urban plans of an area to be reconstructed in Raseborg, Finland. The AR system used real sized models of the planned buildings in loco, stimulating a better comprehension of the proposed plans for the built environment. They focused on a qualitative research on perceived usefulness and ease of use of the system. AR was considered a useful instrument to visualize building plans in a holistic and intuitive way, facilitating the decision-making process and enriching the understanding of the plan.

The system designed by [8] uses a smartphone to superimpose 3D models to real buildings and the system used by [11] uses a smartphone to add 3D models of future buildings on a proposed area, while equipAR! uses a tablet to superimpose 3D models to markers, showing scaled models on a tabletop. Therefore, the purpose of equiAR! is not only to allow users to share common experience of design but also to allow participationin design by handling tangible AR elements and positioning them on an image of the space under design. In [11] the system was evaluated by decision makers - mostly city officials and members of the municipal government. On the contrary, this particular research is based on a different target user group, in which many participants didnot have schooling at all and had never touched a mobile device before. While the overall purpose of this research is similar to [8, 11], the combination of system functionality, participants profile and user evaluation setup, makes this research unique, reinforcing the need for further investigation.

3 The evaluation

In this evaluation, the recognition of multiple models disposed in leisure area layouts were verified, associated to different forms of visualization (iPad screen with or without external projection) or participant mobility (with various angles of visualization). These issues coulddirectlyinfluence the dynamic of a Participatory Design(PD) with the use of RA.To proceed with the evaluation of multiple models recognition simultaneously, first, it was necessary to certify that the participant would recognize each of the urban equipment individually. In order to be able to measure these issues exclusively, a routine to guarantee individual correct recognition of each model was incorporated in the user evaluation.

The studies of human factors allowed us toestablish a limit to the number of models of urban equipment exhibited. According to [12], the representations of the models seen sequentially are stored in the short-termmemory;it was thenreasoned that the study of visual recognition of multiple virtual models in AR should consider the limited capacity of this memory. This way, [13]recommendation forseven chunks of informationwas taken into account;therefore,seven different types of virtual models of urban equipment for leisure areas were used.

Given the fair recognition of the equipment in the scales of 1/100 and 1/50 - obtained in previous evaluation [9, 10] - and the preference for a smaller scale to discuss the leisure area project, the scale 1/100 was adopted to perform this evaluation. As the results of the previous user evaluation[9, 10] pointed to the preference of using fiducial markers, those were also adopted in this evaluation.

A second version of the equipAR! application (iOS) was developed, containing seven fiducial markers associated to seven virtual models of urban equipment for leisure areas in the scale 1/100 (Fig. 1), that is: a soccer field, a skate course, a multi-purpose sports court, an open-air gym, a playground, a set of tables with seats, and park benches. In this versionof the equipAR! application, all the models were added with a neutral base to block the visualization of markers in AR, in order to avoid visual conflict, according to the need pointed out in previous user evaluation [9, 10].

