Journal Pre-proof

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Please cite this article as: A. Ruiz-Calleja, M.L. Bote-Lorenzo, J.I. Asensio-Pérez et al., Orchestrating ubiquitous learning situations about Cultural Heritage with Casual Learn mobile application. *International Journal of Human - Computer Studies* (2022), doi: https://doi.org/10.1016/j.ijhcs.2022.102959.

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Orchestrating ubiquitous learning situations about Cultural Heritage with Casual Learn mobile application

Adolfo Ruiz-Calleja[a], Miguel L. Bote-Lorenzo[a,*], Juan I. Asensio-Pérez[a], Sara L. Villagrá-Sobrino[b], Víctor Alonso-Prieto[b], Eduardo Gómez-Sánchez[a], Pablo García-Zarza[a], Sergio Serrano-Iglesias[a], Guillermo Vega-Gorgojo[a]

[a]*School of Telecommunications Engineering, Universidad de Valladolid, Paseo de Belen, 15, Valladolid, 47011, Spain*
[b]*Faculty of Education, Universidad de Valladolid, Paseo de Belen, 1, Valladolid, 47011, Spain*

Abstract

Cultural Heritage learners can highly benefit from ubiquitous learning approaches that connect in-classroom activities with active on-site learning opportunities. However, teachers face the problem that the current landscape of technological support for learning Cultural Heritage mostly consists of mobile applications for informal contexts, completely decoupled from curricular activities. This paper presents the results of an exploratory-sequential mixed-methods study that focuses on the feasibility, for non-technical expert teachers, of repurposing an existing mobile application in formal Cultural Heritage ubiquitous learning situations. Such feasibility is explored from the perspective of the orchestration metaphor. More specifically, we used the "5+3 aspects orchestration framework" to understand the orchestration challenges of four ubiquitous learning situations about Cultural Heritage carried out in two secondary schools. These situations involved five teachers and 139 students who used a mobile application called Casual Learn for several weeks. The results of the study suggest that, after a brief training, teachers can design, enact, and orchestrate ubiquitous learning situations that involve both in-classroom and out-classroom activities. The teachers were able to transfer to the students most of the orchestration load of out-classroom activities. The results also showed that the flow of learning artifacts and information between in- and out-classroom activities is a critical issue that needs to be addressed by developers of ubiquitous learning technological solutions.

Keywords: ubiquitous learning, orchestration, Cultural Heritage, mobile applications

1. Introduction

Cultural Heritage is an interdisciplinary and heterogeneous field that aims to give a holistic view about past and present societies (Winter, 2013). This field includes the artistic, historical, cultural, economical, ethnographic, and technological aspects of these societies (Lucas-Palacios, 2018). Learning Cultural Heritage is part of secondary education in most European countries since it is considered of major importance (Sonkoly and Vahtikari, 2018; Council of Europe, 2005): it promotes critical thinking about past and present societies, student's self-identity, and the preservation of historical monuments (Greene et al., 2014; Winter, 2013).

Cultural Heritage learners highly benefit from active on-site learning. Learners obtain a better understanding and critical view of a monument and its context when visiting it than when studying it in a book (Greene et al., 2014; Winter, 2013). This is why, traditionally, school trips are organized to visit Cultural Heritage sites. However, these trips require a significant amount of time and are both economically and logistically complex to implement (Ch'ng et al., 2020; Greene et al., 2014). Hence, culturally enriching field trips are in decline (Ch'ng et al., 2020; Erickson et al., 2022). Some researchers have explored alternatives to school trips, such as serious games (Mortara et al.,

*Corresponding author
Email addresses: adolfo@gsic.uva.es (Adolfo Ruiz-Calleja), migbot@tel.uva.es (Miguel L. Bote-Lorenzo), juaase@tel.uva.es (Juan I. Asensio-Pérez), sarena@pdg.uva.es (Sara L. Villagrá-Sobrino), victor@gsic.uva.es (Víctor Alonso-Prieto), edugom@tel.uva.es (Eduardo Gómez-Sánchez), pablogz@gsic.uva.es (Pablo García-Zarza), sergio@gsic.uva.es (Sergio Serrano-Iglesias), guiveg@tel.uva.es (Guillermo Vega-Gorgojo)

