Teacher Readiness to Adopt Game-based Mobile Learning With Augmented Reality

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Abstract. Mobile augmented reality (AR) games have potential in Education, as they can enhance learning experiences, by offering to learners contextualized information. This study aim is to reveal teachers' readiness to adopt these strategies, after training. Hence, this is a case study of two editions of a workshop under the EduPARK project, designed to support teachers' adoption of strategies involving game-based mobile learning with AR. The workshops required collaborative exploration of the EduPARK app and educational resource planning. Data collected from individual questionnaires and focus group interviews were analysed through content analysis, descriptive statistics, and computing of the Educational Value Scale and of the System Usability Scale. The 45 teacher-trainees consider they are ready to integrate mobile AR games in their practices, but they are foreseeing difficulties that need to be addressed. This work presents a typology of teacher training that, according to the participants, is successful in promoting their readiness to adopt innovative practices.

Keywords: Mobile Learning, Augmented Reality, Game-Based Learning, Outdoors, Teacher training, Case study.

1 Introduction

Nowadays, the ubiquity of mobile technologies is highly recognized both in academia and in non-academia contexts. The use of mobile devices for educational purposes has been a growing field of research with a history of positive empirical results [1]. Moreover, the use of these devices in game-based learning approaches has also been documented as effective [2]. These educational approaches, when combined with emerging augmented reality (AR) technologies, can enhance learning experiences, as they can enrich and contextualize learning information offered to learners [3].

Mobile AR games have been adopted for educational purposes only recently [4]. Yet, research so far has been quite enthusiastic regarding their potential for education [5] and offers guidelines for their use in education [4, 6]. It's time for teachers to adopt these approaches, but they must feel familiar with those technologies.

Additionally, literature has reported the need of teacher training in AR [7], game-based learning [8] and mobile learning (mLearning) [9].

This paper reports a research study carried out with the purpose of unveiling teachers' readiness to adopt AR game-based mLearning practices, after teacher training on these issues. Previous works presented in the literature [10–12] rely mainly on quantitative methodologies to measure constructs related to technology acceptance. However, given the scarcity of research analysing in-service teacher adoption of game-based mLearning with AR, a more qualitative approach is needed to fully understand this phenomenon. For that aim, a case study was conducted on two editions of a workshop designed to support teachers' adoption of AR game-based mLearning, which remain innovative strategies in the Portuguese context. The choice of this case study is related to the authors' privileged access, who were involved in both editions of the workshop, thus allowing an in-depth analysis. The workshop was developed under the EduPARK project (http://edupark.web.ua.pt/?lang=en) and offered teacher-trainees the opportunity to collaboratively explore the EduPARK app, an interactive, mobile app that integrates quiz-like treasure hunt games with AR experiences [13, 14]. This app, freely available through the project website, was developed to promote contextualized and authentic learning in the Infante D. Pedro Park (in Aveiro, Portugal), so the workshop was conducted entirely in this outdoor learning environment. The workshop also prompted trainees to plan educational resources, having the model of the educational resources of the experienced app, allowing them to appropriate these technologies and educational strategies. The novelty of this work relies on an in-depth analysis of a typology of teacher training that, according to the participants, is successful in promoting their readiness to adopt innovative practices.

The following sections of this paper include: i) literature related to game-based learning, mLearning, and AR use for educational purposes; ii) the case study methodology, which includes the case's/workshop's description and the data collection and analysis techniques; iii) the presentation and discussion of the results organised according to the four objectives of this study; and, finally, iv) the concluding remarks that summarize this study main findings, limitations, recommendations and lines of future work.

2 Related literature

This section presents a brief analysis of literature on game-based learning, mobile learning (mLearning) and augmented reality (AR) use in education, which theoretically framed the workshop for teachers analysed in this study.

Games capitalize the natural human activity of playing, which is recognized as having an important role in learning [15, 16]. Several types of learning emerge while playing games, as players may learn: a) to do things (to fly airplanes, to drive fast cars, to be civilization builders, etc.); b) to gather information from different sources and make decisions; c) to deduce the game's rules from playing instead of being told; d) to create strategies for overcoming obstacles; e) to understand complex systems through experimentation; and f) to learn to collaborate with others [17]. Besides

supporting learning of high-level skills, games are also highly competent in promoting player engagement [17] and motivation [4, 16, 18].

Considering the above, it makes sense to use game-based approaches in education. Games educational potential includes keeping students in learning tasks [15], and transferring game-acquired capabilities or attitudes to non game contexts [16, 18]. However, learning gains from games may result from increased time spent by learners playing them [18].

Games have been pointed as disrupting the traditional instruction structure, as they require longer lessons, cross-subjects approaches, social learning, among others [16]. To be effective and support learners in achieving the desired learning goals, game-based approaches need to be carefully designed and integrated into the curriculum [15, 18, 19]. Still, to be able to use these approaches, practitioners need effective supporting materials (guidelines, case studies and practice exemplars), training offers and time to explore and experiment existing tools and game spaces [20].

