Game-based mobile learning with augmented reality:
Are teachers ready to adopt it?

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Abstract. Although only recently mobile augmented reality (AR) games have been adopted for educational purposes, research recognizes their potential and offers guidelines for their use in education, to create smart-learning ecosystems. It's time for teachers to adopt these technologies, but are they receptive to them? The aim of this study is to reveal teachers' readiness to adopt mobile AR technologies in their practices, after training, bridging the gap between educational practices and research in educational sciences. This paper reports a case study based on a workshop designed to support teachers' adoption of teaching strategies involving game-based mobile learning (mLearning) with AR. The workshop was conducted under the EduPARK project and offered trainees the opportunity to collaboratively experience the use, *in loco*, of the EduPARK app for outdoor learning with AR, as well as prompted them to plan educational resources appropriating these technologies. Data were collected through individual questionnaires and focus group interviews and they were analyzed through descriptive statistics, the computing of the Educational Value Scale (EVS) and of the System Usability Scale (SUS), as well as content analysis. Results show that teachers consider they are ready to integrate mobile AR games in their practices but they are foreseeing difficulties that need to be addressed. This paper contributes to the field of teacher training in game-based mLearning with AR as it unveils teachers' readiness to adopt these technologies and why. Moreover, it characterizes a typology of teacher training in this area that, according to the trainee teachers, is successful.

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] and their use 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].

Only recently have Mobile AR games been adopted for educational purposes [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], to create smart-learning ecosystems. 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].

With the purpose of unveiling teachers' readiness to adopt AR game-based mLearning practices, after teacher training on these issues, a case study was conducted on a workshop designed to support teachers' adoption of these strategies. The choice of this case study is related with the authors' privileged access, who were involved in 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 trainees the opportunity to collaboratively use, *in loco*, of the EduPARK app. The workshop also prompted trainees to plan educational resources appropriating these technologies.

The following sections of this paper include: i) a brief theoretical framework on mLearning, game-based learning and AR use for educational purposes; ii) the case study methodology, which includes the case/workshop description and the performed data collection and analysis; iii) the results presentation and discussion; and iv) the concluding remarks that summarize the results, present this study limitations and emergent recommendations.

2 Theoretical framework

The increasing mobile devices pervasiveness has set the stage for the use of technologies to support learning "anytime, anywhere". Devices, as smartphones or tablets, allow user interaction with learning content and with others (both learning peers and experts) across physical locations, educational contexts and time [10, 11]. 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 [12], which, according to the literature, are linked to positive cognitive and affective results [10, 13]. Nonetheless, mLearning criticisms include students off learning task behaviour, cheating, cyberbullying and accessing inappropriate content on the Internet [9] and instruction involving mobiles require a high teachers' preparation [13], who may not be tech-savvy.

Mobile devices can support the use of game-based learning approaches in education. Games capitalize the natural human activity of playing, which has an important role in learning [14, 15] and their motivational and engagement qualities are recognized in the literature [4, 15, 16]. Therefore, it makes sense to use these approaches in education, as games potential include keeping students in learning tasks [14], transfering game-aquired capabilities or attitudes to nongame contexts [15, 16], among others. However, their learning gains may result from increased time spent by learners playing them [16]. Games have been pointed as disruptive of the traditional

formal instruction structure, as they require longer lessons, cross-subjects approaches, social learning, etc. [15]. Nevertheless, to be effective, game-based approaches need to be carefully designed and integrated into the curriculum, for learners to achieve the desired learning goals [13, 14, 16].

Finnaly, AR is one of the most recently emerging technologies that can leverege educational gains. Mobile technologies can support AR experiences, which involve real-time visualization and interaction with virtual elements (e.g., 3D models, annotations, and videos) overlaid on top of real objects from the physical world, through a real-time camera feed [4, 17]. 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 and can be used to provide immediate feedback as well as support autonomous learning. So, AR has potential to increase learning performance; however, its pitfalls include its usability and GPS related problems [18].