2014) or virtual reality applications (Ch'ng et al., 2020). However, research evidence suggests that these types of technological solutions cannot replace the experience of visiting the actual monument (Ch'ng et al., 2020; Mortara et al., 2014). A different approach relies on existing mobile applications that offer on-site learning opportunities when a learner is close (or is visiting) a museum (Abril-López et al., 2021; Ruotsalo et al., 2013) or a Cultural Heritage site (Fermoso et al., 2015; Ruiz-Calleja et al., 2021b). The learning opportunities triggered by these applications (sometimes developed for touristic purposes) are informal in nature (Marsick and Watkins, 2001) since they happen serendipitously and independently of the formal learning context of their users. However, if these applications could be used in conjunction with formal contexts of Cultural Heritage learning, they could potentially help to overcome the aforementioned problem in the organization of field trips. Indeed, this connection between on-site and in-classroom learning has been the focus of the so-called ubiquitous learning (UL), which is especially interesting for learning Cultural Heritage (Alkhafaji et al., 2020).

UL is sometimes defined as "using mobile technologies to facilitate learning" (Hwang and Tsai, 2011). UL promotes learners' autonomy and encompasses across-spaces learning, thus involving different physical and virtual learning spaces in the same learning situation (Delgado-Kloos et al., 2012; Pishtari et al., 2020). UL also promotes situational learning (Hwang and Tsai, 2011; Pishtari et al., 2020), in an approach sometimes called "seamless learning" (Milrad et al., 2013), understanding that UL implies "learning anywhere and at anytime" (Hwang and Tsai, 2011). However, UL potential is commonly not fully exploited in real settings because of the challenges of designing, enacting, and assessing learning situations that involve different physical and virtual spaces (Delgado-Kloos et al., 2012).

In order to illustrate these challenges, we can consider a UL situation in a class of History of Art where the teacher explains Gothic Art in the classroom (in-classroom physical space). Then, they propose their students watch a video (in-classroom virtual space) about local history and, later on, visit some local churches (out-classroom physical space) where the students will carry out learning activities using one of the existing Cultural Heritage learning applications that run in their mobile devices. This UL situation requires the teacher to design a situation that relates multiple spaces; to support and coordinate the students when not being at the classroom; to assess what the students learned in in- and out-classroom contexts; to use new technological tools and platforms; among many other difficulties that increase when using technology that is not explicitly developed to support formal learning processes (Song, 2021).

All these difficulties –which challenge teachers when dealing with complex Technology Enhanced Learning (TEL) environments– have been researched by the TEL community under the umbrella of the orchestration metaphor (Dillenbourg et al., 2013). Different aspects such as design issues of orchestration (Lachand et al., 2018; Kharrufa et al., 2013) or the physical and cognitive load that it generates for teachers (Prieto et al., 2015b) have also been recurrently studied from the perspective of Human-Computer Interaction (HCI). Orchestrating UL situations is especially challenging since they typically imply the coordination of learning processes that happen across multiple contexts and spaces (Muñoz-Cristóbal et al., 2017). Indeed, several authors have argued for the need to research on the practical implications of UL (Virtanen et al., 2018), including a better orchestration support for teachers, without technical expertise, in UL situations (Mendes Gabriel Pedro et al., 2018; Pimmer et al., 2016). However, not much attention has been given to the orchestration of UL situations yet (Mendes Gabriel Pedro et al., 2018), and those who have (see, e.g., Mettis and Väljataga (2020); Pérez-Sanagustín et al. (2014)) did not tackle the specific challenge of repurposing an already existing informal learning tool; instead, they involved in their studies applications specifically developed for formal learning purposes. Furthermore, none of the existing research work focused on orchestrating ubiquitous Cultural Heritage learning situations (Mendes Gabriel Pedro et al., 2018; Pishtari et al., 2020). Hence, the following research question emerges: *how is it possible for non-technical expert teachers orchestrate UL situations about Cultural Heritage as part of their teaching practice using informal learning tools?*

In order to tackle this question, this paper explores the orchestration challenges that arise when non-technical expert teachers orchestrate informal–learning tools to support UL activities about Cultural Heritage. For this purpose, it presents an exploratory-sequential mixed-methods (Creswell, 2009) study that tackles this question and provides further evidence of the orchestration of UL situations. More specifically, this study aims to deeply understand the particularities of four UL situations to learn Cultural Heritage following an interpretive research paradigm (Orlikowski and Baroudi, 1991). These situations are supported by Casual Learn (Ruiz-Calleja et al., 2020, 2021a), a semantic mobile application originally designed and developed by the authors to support informal learning about Cultural Heritage. We choose Casual Learn for two main reasons. First, it offers information and proposes learning tasks to carry out in Cultural Heritage sites, many of them in the vicinity of the schools that took place in the evaluation, hence