Game-based learning approaches can be supported by mobile devices, as smartphones or tablets. Their increasing pervasiveness facilitates learning "anytime, anywhere", that is, across physical locations, educational contexts and time [21, 22]. To leverage this pervasiveness, teachers need to be aware of both the advantages and constraints of mobile devices for teaching and learning processes [23]. Among mLearning advantages are their potential to promote innovation in teaching and learning practices, to extend the learning environment and to promote collaborative practices [9]. The proliferation of mobile hardware and apps supports a high variety of contextual and situated learning activities [24]. Criticisms include students off-task behaviour, cheating, cyberbullying and accessing inappropriate content on the Internet [9]. Moreover, instruction involving mobiles requires a high level of teachers' preparation [19], who may not be tech-savvy. Nevertheless, studies reveal evidence of positive educational impacts from using mobile technologies in education [19] The positive outcomes depend on different variables, such as the promotion of teachers' empowerment, a strong technical team or even the implementation context (formal vs informal) [19, 25]. Mobile devices can also support AR experiences, as their camera feed can sustain real-time visualization and interaction with virtual elements (e.g., 3D models, annotations, and videos) overlaid on top of real objects in the physical world [4, 26]. AR content can be triggered, e.g., by image recognition or by the user's location (from GPS or wireless network). In educational contexts, AR can make boring learning content more enjoyable, be used to provide immediate feedback, or support autonomous learning. So, AR has potential to increase learning performance; however, its pitfalls include usability and GPS related problems [27]. Once more, the incorporation of AR into educational practices for an effective learning, instead of for merely beautiful scenography, requires training in teaching methodologies with AR technologies [28].

Integrating emerging technologies in teacher training is acknowledged as essential to both the innovative use of ICT in education [29] and the innovation in pedagogical practices [30]. In the case of mLearning, some authors [19] point that implementing effective programs requires teachers' preparation, through professional development, and highlight that teachers should be encouraged to customise existing research-based programs, minimizing the workload and time needed to innovate their practices. In this line, the research presented in this work analyses a teacher training initiative that

integrates mobile AR technology, supporting game-based learning to determine teachers' readiness to adopt these approaches after training.

3 Methodology

This work follows a case study approach [32] as it presents an in depth analysis of two editions of a workshop designed to support teachers' adoption of teaching strategies involving game-based mobile learning (mLearning) with augmented reality (AR), conducted under the EduPARK project. The workshops, which will be described in Section 3.1, involved 45 in-service teachers from several subjects and school levels. The research question is "What is teachers' readiness to adopt game-based mLearning with AR practices after a teacher training intervention on the topic?" so, the objectives are:

1. To assess teachers' self-reported training needs that prompt them to seek teacher training and if those needs are perceived as met;
2. To elicit teachers' perceptions on the development of mLearning strategies in their practice, after attending a teacher training on these issues;
3. To uncover teachers' assessment of an app – the EduPARK app – that aims to promote game-based mLearning with AR, regarding the app's: i) learning value, ii) intrinsic motivation, iii) engagement, iv) authentic learning, v) lifelong learning, and vi) conservation and sustainability habits;
4. To determine the usability of the EduPARK app.

3.1 The case: EduPARK workshop for teachers

The project EduPARK main challenge is the creation of original, attractive, and effective strategies for cross-subjects learning in Science. For that, the project team developed a mobile application (app) for Android devices through a design-based research methodology, which was presented in previous works [e.g., 5, 14, 33]. The EduPARK app, freely available on the project website (http://edupark.web.ua.pt/instalar), is interactive, includes AR contents, contains cross-subjects information and challenges, and integrates Geocaching principles (hunting virtual treasures/caches) to promote outdoor learning. The app was developed for teachers, students and the public to explore an urban green park in Aveiro (Portugal), the "Infante D. Pedro" Park, with a high botanical diversity and historical patrimony [34]. The EduPARK team designed and integrated in the app cross-subjects learning guides, or quiz games, developed for specific audiences: 1st cycle of basic education (1CBE); 2nd and 3rd cycles of basic education (2&3CBE); secondary and higher education (SHE); and tourist or public in general (tourist). These guides were developed in articulation with the Portuguese National Education Curriculum. The innovation of the EduPARK project relies on the articulation of: the use of a new and easy to explore AR mobile app; game-based learning in outdoor environments; and cross-subjects educational materials (the guides) [5]. More

information regarding the project is found in its website (http://edupark.web.ua.pt/?lang=en) or in [13].

To better articulate educational practices and research in educational sciences, the EduPARK project promotes accredited teacher training that incorporates recommendations from the literature on AR game-based mLearning. One teacher training initiative was the "EU AMO EduPARK - Educação Ubíqua com a Aplicação Móvel Outdoor EduPARK" [I LOVE EduPARK - Ubiquitous Education with the Outdoor Mobile Application EduPARK], a 4h-workshop conducted entirely in the outdoors, in the "Infante D. Pedro" Park. It was developed in two editions, one in 2018, after the end of the school year, and another in 2019, near the end of the school year. Both editions of the workshop were accredited, so that teachers could get credits for their career progress.