3 Methodology

This work follows a case study approach [19] as it analyses in depth a workshop designed to support teachers adoption of teaching strategies involving game-based mLearning with AR, conducted under the EduPARK project. 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 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;
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 [5, 20, 21]. The app, freely available in the Google Play Store, is interactive, includes AR contents and contains cross-subjects information and challenges, following Geocaching principles (hunting virtual treasures/caches) and promotes outdoor learning. The app was developed for teachers, students and the public to explore an urban park in Aveiro (Portugal), the 'Infante D. Pedro' Park, with a high botanical diversity and historical patrimony [22]. The EduPARK team designed and integrated in the app cross-subjects

learning guides, or quiz games, developed for specific audiences, from basic to higher education, but also for tourists/public in general. These guides were developed in articulation with the Portuguese National Education Curriculum.

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, after the end of school year. The workshop main purpose 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 followed the subsequent 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 work to plan activities and to create 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 workshop involved a total of 26 teacher trainees from several subjects and school levels.

3.2 Data gathering and analysis

Data were collected immediately after the workshop, through individual questionnaires and focus group interviews, providing multiple sources of evidence to answer the research question. 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, manly with multi-choice 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. Other section is about the interest regarding the activity of playing the EduPARK game in the park, the intention of use this approach with their classes and if they would recommend it to other teachers. Other section refers to the Educational Value Scale (EVS), and another section is based on the System Usability Scale (SUS) [23, 24] as teachers' perceived mobile technology ease of use seems to be positively related to their intention of use in their teaching practice [25]. The last section is for the workshop evaluation.

The focus group initial question 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. The final question prompted teachers do add any further reflections.

As to data analysis, individual SUS scores and EVS score were computed according to Brooke [24], with values varying from 0 to 100. In the present study, SUS

scores were interpreted according to Sauro [26] and to Bangor et al. [27]. The remaining data were analysed through descriptive statistics and content analysis with predetermined categories. These sets of data were triangulated to provide a more comprehensive knowledge of teachers' readiness to adopt game-based mLearning with AR practices. This analysis will be presented in the next section.

4 Results and discussion

This study teacher cohort comprises 23 female and 3 male trainees, with age range from 28 to 62 years-old (about 48 of average), 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, mostly high degree (21) or higher (remaining 5).

Regarding **research objective 1**, teachers expressed their training needs by selecting reasons for enrolling in the EduPARK workshop (Fig. 1). The three main reasons were: i) getting access to new resources (23 teachers); ii) professional development (19); and iii) knowledge update (16).

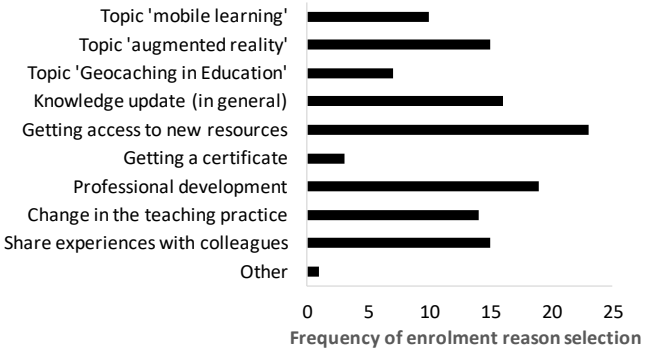

Fig. 1. Teachers' reasons for course enrolment.

The relevance of providing adequate teaching material for mLearning [28] and game-based approaches [29] was pointed before; however, our results empirically support these claims, despite most teachers enrolled in this workshop having 15 or more years of teaching experience. These teachers are still interested in updating their professional knowledge, although not necessarily in what concerns mLearning, AR and game-based approaches. This 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). The less selected reasons for enrolment were: i) getting a certificate (3); ii) the topic 'Geocaching in Education' (7); and iii) the topic 'mLearning' (10). The workshop topics reached a moderated-low importance, with a total of 32 selections.

Teachers' evaluation of the EduPARK workshop was very positive (Fig. 2), revealing feelings of at least partially fulfilled training needs. They highlighted that the workshop resources – mainly the EduPARK app – are very interesting (23 teachers)

or interesting (1), with not too hard activities (23). Hence, the vast majority was strongly pleased to have attended the workshop (25) and many reported they were prepared to integrate mobile devices in learning (15 strongly agreed and 7 agreed).