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making it attractive for the instructors. Indeed, Casual Learn already includes more than 10 000 ubiquitous learning tasks related to Cultural Heritage sites (Ruiz-Calleja et al., 2021b). Second, we maintain and fully control Casual Learn. So we can add new tasks if required by the teachers, integrate it to the classroom's technical environment, provide full guarantees that no personal data is collected from users, and react to any technical problem that may arise during the enactment of the learning situations. The learning situations involved five teachers and 139 students from two secondary schools of the Spanish region of Castile and Leon.

In addition to the expansion of the empirical evidence about the affordances and limitations of UL, a need that has been explicitly pointed out in the literature (see, e.g., Pimmer et al. (2016)), the findings from the presented study can be significant to the field of technology-enhanced UL and HCI for several reasons: they can help researchers to better understand the particularities of orchestration in the Cultural Heritage learning field; they lead to design recommendations that can help to improve the support of orchestration of UL; and they can help designers of secondary-education teachers training programs identify skills that teachers need to design UL situations supported by mobile technologies.

The rest of the paper is structured as follows: section 2 summarizes several approaches to orchestrate UL situations. Section 3 details the research approach, educational context and data gathering and analysis techniques used in the study, whose results are reported in section 4. Finally, section 5 critically discusses these results, and section 6 distills the main conclusions and limitations of the study.

2. Background

This section briefly describes the state of the art on the orchestration of UL situations. Subsection 2.1 introduces the *5+3 aspects orchestration framework*, which is key to structure our case study. Then, subsection 2.2 reports other research proposals related to the orchestration of UL situations.

2.1. 5+3 aspects orchestration framework

Orchestration is a TEL term that refers to "how a teacher manages in real-time multi-layered activities in a multi-constraints context" (Dillenbourg et al., 2013). It is a complex term that has led to multiple conceptualizations. Orchestrating a learning situation and analyzing this orchestration are both challenging tasks, especially in technologically-enriched learning environments. For this reason, orchestration frameworks have been proposed both for practitioners (Phiri et al., 2016) and for researchers (Prieto et al., 2015a).

In order to structure the research study, in this paper we follow the *5+3 aspects orchestration framework* (Prieto et al., 2015a). This framework has been proposed for the research community to achieve a common ground about orchestration and to facilitate the analysis of the orchestration of learning situations. The framework emerged as the result of a literature review that identified, compared, and synthesized recurrent conceptual components of existing orchestration models (Prieto et al., 2015a). Indeed, other authors such as Muñoz-Cristóbal et al. (2017); Mettis and Väljataga (2018) have already used the *5+3 aspects orchestration framework* as a conceptual basis. Song (2021) and other authors used different conceptual frameworks to analyze UL situations, but the dimensions employed are a subset of those included in the *5+3 aspects orchestration framework*.

The *5+3 aspects orchestration framework* entails five dimensions that describe the orchestration in an educational setting, as described next:

- Design: the preparation of the learning situation before the enactment. This includes the planning of the learning activities, the tools, devices, and artifacts used to support these activities, and setting up the technological environment.

- Management: the coordination of the activities during the enactment. This includes the regulation of the activities and the management of time, tools, artifacts, spaces, etc.

- Awareness: the consciousness of what happens in the learning situation.

- Adaptation: the interventions to the planned learning activities needed because of unexpected events.

- Roles of teacher and other actors: the role that the teachers and students take in the orchestration.

Additionally, the *5+3 aspects orchestration framework* includes three dimensions to describe the way the orchestration is carried out. These are the following:

- Pragmatism: the availability of the TEL results to non-technical teachers, fitting the constraints of authentic settings in everyday practice.

- Alignment: the coordination of the elements to be orchestrated, including the relationship of new technology and legacy tools.

- Theory: the pedagogical beliefs, attitudes, and other ideas of the different actors that influence the learning scenario and how it should be orchestrated.