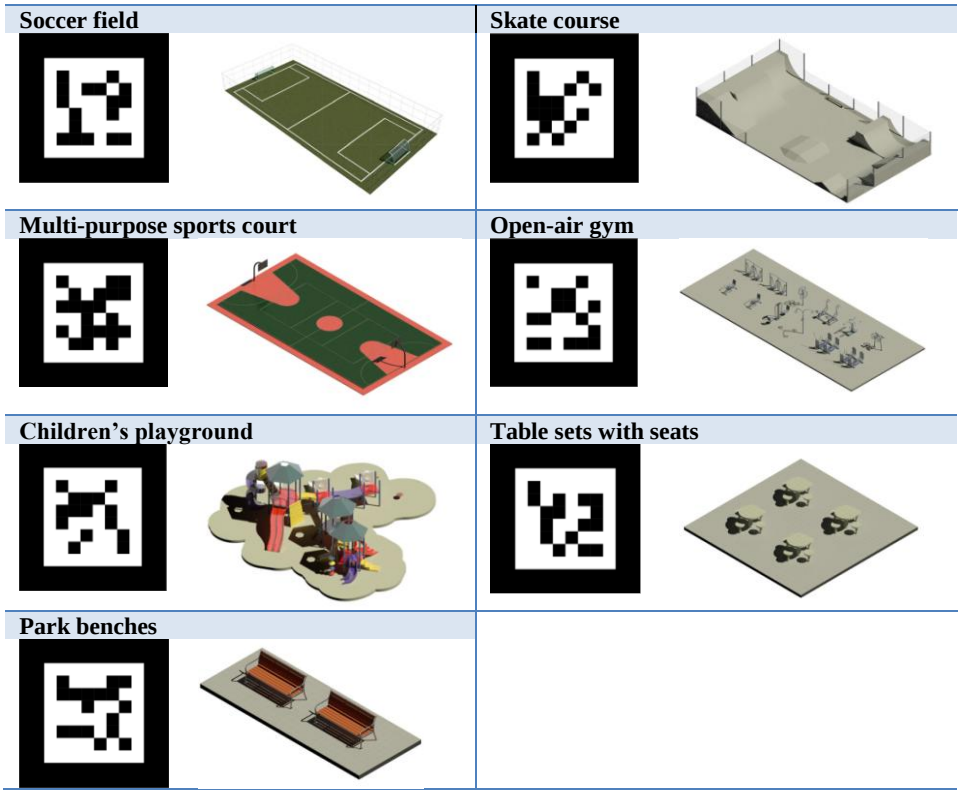


Fig. 1. Fiducial markers and virtual models associated to them.

To perform this user evaluation, the method described by [3] of subjective measures to evaluate the recognition was used. The evaluation was performed with non-specialists, individually.

4 Evaluation plan

The procedure to perform this User Experience evaluation was followed in phases, and performed according to the flowchart shown in Fig. 2.

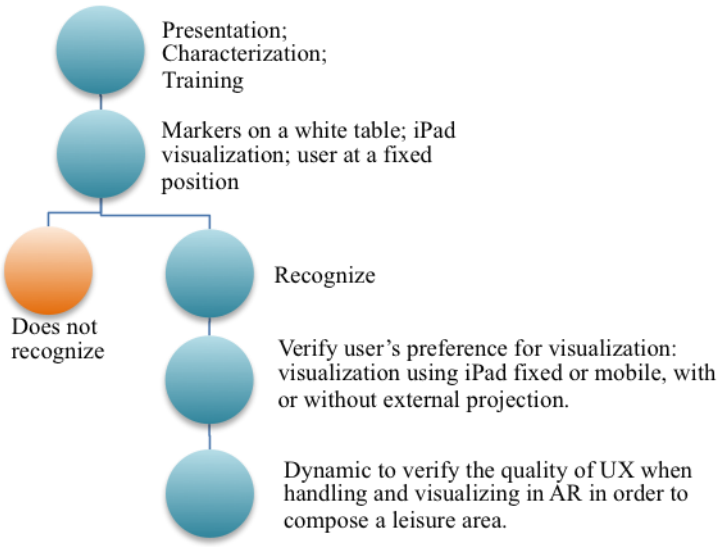


Fig. 2. Evaluation Plan.

(A) Presentation, characterization, and training

This phase would be comprised of three moments: a) presentation of the equipment; b) characterization questionnaire of the participant and c) training/learning. At first, the presentation of the equipment to the participant was performed, explaining the objective of the evaluation and the application's function. Then, characterization questionnaire of the participant was applied, checking the age, gender, education level, the frequency of smartphone or tablet use and the previous use of any AR systems.

Finally, training or learning session was performed. To proceed with the evaluation of recognition of multiple models of urban equipment of leisure areas simultaneously, it was first certified that the participant would recognize each of the urban equipment individually. It was asked if the participant recognized each one of the seven models used in this evaluation. Then, each one was displayed the models in AR and asked, "What is this? - taking note of everything the participant could recognize. If they could recognize all, then they would move on to Phase B. If not, each of the urban equipment should be presented individually to the participant in AR until there was a guarantee of correct recognition. When identifying all correctly, the participant would be able to proceed to Phase B otherwise the evaluation would end.

(B) Recognition of multiple models: iPad in a fixed position

On a table with a white base seven fiducial markers would be displayed in three different layouts (Fig. 3). Different people would visualize each layout, individually. To verify if the leisure equipment of larger dimension interfere in the recognition of the ones with a smaller dimension, the ones with a smaller dimension would be positioned surrounded by the ones with a larger dimension, Layout 1. To verify if the leisure equipment of smaller dimension would be more easily recognized if positioned at the extremity and in the front, Layout 2 was configured. To verify if there would be any difficulty in recognizing when the leisure equipment of smaller dimension was positioned separately at the extremities, Layout 3 was configured.