The workshop involved a total of 45 teacher-trainees from several subjects and school levels, 26 in the first edition and 19 in the second. In the first workshop edition, the teacher cohort comprised 23 female and 3 male trainees, with an age range from 28 to 62 years-old (average of about 48), revealing an experienced group (from 15 to 38 years of teaching, except for one teacher who was in her first year) that might not be as proficient in the use of modern technology as their students. All teachers had High Education courses, most High Degrees (21) or higher (remaining 5).

In the second workshop edition participated 18 female teacher-trainees and 1 male, with an age range from 46 to 65 years-old (average of about 56). This is also an experienced group, with 21 to 38 years of teaching experience. Once more, all teachers had High Education courses, 16 with High Degrees and 3 with other higher education courses. Reported previous experience with game-based and/or AR-based learning technologies were scarce in both teacher cohorts.

Fig.1. Photographs of the first edition of the workshop: a) in the presentation of the EduPARK project, when the trainers contextualize teachers on mobile, AR and game-based learning approaches, b) and c) teachers are exploring the EduPARK app *in loco*.

The main purpose of the workshop was to disseminate the app and educational practices involving AR game-based mLearning in the park. This workshop was based in the assumption that being familiar with new practices is a requirement for developing new competencies and changes in the installed practices. The workshop (Fig. 1) followed the structure: i) presentation of the EduPARK as an example of a research & development project based on games and mobile AR technologies in the outdoors; ii) exploration, *in loco*, of the EduPARK app for collaborative game-based learning with AR, as if teacher trainees were students; iii) collaborative planning of

activities and creation of educational resources that may be integrated in an AR mobile game-based educational app, to implement with students; and iv) evaluation of the implemented activity and of the workshop.

The authors of this paper were the workshop trainers and initiated it with a brief presentation of their own background, as well as of the game-based learning approach and mobile AR technologies exploration for learning in the outdoors. The EduPARK project was presented as an example of how those strategies may be articulated in practice, so trainee-teachers were contextualized with information regarding: the main aim of the project; the adopted pedagogical framework (including contextualized and authentic learning); the methodological options for reaching the project's aim – the creation and exploration of an interactive app with AR games for cross-subjects outdoor learning; the app features; and main results from activities with users, such as increased student motivation and engagement with learning, changing mentalities on how mobile devices and game-based approaches can promote learning. The focus of this discussion did not include advantages nor constraints of mlearning, game-based learning and AR-based learning, so it would not create validity issues regarding data collection.

After the initial contextualization, teachers were associated in small groups (from 2 to 4 members), based on common interests and school levels they taught, to explore one of the four learning guides in the park. Each group used only one smartphone (owned by one of the participants), in order to promote collaborative dynamics.

Table 1 presents game data that were collected anonymously at the end of this part of the workshop. In the first edition, 5 groups selected the 2&3CBE guide, 3 groups selected the 1CBE guide, and 1 group selected either the SHE or the tourist guides. The task of playing the selected game lasted between about half an hour to two hours (the group with the tourist guide). The groups' variable time on this task (from about half an hour to two hours) can be partially explained by the variable number of quiz questions in each learning guide, from 27 in the guide for the younger students, to 35 in the secondary/higher education guide, having the remaining two guides 29 questions. The other factor that may have contributed to the differences in the time of play is the intensity of exploration of the AR and multimedia resources. The groups' percentage of rightly answered questions varied from 77.1% to 100% (two groups). Three groups did not catch one hidden treasure (cache).

In the second edition, 5 groups also selected the 2&3CBE guide, and only 1 group selected the SHE guide. The activity lasted between one hour and fourteen minutes and one hour and forty-one minutes (the group with the SHE guide). The groups' percentage of rightly answered questions varied from 90.3% (two groups) to 96.8%. One group cached only 2 caches, two groups cached 3 caches and three groups cached all the caches. Overall, the groups' performance in both editions of the workshop was good to excellent.

After the experience of exploring the app in the park, teachers collaboratively developed one activity with original questions that could be used in a game-based mlearning. These activities were orally presented and discussed in the workshop.

Finally, the closure of the workshop included the evaluation of the EduPARK activity & app, as well as of the workshop itself. For that, trainees filled in an individual questionnaire that is described in the following section.

Table 1. Game data results from the groups of teachers of the two workshops.

Group	Learning guide	Number of participants	Number of right answers	Percentage of right answers	Number of caches	Final score	Time on task
WS1A	Tourist	3	22	81.5	3	245	**02:02:37**
WS1B	2&3CBE	3	30	96.8	3	332	01:23:11
WS1C	2&3CBE	3	31	**100.0**	4	346	00:50:05
WS1D	2&3CBE	2	28	90.3	4	305	01:29:22
WS1E	SHE	2	27	**77.1**	4	288	01:33:03
WS1F	1CBE	2	25	92.6	4	274	01:24:24
WS1G	1CBE	3	25	92.6	4	296	01:41:07
WS1H	1CBE	2	24	88.9	3	255	01:27:32
WS1I	2&3CBE	4	30	96.8	4	338	01:45:10
WS1J	2&3CBE	2	31	**100.0**	4	352	**00:28:34**
WS2A	2&3CBE	4	30	96.8	4	338	01:14:56
WS2B	2&3CBE	3	28	**90.3**	3	310	**01:14:36**
WS2C	2&3CBE	2	28	**90.3**	3	321	01:18:17
WS2D	2&3CBE	3	29	93.5	2	325	01:15:17
WS2E	SHE	4	32	91.4	4	342	**01:41:19**
WS2F	2&3CBE	3	29	93.5	4	334	01:25:09

1CBE: 1st cycle of basic education; 2&3CBE: 2nd and 3rd cycles of basic education; SHE: secondary and higher education.