2.2. Ubiquitous learning orchestration

During the last decade many authors have reported UL situations (Pishtari et al., 2020; Cárdenas-Robledo and Peña-Ayala, 2018). Many of the existing research works aim to assess some UL technology or technique. In these cases, the students typically carry out an activity in a single session that is not clearly related to the curriculum of their formal education. But the orchestration of the UL situations is not the focus of most of these studies. In a few cases the research proposals focus on the support offered by some technological solution to a specific orchestration dimension. For example, Pishtari et al. (2020) list several examples that focus on the *design* of the UL situation or the teacher awareness. Nonetheless, other dimensions such as *pragmatism*, *alignment*, *theory*, or *roles of teacher and other actors* are almost never covered in these studies (Pimmer et al., 2016; Sharples et al., 2015).

Several authors argued for the need for holistic support for teachers to orchestrate UL situations (Mendes Gabriel Pedro et al., 2018; Pimmer et al., 2016). This is especially challenging since these are situations that many times involve multiple contexts and spaces and use technologically complex devices (Muñoz-Cristóbal et al., 2017). Muñoz-Cristóbal et al. (2017) argued that orchestration support is especially important in across-context situations, in those that connect daily life learning experiences with formal education (Pimmer et al., 2016), and in inquiry-based UL situations (Sharples et al., 2015). Interestingly, Sharples et al. (2015); Mettis and Väljataga (2020) underline that, since the orchestration load of a UL situation is so high, it is desirable to balance it between teachers and students. As a consequence, the dimension *roles of teacher and other actors* becomes very relevant in UL situations.

Taking the orchestration of UL as a challenge, a few authors proposed "orchestrating technology" (Tchounikine, 2013), i.e. tools that support the activity of orchestrating, either supporting teachers or automatizing some orchestration tasks. For example, Martinez-Maldonado et al. (2013) proposed a conceptual model to integrate orchestration mechanisms into UL environments using remote virtual learning environments. A similar approach was followed by Muñoz-Cristóbal et al. (2017), who evaluated the orchestration of the across-spaces use of Moodle together with configurable containers of learning artifacts in five learning situations of Physical Education in the natural environment.

Other authors explored the use of "orchestrated technology" (Tchounikine, 2013), i.e. tools that can be used and adapted by teachers and learners while orchestrating the setting. This is in line with the idea of "unplatformed design" in the ubiquitous computing community (Lambton-Howard et al., 2020), proposing to repurpose existing applications in a loose ecosystem of tools to meet the users' needs without developing a centralized platform. For example, Pérez-Sanagustín et al. (2014) analyzed the learning benefits and practical issues of using Augmented Reality in blended learning situations across formal and informal contexts. These authors reported three UL situations: two of them carried out in the university campus, and another in the city of Barcelona. Other case studies were reported by Mettis and Väljataga (2018) and Mettis and Väljataga (2020). These authors tested the suitability of two learning applications (SmartZoos and Avastusrada) in real settings by analyzing how primary school teachers orchestrated them in two UL situations carried out in zoos.

All these studies provide evidence of the orchestration problems in UL situations. But all of them share some contextual characteristics: the UL situations were carried out in a single session; they took place in a controlled environment; they do not have any explicit relationship with the formal curriculum; the participants are either primary school or university students; and they used technology that was specifically developed for formal learning purposes. Additionally, none of them focus on the Cultural Heritage domain.

Indeed, for the Cultural Heritage domain, we can only find mobile applications that offer information about museums (Abril-López et al., 2021; Ruotsalo et al., 2013) or historical sites in open contexts (Fermoso et al., 2015;

Alkhafaji et al., 2019; McGookin et al., 2019), or that suggest learning tasks (Ruiz-Calleja et al., 2021b) based on the learner's geo-position. While sometimes the tasks proposed in these situations are driven by pedagogical purposes (Fermoso et al., 2015; Ruiz-Calleja et al., 2021b), they are designed to be used autonomously by a learner, without a teacher who guides and orchestrates the UL situation. Interestingly, Abril-López et al. (2021) reported a case study where preservice teachers carried out a UL activity bridging the classroom and a local museum. While this is an interesting learning situation, the assessment focuses exclusively on the tool's use and does not report its orchestration problems. The research by Alkhafaji et al. (2020) is also relevant, as they propose a framework for designing Cultural Heritage UL situations, but these authors do not explore the rest of the orchestration dimensions.