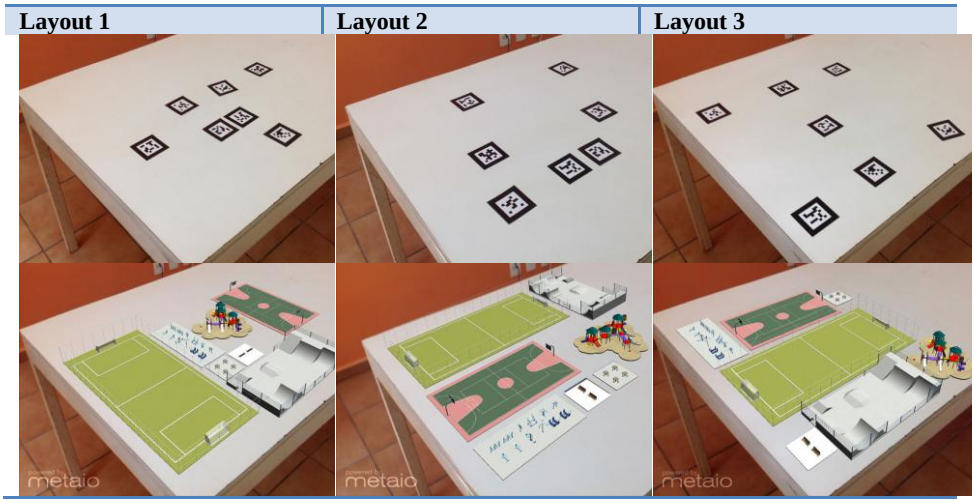


Fig. 3. Three kinds of layout of urban equipment in AR –markers positioned on a tabletop(up) and models of urban equipment seen in AR (down).

Initially, the participant visualized the scenario in AR from a fixed position. For that, the iPad was set on a tripod with the camera directed to the table with the application equipAR! active. At this moment, the models of urban equipment of leisure area could be visualized in AR in scale 1/100.

Then, the researcher pointed and asked whether the participant was able to say which equipment was indicated. On a printed sheet, with a map of the equipment layout, the researcher registered whether each one of them was recognized. If all were recognized, the participant performed Phase C. If not, the evaluation would move on to another procedure; however, since it was not necessary to perform it, it wasomitted.

(C) Visualization Preference

The purpose of this phase was to verify the visualization preference of the participant: the iPad on the tripod, the iPad on the tripod with an external projection, the iPad

being held by the participant with the option of mobility, the iPad being held by the participant with the option of mobility and external projection. To conclude, the participant was asked to say which was the best way to visualize all the set: with the iPad on the tripod, the iPad being held on the hands, iPad with the external projection on the tripod or the iPad with external projection being held by the hands. The researcher took note all the answers. Then, the evaluation continued on to Phase D.

(D) Assess the quality of the participant's experience while handling and visualizing in AR

The purpose of this phase was to verify the quality of the participant's experience when handling and visualizing in AR in a way to compose the leisure area. For that, each participant was asked to compose the leisure area with the available equipment in the application equipAR! Each participant performed one of the following tasks: (i) compose a leisure area for children; (ii) compose a leisure area for young people; (iii) compose a leisure area for the elderly. Each one had about 10 minutes. The participant could opt for a visualization form: with the iPad held by the hands or on a tripod, with or without external projection.

During the process, the researcher observed and noted how the participant performed the task: the visualization form and the difficulties found. Besides, the participant was asked to talk about the impressions, difficulties and opinions about the use of this technology. The researcher took notes and registered the process with photographs and video for further analysis.

At this phase, the **quality** of the interaction with the system was evaluated; therefore, the method proposed by [14] was adopted. [15] and [14] suggest that experiments that aim to evaluate cognitive performance be the most indicative of the user experience with the interface and, therefore, subjective measures or qualitative analysis should be adopted. In this situation, participants are usually asked to perform specific tasks. The biggest advantage of using tasks is that they tend to be more similar to the actions that users would perform with the system. Therefore, the acquired information with the cognitive performance evaluation tends to be more relevant and precise about the use of the application.

In this sense, [14] describes some categories of User Experience that can clarify user interaction with AR services. These categories are classified into six classes that represent subjective levels: (1) instrumental experiences, (2) cognitive and epistemic experiences, (3) emotional experiences, (4) sensory experiences, (5) motivational and behavioral experiences and (6) social experiences. These categories of User Experience should be used to perform measures in a qualitative evaluation. According to [14], measures may structure the evaluation process, supplying information that is comprehensible and subject to comparison, and may favor solution restructure.