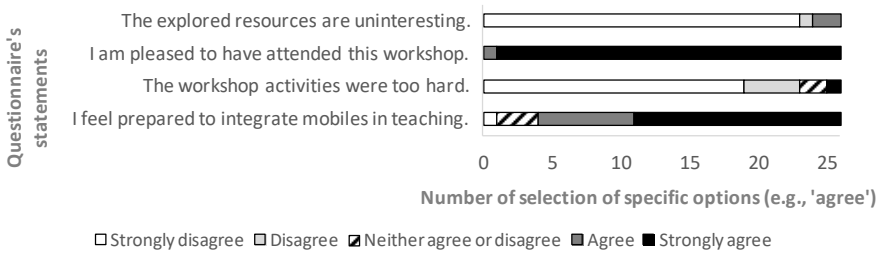

Fig. 2. Teachers' evaluation of the EduPARK workshop.

To elicit teachers' perceptions on mLearning, **research objective 2**, several aspects are analysed, such as devices ownership, their use in teaching practice and their advantages and disadvantages. Most teachers (22) referred owning an Android device and claimed they sometimes used mobile devices to promote learning (20). Only 3 teachers mentioned they never had used mobiles for that purpose and also 3 claimed they used them frequently to promote leaning. Considering that Prieto et al [25] found that male future teachers have a better disposition towards the use of mobiles in teaching practice, one could expect this study's cohort of mainly female teachers to reveal a low propensity for mLeaning. However, participating teachers showed a positive perspective, as each one acknowledged 2 to 7 advantages of mLearning, with an average of 5. These results point to some degree of teacher openness to the adoption of these technologies in their practices.

Fig. 3 shows the level of agreement with each mLearning advantage sentence. The most selected were: 'it motivates to learn' (22), 'you can learn in a fun way' (21), and 'you can learn in a different way' (20). Also, two teachers added new gains: 'it facilitates teachers work, namely in assessment' and 'it prepares for future technological advances'. This concern aligns with the literature regarding the aim of 'equipping young people with the skills for living and working in a digital age' [30, p. 3].

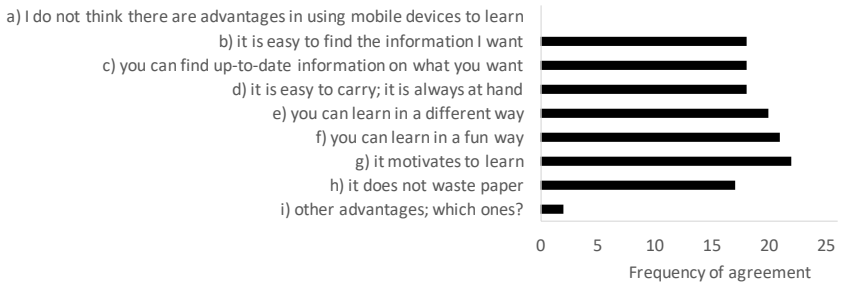

Fig. 3. Teachers' opinion about advantages in using mobile devices to promote learning.

One teacher did not recognize any difficulties in the use of mobile devices to promote learning (Fig. 4). The same teacher claimed she was already using them frequently in

her practices, indicating some relation between difficulties recognition and mobile devices adoption. However, the majority selected 1 to 5 difficulties, with an average of 2.8. The most mentioned were: 'increased battery consumption' and 'risk of developing mobile device dependence' (both pointed by 16 teachers), followed by the 'prohibition of mobile device use in classes' (10) and 'access to distractions'.