In this paper, we explore the orchestration problems when introducing informal learning tools in the classroom to support UL situations about Cultural Heritage. Following this aim, we describe in section 3 four real learning situations carried out by students and orchestrated by secondary school teachers. Thus, we explore the orchestrating issues of real Cultural Heritage UL situations, and we also enlarge the empirical base of UL orchestration in a novel context with respect to those reported in the literature so far.

3. Method

3.1. Research approach

The research question addressed in this study is: *how do non-technical expert teachers orchestrate UL situations about Cultural Heritage as part of their teaching practice using informal learning tools?* This study is framed in an interpretive research paradigm (Orlikowski and Baroudi, 1991) as it aims to obtain a deep understanding of the particularities of the concrete phenomena under study, in this case how teachers orchestrate a Cultural Heritage UL situation with the support of an existing mobile application. This exploratory study focuses on five particular secondary-school teachers that use Casual Learn (see section 3.2) in their own practice. The study conditions are authentic, as it was carried out in four courses of History and History of Art (see section 3.3) whose curriculum includes Cultural Heritage learning. The analysis of the study mainly relies on qualitative evidence (see section 3.3.1), not looking for statistically significant results or generalizations (Guba, 1981; Twining et al., 2017).

We contextualized the research question in an issue. According to (Miles and Huberman, 1994), issues are conceptual organizers typically employed in qualitative evaluation studies to facilitate the data collection and analysis. They represent a potential tension to be assessed in a specific context or conditions. In our case, the issue contextualizes the research question by exploring it using Casual Learn (see section 3.2) in secondary education (section 3.3). As a consequence, the research question is contextualized in the following issue to guide the data interpretation (see Figure 1): *how do secondary-school teachers orchestrate UL situations about Cultural Heritage in their own practice using Casual Learn?*

Note that the findings of the evaluation (section 4) are related to the issue we defined and structured according to the topics of the anticipatory data reduction process that we followed. These findings do not aim to fully answer our original research question, but rather to illuminate it. Section 5 discusses how the results can illuminate our original research question and which contextual or pragmatic restrictions may have biased our results.

3.2. Research context: the learning tool

Casual Learn (Ruiz-Calleja et al., 2020, 2021a) is a mobile application originally developed to learn Cultural Heritage in informal contexts. It offers tasks geolocalized in Cultural Heritage sites of Castile and Leon through two different modes: in passive mode, learners walk by and receive notifications when they are close to a site, so that the can complete learning tasks associated to it; in active mode, learners browse in a map, and look for sites and tasks, though the tasks cannot be answered unless they are physically close to the sites. Tasks can be of varied nature, like reading a text, taking notes or photographs or recording a video. Completed tasks can be shared in social networks or integrated in a portfolio that could also be shared. Since Microsoft Teams is highly used in Castile and Leon public secondary schools, teachers wanted to see their student's answers published there. The approach of students doing it manually (publishing their answers or URL of CasualLearn portfolio) was initially considered. Though this procedure of "soft augmentation" (Lambton-Howard et al., 2020) was feasible and creates an integration seam that some researchers consider an opportunity to gain awareness of the technological diversity (Chalmers and Maccoll, 2003), the teachers in our initial scenario asked us to create a functionality so that students could directly

Table 1: Characteristics of the four learning situations ("#Tea.". means "number of teachers"; "#St." means "number of students"; "Age st." means "age of the students").

ID	City	#Tea.	#St.	Age st.	Begin	End	Mandatory	Topic
S1	Palencia	1	11	17	12/04/20	12/20/20	Yes	Gothic Era in Palencia
S2	Palencia	2	5	17	12/18/20	01/10/21	No	Medieval Art in Palencia
S3	Valladolid	1	43	16	12/18/20	01/15/21	Yes	Industrialization of Valladolid
S4	Valladolid	1	80	15	02/15/21	03/14/21	No	Bourgeoisie in Valladolid

publish finished tasks in Teams, just clicking a button in Casual Learn. Teachers thought students would not forget reporting tasks and thus teachers would gain awareness of their students progress (see later discussion on the alignment dimension). Additionally, Casual Learn supports the definition of collections of tasks (e.g. tasks related to a certain topic, like industrial heritage sites).