In the adopted method,the User Experience evaluation is classified according to determined characteristics and graded with the Likert scale. The use of quantitative metrics of subjectivity allows for a better validity of conclusions and generalizations[14]. Therefore, at the end of the task of composing a leisure area with the use of AR system, each participant answered a questionnaire as shown on Table 1.

For all the statements, the participants marked one of the alternatives: Totally agree / Agree / Nothing to say / Disagree / Totally disagree.

The statements 1, 2, 3, 4 and 5 are related to instrumental experiences, which are the pragmatic experiences originated from the utility of the system (suitable to the proposed task), performance of the product, support to the participants activities, difficulties of interaction.The statements 6, 7, 8, 9, and 10 indicate the quality of the subjective emotional experiences originated from the use of equipAR!, such as pleasure, entertainment, and positive values of feelings.The statements 11 and 12 intend to verify the quality of the sensorial experiences.The statements 13 and 14 are related to the motivational and behavioral experiences, which are created when the participant is inspired or motivated to reach one objective with the help of technology.

Table 1. User Experience evaluation questionnaire. Statements based on [14]

1	The experience of trying to compose a leisure area using Augmented Reality was easy.
2	The way to interact with the urban equipment in Augmented reality was natural to me.
3	When I used the Augmented Reality system I felt pleased for having a good performance doing and concluding it.
4	I feel that using the Augmented Reality system is appropriate to the proposed task (Composition of a leisure area).
5	The Augmented Reality system had the urban equipment I wanted.
6	I felt surprised when using the Augmented Reality system, it was a novelty.
7	I had fun while using the Augmented Reality system.
8	I felt I was discovering things while using the Augmented Reality system.
9	Using the Augmented Reality system was lively and dynamic, allowing for continuous changes in the organization of the equipment.
10	I enjoyed the experience of trying to compose a leisure area using Augmented Reality.
11	I felt the desire to keep going while using the Augmented Reality system.
12	I was able to express my ideas for the leisure area using Augmented Reality.
13	I felt encouraged and motivated to conclude the task while using the Augmented Reality system.
14	I felt myself creative when composing the leisure area while using the Augmented Reality system.

Fifteen non-specialists participated in this evaluation.

5 Pre-test

To validate this user evaluation, a pre-test with seven participants was performed at the Laboratory of Architecture, Methodology of Project and Automation (LAMPA), located at the FEC building, UNICAMP. All the participants were students of the Post graduation Program of Architecture, Technology and City of FEC. It was observed that the participants hadfacility in recognizing the urban equipment individually as well as in a set, even when seen from the iPad screen only (Phase B). Therefore, a need was noticed to verify which would be the preference of visualization even in the situations where there is no difficulty in recognizing the set of equipment when seen

only from the iPad screen. Thus, Phase D was added – not previously elaborated – that intended to compare the various forms of visualization: iPad fixed or mobile, with or without external projection.

During the task development of composing a leisure area, most of the participants opted to let the iPad on the tripod and visualize through the external projection.All of them were able to compose a leisure area using this technology.

6 User ExperienceEvaluation

To perform this evaluation it was necessary an environment with the following characteristics: wall or screen for projection, electric power for the projector connection, a table for displaying markers, leveled floor for positioning the tripod, protection to avoid the incidence of direct light on the markers (which would make it difficult for the detection of these markers by the AR system). Since the Journalist Roberto Marinho School was located next to the social housing Campinas F, it was necessary to ask for an authorization for the evaluation to take place in its facilities. The teachers' room was made available in a full-time basis for this evaluation that was performed in March 2014.

The evaluation involved fifteen participants, among which, users or residents from the social housing Campinas F. Five people at a timeperformed the evaluation with a distinct task (compose a leisure area for children, young people and elderly).

6.1 Participants characterization

Nine participants were male (60%) and six were female (40%), **Fig. 4** (left). The age group of the participants variedfrom 11 to 60 years old, **Fig. 4** (right).

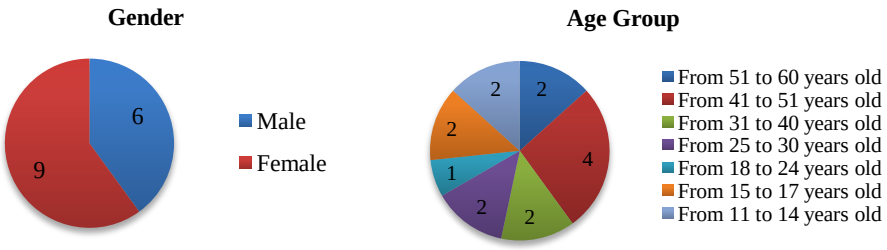


Fig. 4. Participants' gender (left) and participants by age group (right).