3.2 Data gathering and analysis

This research relies on two sources of evidence to answer the research question, as two data gathering instruments were used to triangulate quantitative and qualitative data: mandatory workshop evaluation individual questionnaire; and voluntary focus group interviews. Both data sources give access to teachers' opinion on their readiness to adopt game-based mLearning with AR, taking as an example their experience with the EduPARK app, which explores those strategies.

The questionnaire comprises five sections, mainly with closed questions in a Likert scale. One section collected basic demographic data, such as age and gender, use of mobile devices to promote learning and their advantages and disadvantages in Education. The following section collects information regarding the teachers' evaluation of the EduPARK workshop, for example with questions about their interest regarding the activity of playing the EduPARK game in the park, their intention of using this approach with their classes and if they recommended it to other teachers. The next section refers to a version for teachers of the Educational Value Scale (EVS) [35]. This scale's items (e.g., "This app helps you fostering curriculum related learning") may be partially associated with Venkatesh et al. [11] performance expectancy construct (e.g., "Using the system increases my productivity"), as teacher

perception on the new technology capacity to contribute to student learning is a gain in teacher job performance. The following section is based on the System Usability Scale (SUS) [36, 37]. This scale items (e.g., "I thought the system was easy to use") can also be associated with another Venkatesh et al. [11] construct, the effort expectancy (e.g., "I would find the system easy to use"). According to [10], teachers' perceived ease of use of mobile technology seems to be positively related to their intention to use them in their teaching practice. Venkatesh et al. [11] remaining constructs have not associated items in this study questionnaires because: a) social influence does not seem to influence intention of use in voluntary settings, which is the case of this study; and b) the workshop under study cannot have an impact on most dimensions of the facilitating conditions construct, namely having access to the required resources (as the smartphone). The last section is devoted to the workshop evaluation. The questionnaires were implemented at the end of each workshop and, thus, the response rates were 100%. The average response time was 10 minutes.

The initial question of the focus group is about teachers' perceptions of the experience of using an app in outdoors as a teaching strategy. This is followed by questions regarding the EduPARK app impact on: i) learning value, ii) intrinsic motivation, iii) engagement, iv) authentic learning, v) lifelong learning, and vi) conservation and sustainability habits, which correspond to the assessed dimensions in the EVS. The final question prompted teachers do add any further reflections. Five interviews were performed to a total of 11 teachers.

As to questionnaire data analysis, individual SUS scores and EVS scores were computed according to Brooke [36], with values varying from 0 to 100. In the present study, SUS scores were interpreted according to Sauro [38] and to Bangor et al. [39]. The remaining data were analysed through descriptive statistics and content analysis with predetermined categories was used for the interview data. These sets of data were triangulated to provide a more comprehensive knowledge of teachers' readiness to adopt game-based mLearning with AR practices. The analysis is presented in the next section.

4 Results and discussion

In this section the results are presented and discussed in four parts, each one addressing a research objective. Therefore, rather than presenting the results according to the data collection tool, they are organised by themes that contribute to answer the defined research question.

4.1 Research objective 1

To assess teachers' self-reported training needs that prompt them to seek teacher training and if those needs are perceived as met.

Teachers expressed their training needs by selecting reasons for enrolling in the EduPARK workshop (Fig.2). They selected an average of five reasons each and the three main reasons pointed by both cohorts for enrolling in the EduPARK workshop

were: i) getting access to new resources (38 teachers); ii) professional development (32); and iii) share experiences with colleagues (30).

The less selected reasons for enrolment were: i) getting a certificate (8); ii) the topic "Geocaching in Education" (15); and iii) the topic "mLearning" (24). Hence, the workshop topics reached a moderated-low importance, with a total of 66 selections. Two teachers selected the "Other" option, being their reasons for enrolment the following ones: "To boost what I learned in training at the University of [removed for peer review]!" and "I want to do the activity with a class".

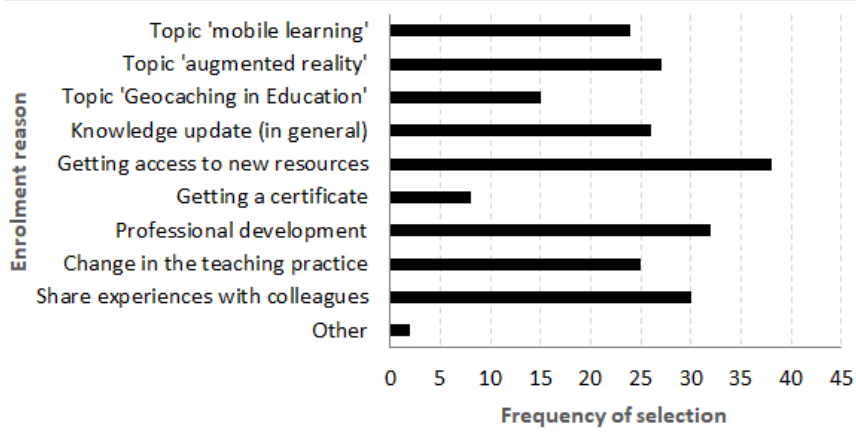

Fig.2. Teachers' reasons for enrolment in the workshop.