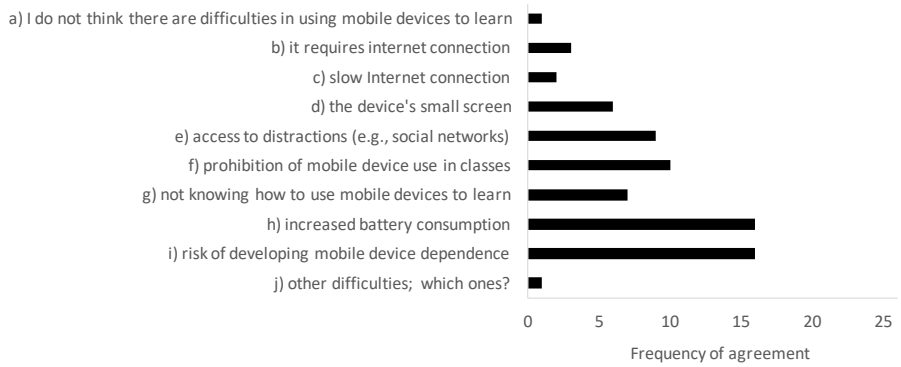

Fig. 4. Teachers' opinion about disadvantages in using mobile devices to promote learning.

Finally, 1 teacher 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 for the outdoors. This cohort of teachers echoes concerns found in the literature regarding students' of-task behaviours [9,30], reinforcing the position of those that support mobile technologies ban in schools. Curiously, this prohibition was pointed by this group of teachers as one of the main difficulties in mobile integration in teaching practices. The EduPARK approach contributes to reduce some of these constrains, as it promotes teachers' support in the use of mobile devices to learn, and reduces students' use of other mobile devices software, as they are engaged with the game in the park [5].

All teachers found the EduPARK activity very interesting. One even mentioned 'Excellent. I was amazed!' (teacher E). However, being interesting does not always means integration in their practices. Nevertheless, it seems an activity they would recommend to other teachers (22 strongly agreed and 4 agreed).

Under **research objective 3**, teachers revealed a positive perception regarding the EduPARK game educational value (Fig.5). For instance, 21 teachers strongly agreed and 2 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 17 strongly disagree and 7 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).

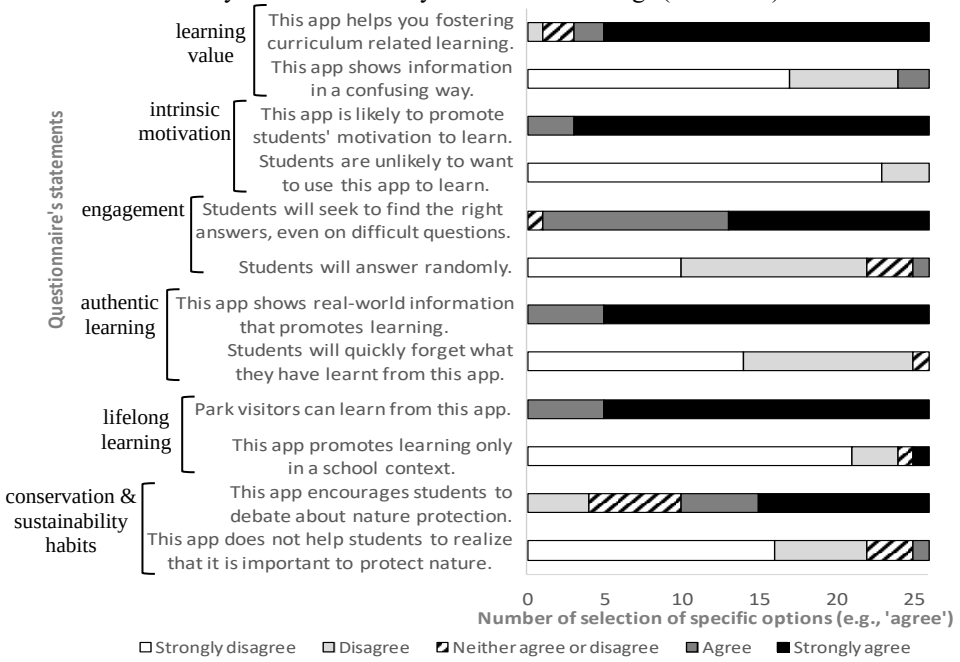

Fig. 5. Teachers' opinion regarding the educational value of the EduPARK app.

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 88.9, which seems to be a high value, although more studies are needed to sustain that claim. These results reveal that the EduPARK game has educational value for this workshop teacher cohort.