The education level of the participants varied, being five (33%) of them with a university degree and one (7%) who did not complete primary school, **Fig. 5** (left). If compared by age group, out of eight participants over thirty years old, four had completed primary school, one high school, and three had university degrees.When asked about the frequency of use of smartphone or tablet, five (33%) were using it for the first time, four (27%) rarely use it or at least used it once, and only three (20%)

use it daily, **Fig. 5**(right). None of the participants had a previous experience of any kind of AR system.

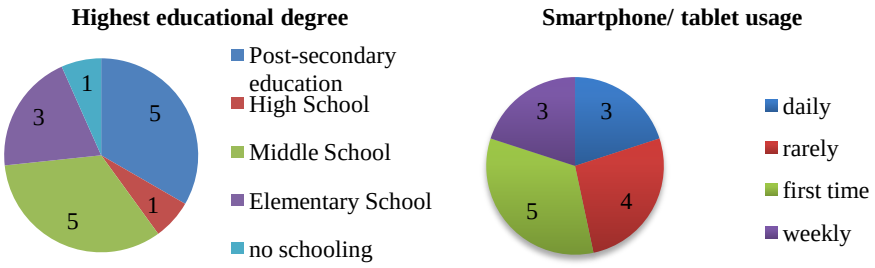


Fig. 5. Participants' education (left), Smartphone/ tablet usage (right).

6.2 Results

Initially, the participants should recognize the urban equipment individually in AR. All the equipment was recognized without the need of training. However, in three situations it was necessary the researcher's intervention in order to assist the use of the iPad searching for angles of vision that favored the recognition. The equipment that was recognized with difficulty was a table with seats and the open-air gym.

Then, the participants saw the set of equipment through only one angle of vision: iPad fixed or mobile, with or without external projection,**Fig. 6**. When the participant was asked about the visualization with or without mobility, without projection (graph A), seven (47%) preferred holding the iPad and moving around, two (13%) preferred leaving the iPad on the tripod, and six (40%) enjoyed the two forms, for they completed each other.

When the participant was asked about the choice of visualization without mobility, with or without the aid of external projection (graph B), six (40%) preferred only the external projection, five (33%) preferred the two forms together, and four (27%) preferred only the visualization from the iPad screen.

When the participant was asked about the choice of visualization with mobility, with or without the aid of external projection (graph C), eight (53%) preferred to visualize only through the iPad screen, two (13%) from the external projection and five (34%) enjoyed the two forms.

Finally, the participants were asked which would be the best form to visualize all the equipment once (graph D); seven (47%) preferred the iPad mobile with the external projection, five (33%) preferred the iPad fixed with the external projection, two (13%) the iPad mobile and one (7%) preferred the iPad fixed. If the choices that include the external projection as one of the forms of best visualization of content in AR are added, there are twelve (80%) that consider the use of external projection important.