The relevance of providing adequate teaching material for mobile learning (mLearning) [40] and game-based approaches [20] was pointed before; however, our results empirically support these claims. It is worth noting that, despite most teachers enrolled in this workshop having 15 or more years of teaching experience, they are still concerned with getting access to new teaching resources. This result points to the relevance of developing high quality resources incorporating innovative technologies and teaching approaches. Moreover, these experienced teachers are also still interested in professional development and, hence, in updating their knowledge, although not necessarily in what concerns mLearning, augmented reality (AR) and game-based approaches. This aspect is illustrated by this citation from the focus groups: "We can't teach now how we taught five years ago; we have to be constantly updated because of the way technology and society are evolving" (teacher A).

Teachers' evaluation of the EduPARK workshop was very positive (Fig.3), revealing feelings of fulfilled training needs. The vast majority considered the workshop methodology suitable (39 teachers strongly agreed and 6 agreed with this statement), was strongly pleased to have attended the workshop (43 teachers) and would recommend attending this workshop to other teachers (41 teachers). The participant teachers highlighted that the workshop resources – mainly the EduPARK app – were very interesting (40 teachers), with activities with the right level of difficulty (34 teachers). Many teachers reported they felt prepared to integrate mobile devices in learning (21 strongly disagreed and 12 disagreed with the negative

sentence). This result seems to point to the need of providing multiple opportunities for the teachers to experience and explore emergent technologies and teaching approaches, before feeling able to use them in their practices.

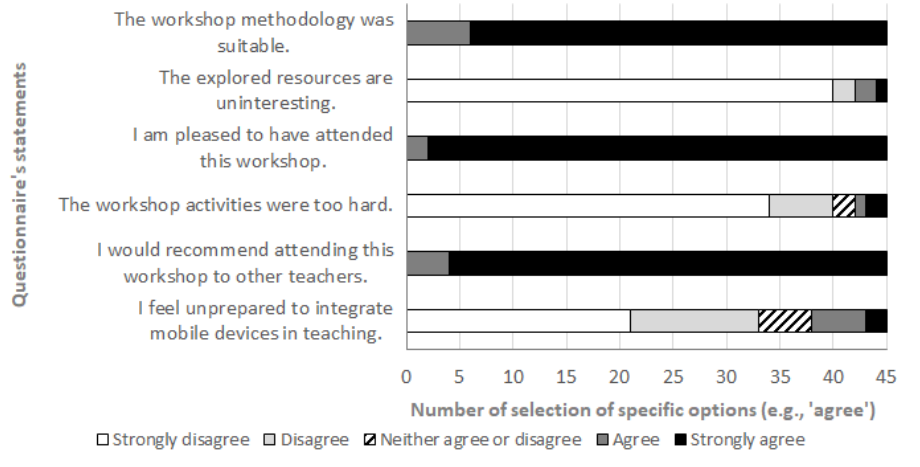

Fig. 3. Teachers' evaluation of the EduPARK workshop.

4.2 Research objective 2

To elicit teachers' perceptions on the development of mLearning strategies in their practice, after attending a teacher training on these issues.

To address this research objective several aspects are analysed, such as devices ownership, their use in teaching practice and their advantages and disadvantages. Most teachers (38) referred owning an Android device and claimed they sometimes used mobile devices to promote learning (31). Only 9 teachers mentioned they never had used mobiles for that purpose and 9 claimed they used them frequently to promote leaning. Considering that [41] found that male future teachers seem to have a better disposition towards the use of mobiles in teaching practice, one could expect this study's cohort of mainly female teachers (41) to reveal a low propensity for mLeaning. However, participating teachers showed a positive perspective, as each one acknowledged 1 to 7 advantages of mLearning, with an average of 5. This applies to both female and male teachers. Regarding age, both workshop cohorts were composed by teachers mostly over 41 (only two exceptions), so the age moderator was not analysed. The high number of mLearning advantages pointed by teachers reveals some degree of openness to the adoption of these technologies in their practices, regardless gender.

Fig.4 shows the level of agreement with each mLearning advantage sentence. The most selected were: "you can learn in a fun way" (36), and "it motivates to learn" (34), followed by "you can learn in a different way" (33), "it is easy to carry; it is always at hand" (33) and "it is easy to find the information I want" (33). Also, three

teachers added new gains: “it facilitates teachers work, namely in assessment”, “it allows diversifying methodologies’ and ‘it prepares for future technological advances”. This last concern aligns with the literature regarding the aim of “equipping young people with the skills for living and working in a digital age” [29].