At last, in what concerns **research objective 4**, teachers' opinion of the EduPARK app usability is also positive (Fig. 6) as, e.g., 19 teachers strongly agreed and 4 agreed with the statement 'This app was easy to use' and 19 strongly disagreed and 5 disagreed with the statement 'This app has many flaws'. SUS score values ranged from 60.0 to 100, with an average of 87.5, which is a higher value than the average SUS value (68) computed by Sauro [25]. Moreover, according to the classification of Bangor et al. [26], the app achieved an excellent usability for this cohort of teachers.

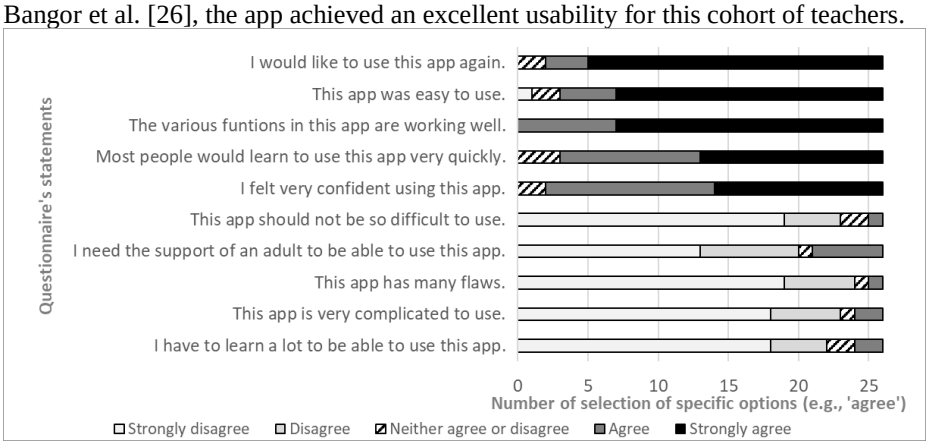

Fig. 6. Teachers' opinion regarding the usability of the EduPARK app.

5 Concluding remarks

This case study analyses teachers' readiness to adopt mobile games with AR in their teaching practices after a workshop on these issues under the EduPARK project. The workshop cohort 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; and iii) updating their knowledge, although not necessarily in what concerns mLearning, AR and game-based approaches. The EduPARK workshop fulfilled those needs, at least partially; although not all reported feeling prepared to integrate mobile technologies in their practices.

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 increased motivation and learning in a different way; and difficulties, such as increased battery consumption and risk of mobile device dependence. However, they 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. Nevertheless, as most teachers are not currently using mobile technologies to promote learning on a regular basis, the difficulties identified in this study must be taken in consideration and properly addressed.

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 in these 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.

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. Another limitation of this study is the use of a convenient rather than random sample, which is due to accessibility issues to teachers' opinions. Nevertheless, this study accomplished its purpose of eliciting this teacher cohort readiness to adopt game-based mLearning with AR in their practices, a feature that contributes to the creation of smart-learning ecosystems.

In sum, this study reveals that teachers seem ready to adopt mobile AR game-based approaches, 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: i) the integration of new technologies and teaching approaches – mobile devices, AR and game-based learning –, a need identified by [7]–[9]; ii) presenting to teachers a mobile AR game exemplar – the EduPARK app –, offering them time to explore and to experiment an existing tool; iii) prompting teachers to develop learning content for the presented tool, as indorsed by [15]; iv) effectively promoting teachers adoption of new teaching strategies, involving technological innovation, and increasing their confidence in using those technologies with their students; v) being entirely in an outdoor environment, illustrating the aimed educational methodologies *in loco*; iv) making available the resource used to illustrate new practices, which is open and free, not being a common situation in the literature [1].

Acknowledgment

This work is financed by FEDER - Fundo Europeu de Desenvolvimento Regional funds through the COMPETE 2020 - Operational Programme for Competitiveness and Internationalisation (POCI), and by Portuguese funds through FCT - Fundação para a Ciência e a Tecnologia within the framework of the project POCI-01-0145-FEDER-016542.

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