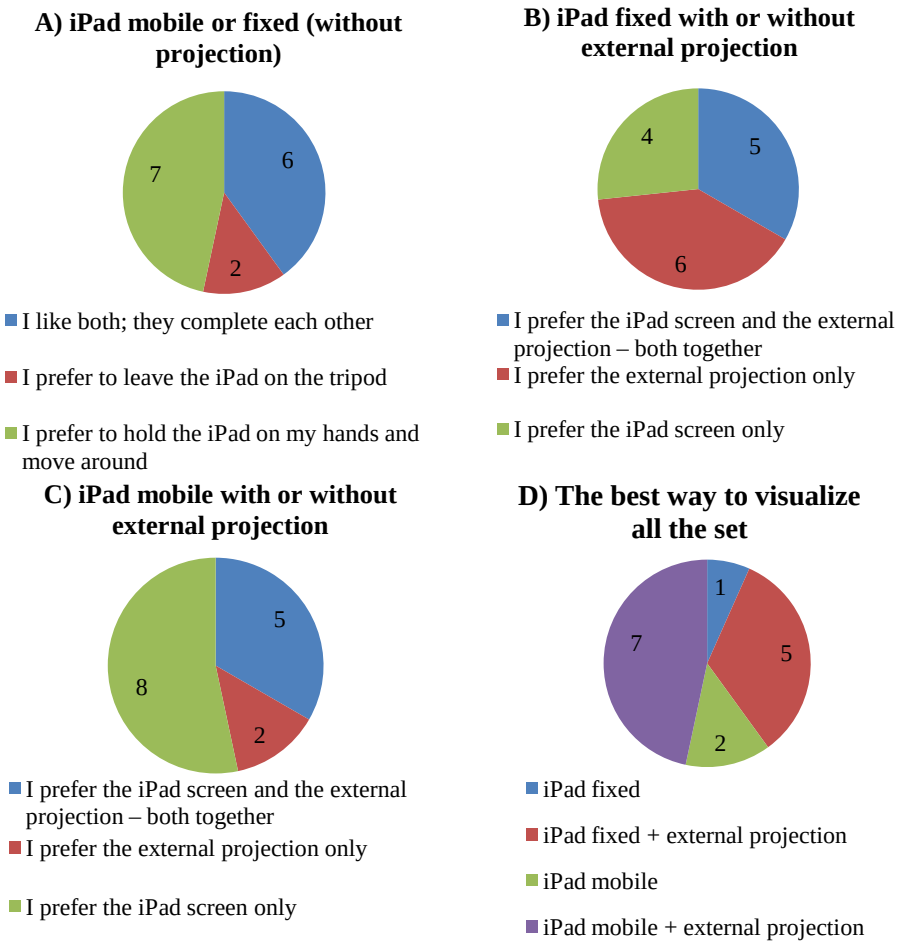


Fig. 6. Visualization preference: iPad fixed or mobile, with or without external projection.

During Phase D the participants were asked to set a leisure area with the same equipment used in this evaluation. The participant could choose the equipment most suitable for the task, i.e., compose a leisure area for children, young people and the elderly. Each participant had the freedom to choose the most suitable visualization form, being able to modify it during the task performance, as wished. **Fig. 7**shows some participants at the moment of elaboration of the leisure area and the final result of the compositions.

Fig. 7. Participants performing the task of assembling a leisure area with the available equipment (up) and the obtained result (down).

During the execution of the task to compose the leisure area using AR, it was registered how the visualization occurred most of the time. It was observed that twelve (80%) of the participants used the iPad in a fixed position together with the external projection and three (20%) participants used only the iPad mobile without external projection, **Fig. 8**. The three participants who opted to use the iPad mobile without external projection had a familiarity with the use of mobile devices (using it daily or once or twice a week). When asked about the choice, the answer was: "It is the custom; I am used to moving and seeing the same screen"; "This way is easier, I see what I am doing right (in relation to the point of view being the same of the iPad)".

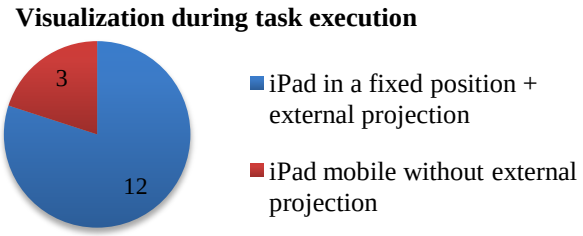


Fig. 8. Strategy adopted by the non-specialist participants to visualize when performing the task of composing a leisure area using AR.

After performing the tasks, the participants answered a questionnaire (according to

Table 1) to evaluate the quality of the experience of the system usage, taking into consideration the task performed. It is possible to observe that, in general, the opinion about the experience was positive,**Fig. 9**.

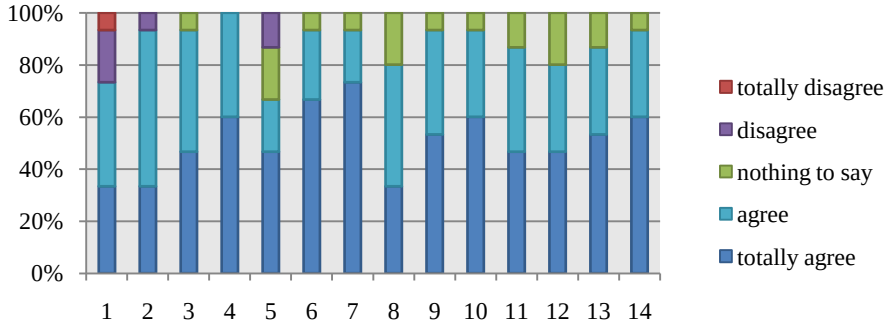


Fig. 9. Results of User Experience evaluation questionnaire.