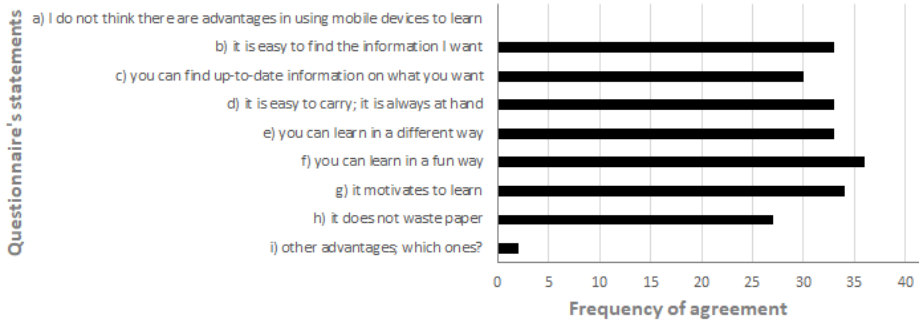

Fig. 4. Teachers’ opinion about advantages in using mobile devices to promote learning.

Two teachers did not recognize any difficulties in the use of mobile devices to promote learning (Fig.5). Both these teachers claimed they were already using mobile devices frequently in their practices, indicating some relation between difficulties recognition and mobile devices’ adoption. However, most teachers selected 1 to 5 difficulties, with an average of 3 (3 for female teachers and 3.25 for male). The most mentioned were: “increased battery consumption” (27 teachers), “risk of developing mobile device dependence” (26 teachers) and “prohibition of mobile device use in classes” (22 teachers). Other relevant difficulties were “not knowing how to use mobile devices to learn” (18 teachers) and “access to distractions” (15 teachers).

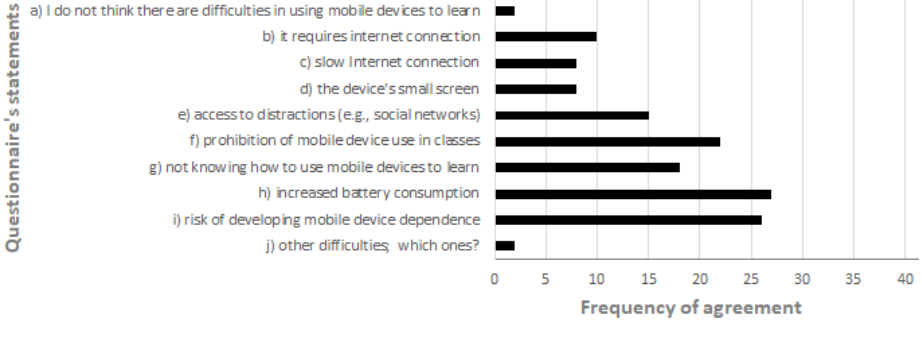

Fig. 5. Teachers’ opinion about disadvantages in using mobile devices to promote learning.

Finally, 2 teachers identified an additional difficulty, the lack of access to mobile devices from some students. These results indicate teachers are foreseeing some difficulties in the integration of these technologies in their practices that need to be addressed, e.g., by presenting them battery charging solutions in the outdoors. This cohort of teachers echoes concerns found in the literature regarding students’ of-task

behaviours [9, 29], reinforcing the position of those supporting mobile technologies' ban from schools. Curiously, this prohibition was pointed by these cohorts of teachers as one of the main difficulties in mLearning integration in their practices. Not knowing how to use these technologies to learn was also a relevant difficulty for teachers. The EduPARK approach contributes to reduce some of these constrains, as it supports teachers' learning in the use of mobile devices to learn and offers them an experience of using that technology for educational aims and the opportunity to acknowledge and reflect upon mobile devices' potential to enrich their practices. Moreover, on the student side, the EduPARK approach reduces students' use of other mobile device software, as they are engaged with the game in the park [5, 42].

All teachers in the focus groups reported finding the EduPARK activity very interesting. One even mentioned "Excellent. I was amazed!" (teacher E). However, being interesting does not always mean integration in their practices. Nevertheless, it seems an activity they would recommend to other teachers (as mentioned above).

4.3 Research objective 3

To uncover teachers' assessment of an app – the EduPARK app – that aims promoting approaches of game-based mLearning with AR, regarding the app's: i) learning value, ii) intrinsic motivation, iii) engagement, iv) authentic learning, v) lifelong learning, and vi) conservation and sustainability habits.

Participant teachers revealed a positive perception regarding the EduPARK app educational value (Fig. 6). For instance, 37 teachers strongly agreed and 5 agreed with "This app helps you fostering curriculum related learning" that assesses positively the app's learning value. Similarly, but opposite results emerge from "This app shows information in a confusing way", with 35 strongly disagree and 8 disagree classifications. These results are in line with the focus group data: "This is a way of taking advantage of (…) a technology they [students] handle very easily, and that is part of their daily lives, to increase their scientific capital" (teacher A).

Identical results can be found for the remaining indicators. Teachers classification of sentences regarding intrinsic motivation reveal they consider the app motivator for students, which is reinforced by the focus groups: "It motivates students. The game serves a competitive spirit and helps them to want to learn to win" (teacher B); "what will make a difference (…) is the part of the augmented reality. (...) for most of them it will be a novelty and it is a novelty to use it in learning" (teacher C).