Note that Casual Learn is an informal-learning application since it lacks many functionalities that most educational applications include to offer more control to the teacher. For example, Casual Learn does not include any user role, so it does not differentiate between teachers and learners. Moreover, it does not provide any kind of control mechanism (e.g., a dashboard) to be used by the teachers. A more detailed description of the application with illustrative screenshots has been provided in Appendix A.

3.3. Research context: experiences and participants

The study was carried out in two public secondary schools of the Spanish region of Castile and Leon, one of them in the city of Valladolid (a city with many XIXth Century buildings) and another in the city of Palencia (a city with many Medieval buildings). Both schools are located in middle-class districts. The study includes four learning situations framed in History and History of Art courses. These courses are carried out in the fourth course of secondary education (15-year-old students), the first course of "bachillerato" (16-year-old students), and the second course of "bachillerato" (17-year-old students).

In Castile and Leon, the curriculum is proposed by the National Educational Law and the regional educational legislation. Teachers are autonomous to define the academic program of their courses and the pedagogical methods to employ, taking into account the school's values and objectives (Prieto-Pariente, 2016). Both schools involved in our study promote critical thinking and the use of innovative technology and pedagogical techniques. Indeed, this study had explicit support from the schools' management board.

It is also relevant that this study was carried out in the academic year 2020/2021 when there were several restrictions due to the COVID-19 global pandemic. For this reason, school trips were not allowed and nobody external to the schools (including researchers) could physically get into the classrooms. Nevertheless, during the day students could freely walk around the city, alone or in small groups. This further motivated teachers to participate in this study, as they saw it as an alternative to traditional school trips that were no longer possible due to the pandemic.

For each school, we had a training workshop for the History and History of Art teachers (7 teachers from Valladolid and 5 teachers from Palencia) in October 2020. In the workshop, we explained the functionality of Casual Learn. Two weeks later we had another workshop with them all. In this second workshop, we invited them to freely (i.e., with no interference from the researchers) design in groups two learning situations where Casual Learn could be used and that they would potentially enact in a real scenario. Once the event finished, five out of twelve teachers freely agreed to further mature one of the learning designs and enact it with their students in authentic settings. Table 1 summarizes the characteristics of the four learning situations that correspond to the four learning designs created. Table 2 summarizes the use of Casual Learn in these four learning situations. Next, we provide further details about the learning situations:

Learning situation S1 happened in a secondary school of Palencia from December 4 to December 20, 2020. The participants were a teacher with 6 years of teaching experience, and 11 students of the second course of "bachillerato" (17 years) who belonged to the same class of History of Art. The topic of the activity was the Gothic Era in Palencia. The teacher wanted the students to reflect on Gothic buildings, understanding the artistic, architectonic, social, and economical conditions of the XVth Century. They also wanted them to reflect on traditions related to these buildings and their current importance for the city. Finally, the teacher aimed at promoting some transversal competences, such as academic writing and oral expression.

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Table 2: Use of Casual Learn in the four learning situations (number of tasks created by teachers; the number of groups formed; the number of total tasks carried out; the number of tasks realized from the ones proposed by the teachers (new); the number of tasks realized from the already existing ones (i.e., not proposed by the teachers).

ID	#T. published	#Groups	#T. realized total	#T. realized new	#T. realized existing
S1	29	5	26	26	0
S2	27	5	60	8	52
S3	30	17	103	100	3
S4	74	23	451	421	30

Before the activity took place, the teacher asked the researchers to publish in Casual Learn 29 additional tasks (i.e. in addition to those already existing in the repository) located in four Gothic buildings in Palencia. One of the tasks published is depicted in Figure A.3(d). Then, the teacher asked their students to carry them out during the following two weeks in groups of three or four students. Students were also invited to do, if they wished, any other task that they found in Casual Learn. After completing all the tasks, each group had to create a presentation that offered a coherent view of the tasks done. They had to send it to the teacher and, later on, present it to the whole class at the classroom to the whole class.

As it was a compulsory activity, all the students completed it forming 5 groups. They carried out a total amount of 26 tasks, all of them proposed by the teacher. No problem was reported during the enactment of the learning situation.

Learning situation S2 happened in a secondary school of Palencia from December 18, 2020 to January 10, 2021. The participants were two teachers with 20 and 2 years of experience, respectively, and 5 students of the second course of "bachillerato" (17 years). These students belonged to two classes of History and none of them had taken the History of Art course. After an introductory explanation in the classroom about Medieval Art, the teachers suggested them to voluntarily use Casual Learn to do some tasks about Medieval Art, so they could reinforce some knowledge that they had learned in past courses, eventually relevant to understand what was explained in their current History course.