7 Discussion

7.1 Leisure area layouts and the recognition of multiple models

The recognition of three sets of leisure area composition was always positive, even when using only the iPad, without external projection. Therefore, the leisure equipment of larger dimension did not interfere in the recognition of the ones of smaller dimension. It is important to say that the chosen angle for static visualization did not cause occlusion of any equipment.

Therefore, when visualizing three different layouts, through the iPad fixed on a tripod, the participant was able to associate the equipment that had been recognized individually to the ones that were being seen on the iPad screen. In other words, thanks to the phenomenon of the shape constancy, described by [16], the previous individual recognition allowed the participants to memorize the equipment´s shape and, lately, even with the angle variation and distance, it was possible to recognize all of them.

This question was highlighted by the verbalization of some participants who stated: “I know that tables are round because I saw them before, the park benches too. The other equipment is really the model that we have in mind. Like the children’s playground, it is very colorful”; “As I could individually see before, now it is easy to understand”; “I only know it is a Gym because I had seen it standing alone, it is the most confusing”. The conclusion is that the models of equipment that have a small dimension, such as the park benches, or comprised of devices of a small dimension, such as the open-air gym, are more difficult to be seen as a set and need a previous recognition to be used. At this moment, the ones that chose to visualize using only the iPad screen pointed out that the colors were more vivid and the definition wasbetter in this situation – factors related to the quality of the iPad’s image resolution. To express

this question, some phrases were mentioned, such as “The color stands out”; “There is more definition on the iPad screen”; “Here (pointing to the iPad) there are more details”. The ones who preferred to visualize using the external projection said “it gets larger in the projection”. This option was chosen by the participants who had some kind of visual impairment and verbalized it: “I am without my glasses, so seeing it on the wall is better (referring to the projection); “I am getting old, with a tired eyesight, so I prefer there (in the projection)”.

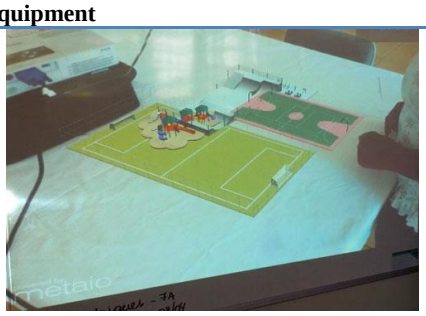
7.2 Forms of visualization and participant mobility

All the participants were able to conclude the task of composing a leisure area using AR. However, it does not mean that they did not have difficulties, since some of them had no familiarity with the use of mobile devices and were over 41 years old. These people were insecure about holding an iPad to visualize and handling the markers.

One example of the difficulty can be demonstrated by the sequence of photos shown on **Fig. 10**, in which one participant tries to organize the leisure area positioning the markers on a table, without considering the dimensions of the equipment. At first, the user picked the markers one by one, turned it over, visualized by the projection and chose the set of equipment she wished. Then, she positioned markers on a table, without visualizing the result in AR. When she saw in AR the result of her composition, she said: “Oh! It is on the... Oh...!”. The researcher asked her, then, to try to organize the equipment without composing one on top of the other. In the end, the user was able to elaborate the leisure area according to her wish.

Participant identifying the leisure equipment

Participant positioning the markers on the table



Partial result of the equipment organization – in which the participant is not visualizing in AR

Participant reorganizing the equipment at the same time she visualizes in AR

Fig. 10. Development process of one participant that presented some difficulties.

Some participants felt the need to previously identify the leisure equipment to be used. This was verbalized as follows: "How am I going to know who is who?" "Are there names behind the markers?". Such comments showed the need for the inclusion of a brief textual description to facilitate the choice of the desired equipment. If the participant does not need to constantly visualize in AR - one by one to choose which equipment to use - the process tends to be faster.

The majority of the participants opted for the use of the iPad fixed in conjunction with the external projection. The familiarity with the use of mobile devices influenced the visualization form (iPad fixed or mobile, with or without external projection) during the activities performance.Out offifteen participants, nine confirmed they were using a tablet for the first time or seldom use a smartphone or tablet, characterizing the low level of familiarity with the mobile devices. Among these, eight chose to position the iPad on a tripod and use the external projection for visualization. Analyzing these data, the conclusion is that this strategy could have been adopted, not only for being considered the best form of visualization, but also for lack of familiarity with the use of this kind of mobile device.