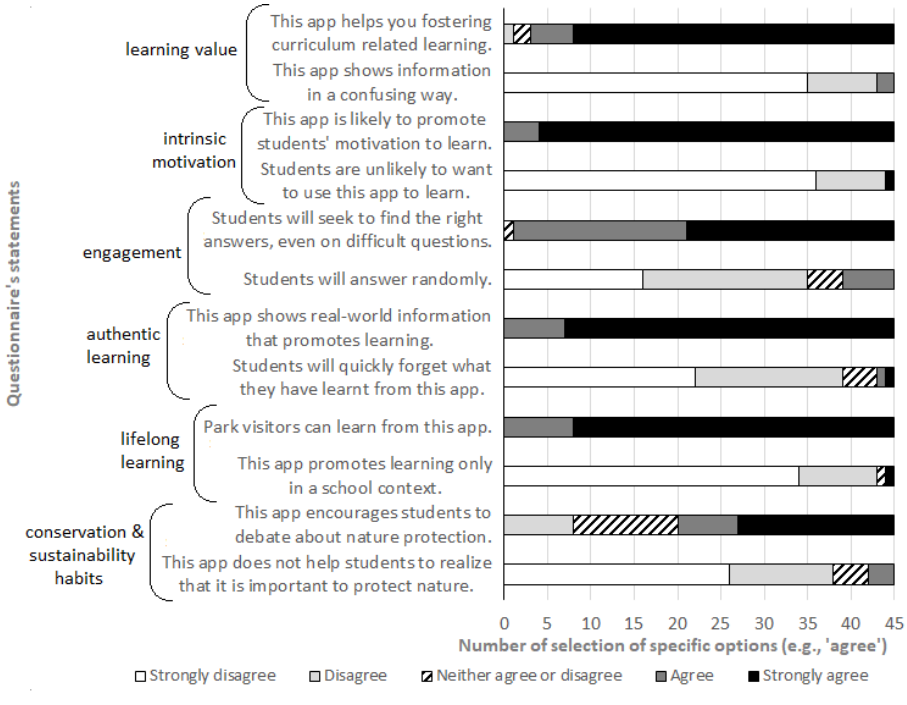

Fig. 6. Teachers' opinion regarding the educational value of the EduPARK app.

Regarding engagement, teachers seem less enthusiastic (questionnaire data), but still on a positive view: "a 2nd/3rd cycle student would probably see half of what I saw (…). I think just the simple attempt (…) is very positive" (teacher D); "It can increase students' engagement in learning because if they are motivated, they will try harder" (teacher E). Teachers also consider this app can promote authentic learning: "It's not just exploring the information on the device, but also seeing the reality (…). And then all the scientific knowledge they will appropriate from this observation" (teacher E). Moreover, the apps contribution for lifelong learning was also reckoned: "Anyone, who is minimally curious and likes to learn, comes here and [with the app] remembers things that he/she has learned and that were forgotten" (teacher G). Finally, the indicator that gathered the least consensus was the app' contribution for conservation and sustainability habits: "This would imply changes in their daily life. (…) I think that required a more direct connection to how they would make decisions in their daily lives" (teacher A); "I think so. Knowing more about a tree, maybe we end up liking it, and then we start creating habits of conservation and sustainability" (teacher F). EVS score values ranged from 66.7 to 100, with an average of 88.2 (88.1 for female teachers, and 89.6 for male teachers), which seems to be a high value, although more studies are needed to sustain that claim. These results reveal that the EduPARK app has educational value for the participant teachers in the two editions of the workshop. As high EVS values can be associated to high performance expectancy, which was found to be the strongest predictor of intention to use [11], this study results also seem to indicate that the participant teachers intended to use mobile AR

games in their practices. As mentioned before [11], behavioural intention was shown to have a direct effect on actual technology usage, so it seems reasonable to consider that both teacher cohorts are likely to use mobile AR games in their practices. This tendency seems stronger for male teachers; however, the number of participants in this study (only 4 male teachers in a sample of 45) does not allow taking conclusions.

4.4 Research objective 4

To determine the usability of the EduPARK app.

Participant teachers' opinion of the EduPARK app usability is also positive (Fig.7) as, e.g., 37 teachers strongly agreed and 6 agreed with the statement "I would like to use this app again" and 31 strongly disagreed and 9 disagreed with the statement "This app is very complicated to use". SUS score values ranged from 60.0 to 100, with an average of 86.3 (85.9 for female teachers and 90.0 for male teachers), which is a higher value than the average SUS value (68) computed by Sauro [38]. Moreover, according to the classification of Bangor et al. [39], the app achieved an excellent usability for this cohort of teachers.