When the participant held the iPad, the AR was visualized in the same position it was before, with the same point of view. On the other hand, when it was used in a fixed position with external projection (situation in which some participants chose in order to have free hands during the task development) the point of view of the external projection was different in relation to the participant's position, generating

confusion and difficulty in the composition of the leisure area. This way, as mentioned by [17], the visual disorganization can cause ambiguity or difficulty of comprehension for contents in AR. Corroborating with this question, one participant declared: "Just a second, it's a bit confusing, I am in one place and the iPad in another [...]"- referring to the point of view different from his. This observation matches the study of [18] that compared the visualization by HMD versus the visualization by a computer monitor. These authors concluded that, when the users visualized the AR using the HMD, they had a better performance developing the tasks. In the same way, it was observed in this User Experience evaluation that, when the users moved the iPad, they visualized the AR from the same point of view they were before and that this situation facilitated the understanding of what was being seen.

Among the participants with little familiarity with the use of smartphones and tablets, it was observed more difficulty to handle the markers and organize the urban equipment of leisure areas than the others. The participants who were not accustomed to using mobile devices behaved in a more reserved way, with less agility during the tasks' performance. Consequently, the familiarity with the mobile devices interfered in the behavior during the task execution. Stressing this observation, if was noticed that all five participants, who indicated that the task of composing a leisure area using AR was difficult, also declared the use of an iPad for the first time or seldom use of smartphones or tablets.

The age, gender and education level of nine participants with little familiarity with mobile devices varied a lot. Among these, four participants declared it was difficult to compose a leisure area using AR. All were female over 41 years old, with education up to a high school level. Therefore, in this User Experience evaluation, the age, gender and education level influenced the difficulty of developing the task. However, it is important to stress that this affirmation is based only on the statements the participants gave at the end of the evaluation in relation to the difficulty of the task execution to compose a leisure area.

From all the participants, only one declared that the way to interact with the urban equipment in AR was not natural; the same participant also affirmed having had difficulty when composing the leisure area using AR. This participant was over 51 years old, female, with education up to junior high and with little familiarity using smartphones or tablets. As there were no more similar cases, it is not possible to draw a conclusion with regard to this question. However, the age group over 41 years old, low education level and little familiarity with the use of mobile devices may have contributed to a greater difficulty interacting with the system.

Among the 15 participants, two declared that the AR system did not have all the desired equipment and other three said nothing about it. This is justified by the fact that only seven different urban equipment of leisure areas were used and did not fulfilled the needs of the participants. During the task performance the participants were encouraged to speak about the experience, express their difficulties and present their ideas - similar to [19]. The desire to use more equipment was evident in the comments registered: "It would be good to use the same equipment twice, I would like to use another multi-purpose court"; "I wanted a swimming pool. A pool is

everything!".

8 Conclusion

All the participants were able to recognize multiple leisure equipment simultaneously, even using only the iPad on a tripod, without the option of external projection. The three different layouts tested did not interfere in the result obtained.

Despite the initial difficulty of some, all the participants were able to organize a leisure area with the available equipment. To overcome the initial difficulty, it was necessary to allow all the participants to experiment this technology previously, in order to familiarize themselves with the language of this media.

Differently from the research of [8], in this User Experience evaluation, in general, the participants showed interest in participating, despite their age, familiarity with mobile devices and the AR system. This contributed to the performance of the participants in the tasks.

The majority of the participants chose to use the iPad fixed in conjunction with the external projection. The familiarity with the use of mobile devices influenced the visualization form (iPad fixed or mobile, with or without external projection) during the activities performance. Also, among the participants with little familiarity with the use of smartphones and tablets, it was observed more difficulty to handle the markers and organize the urban equipment of leisure areas than the others.

The result obtained in this evaluation allowed for the development of new directives for the AR technology to be used in PD, that is:

- For the recognition of a set of virtual models (without manipulation), it is recommended the use of an iPad associated with an external projection. This device can stand on a tripod in an angle that allows the visualization of all the set, without occlusions.
- Before the participants have to use the AR system to compose with virtual models, it is necessary that each one of the models to be used be recognized individually. Therefore, it is recommended to perform a section of tuning of recognition before performing the tasks.
- It is necessary to enable a period of use for the participants to familiarize themselves with language of this media. Having the chance of experimenting AR before, the participants can focus on performing the task and not on finding out how to use the system.
- The inclusion of a brief textual description below the image of the marker is indicated to facilitate the choice by the desired equipment.

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