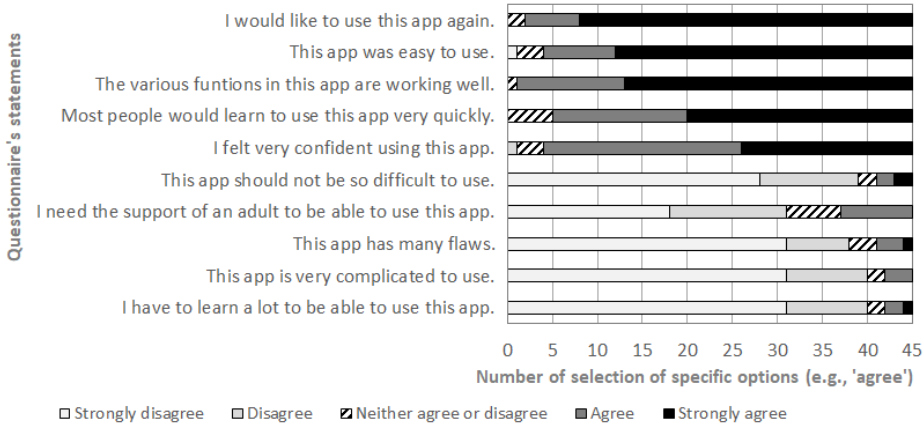

Fig. 7. Teachers' opinion regarding the usability of the EduPARK app.

As high SUS value can be associated to low effort expectancy, this study results also seem to indicate that the participant teachers intended to use and, thus, are likely to use mobile AR games in their practices.

5 Concluding remarks

This case study analyses teachers' readiness to adopt mobile games with augmented reality (AR) in their teaching practices after a workshop on these issues under the EduPARK project. Two editions of the workshop were conducted and the cohorts comprised mainly very experienced female teachers, who identified their training

needs as: i) getting access to new educational resources, the EduPARK app; ii) developing professionally, although not necessarily in what concerns knowledge update regarding mobile learning (mLearning), AR and game-based approaches; and iii) sharing experiences with colleagues. The EduPARK workshop fulfilled those needs, as the educational resource explored during the workshop, the EduPARK app that integrates mLearning with games and AR, was considered interesting. However, not all teachers reported feeling prepared to integrate mobile technologies in their practices after attending the workshop; hence, more training experiences in this area seem to be necessary.

Overall, teachers' perceptions on mLearning are positive. Most of them possess their own device and even claim to sometimes promote learning with these technologies. Teachers acknowledge in mLearning both advantages, such as learning in a different way and increased student motivation; and difficulties, such as battery consumption and risk of mobile device dependence. However, both female and male teachers selected more benefits than constrains, reinforcing the claim of teachers' positive view regarding mLearning. This indicates some degree of teacher openness to the adoption of mobile technologies in their educational practices, regardless gender. Nevertheless, as most teachers are not currently using mobile technologies to promote learning on a regular basis, the difficulties identified in this study, such as students' off-task behaviour, must be taken into consideration and properly addressed.

Participant teachers' evaluation of the EduPARK app educational value and usability reveals that it can be a good starting point to promote mobile AR game-based learning. They acknowledged the app's high learning value, in an authentic way, as well as its capacity to promote students' intrinsic motivation and engagement in learning. Moreover, teachers mentioned the app can be used in a context of lifelong learning. Regarding the app contribution to the promotion of conservation and sustainability habits, data revealed that there is no consensus on the teachers' opinion. Furthermore, this resource has the additional advantage of being open, free of charge and easy to use by teachers, students, and any other visitors. As high educational value can be associated to high performance expectancy and high usability can be associated to low effort expectancy, participant teachers seem to intend to use mobile AR games in their practices. As the literature reports behavioural intention to have a direct effect on technology use, participant teachers are likely to use mobile AR games in their practices. This claim is supported by their reported feelings of being prepared to integrate mobile technologies in learning.

The results of this case study need to be interpreted with caution. Further studies are needed with bigger and more diverse samples to better understand teachers' opinions on mobile game-based learning with AR after teacher training. However, the access to teacher cohorts with other profiles is not easy to accomplish, as the teachers that participated in the studied editions of the workshop reflect very closely the Portuguese teacher profile [43, 44]. Another limitation of this study is the use of a convenient rather than a random sample, which is due to accessibility issues to teachers' opinions. Nevertheless, this study accomplished its purpose of eliciting these two teachers' cohorts readiness to adopt game-based mLearning with AR in their practices.

In sum, this study reveals that teachers seem ready to adopt mobile AR game-based approaches, a factor that must be taken in consideration by educational researchers

and teacher trainers concerned with these topics when planning their work. They may get inspired by the EduPARK workshop, as its relevance relies on: a) the integration of new technologies and teaching approaches – mobile devices, AR and game-based learning – in teacher training, a need identified in the literature [7–9, 29, 30]; b) it creates opportunities for the proper pedagogical use and to support the integration of technology-based innovations in practices, as recommended by [28, 45], particularly in what concerns to: why use these technologies?, what for?, and how to use them?; c) presenting to teachers a mobile AR game exemplar – the EduPARK app –, offering them time to explore and to experiment an existing tool; d) prompting teachers to develop learning content for the presented tool, as endorsed by [16]; e) effectively promoting teachers adoption of new teaching strategies, involving technological innovation, and increasing their confidence in using those technologies with their students; f) being entirely in an outdoor environment, illustrating the aimed educational methodologies *in loco*; g) making available the resource used to illustrate new practices, which is open and free, which is not a common situation in the literature [1].

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