Before the activity took place, the teachers asked the researchers to publish 27 additional tasks in Casual Learn. Six of these tasks were geolocated in two museums and invited to reflect on the characteristics of some Medieval pieces of art. The rest were geolocated in six churches of rural areas so that those students who live in the countryside could also benefit from Casual Learn. Then, they asked the students to do at least six tasks, at least one of each of the following topics: one related to paintings, sculpture, and architecture of Romanesque and Gothic styles. They should also share their Casual Learn portfolio with the teachers.

The five students who participated in the activity carried out 60 tasks, 8 of them proposed by the teachers and 52 previously existing in Casual Learn. The teacher detected a problem: the geolocation of a church was incorrect, so the tasks in Casual Learn were not displayed when visiting the site. This was due to a human error in the transcription of the geolocation, not a problem with the accuracy (VIGIE 2020/654, 2022) of a measurement. Once this issue was notified, Casual Learn developers fixed it.

Learning situation S3 happened in a secondary school of Valladolid from December 18, 2020 to January 15, 2021. The participants were a teacher with 29 years of teaching experience, and 43 students of the first course of "bachillerato" (16 years) who belong to two different classes of History. The topic of the activity was the industrialization of the city of Valladolid during the XIXth Century. The teacher also wanted the students to develop some transversal competences not directly related to Cultural Heritage, such as healthy lifestyles, orientation ability, or their knowledge of the urban landscape of Valladolid.

Before the activity took place, the teacher asked the researchers to publish in Casual Learn 30 additional tasks related to the industrialization of Valladolid located in 20 new Cultural Heritage sites of the city. One of the tasks published is depicted in Figure A.3(e). Then, the teacher explained Casual Learn functionality to the students and gave an overview of the outdoor activity in the classroom. They asked the students to freely form pairs and, during the Christmas break, visit several sites to do their corresponding tasks. The students should share their answers with the teacher via Microsoft Teams, either sending all their answers or the URL of their Casual Learn portfolio to the teacher. For the students to develop the transversal competencies, the teacher asked them to visit Cultural Heritage sites located in different neighborhoods and, if possible, to go by bike or in public transport. After the Christmas break, the teacher moderated a debate in each class, so the students put their knowledge in common.

The students formed 17 groups and carried out a total amount of 103 tasks, 100 proposed by the teacher and 3 previously existing in Casual Learn. No problem was reported during the enactment of the learning situation.

Learning situation S4 happened in a secondary school of Valladolid from February 15 to March 14, 2021. The participants were a teacher with 32 years of teaching experience, and 89 students of the fourth grade (15-16 years) who belonged to four different classes of History. The topic of the activity was the rise of the Bourgeoisie in the city of Valladolid and the main events that happened in the city during the historical period called "Bienio Progresista" (1854–1856).

The learning activity consisted of two phases. During the first phase (compulsory and planned for 14 days) the students of each class were divided into four groups of four to five students. The teacher assigned to each group a topic (culture, economy, politics, and society), a set of four to five Cultural Heritage sites, and some basic bibliography. The students should then write a description of each site and a set of tasks related to their assigned topic that would be relevant to carry out when visiting the specific site. Later, each group gave a short presentation to their classmates explaining the sites assigned to them. After collecting and reviewing the documents written by the students, the teacher asked the researchers to publish the tasks in Casual Learn.

The second phase started five days later and was planned for 14 days. The students used Casual Learn to carry out the tasks proposed by their classmates in groups between two and four students that they freely formed. They had to visit 18 Cultural Heritage sites, read their descriptions, and answer the tasks proposed by their colleagues. They should also send their answers to the teacher via Microsoft Teams. Optionally, the students could write an essay if they preferred not to do this second part.

89 students participated in the first part of the activity and 80 in the second. However, some aspects had to be changed from the original design: the first part took three weeks (instead of two) and the second part 14 days (instead of 10). The teacher had to scaffold the students more than expected, proposing them additional bibliography and some questions to support their critical thinking. Despite this, the tasks proposed by the four groups were very similar. Hence, the teacher decided to implement in Casual Learn the tasks and descriptions proposed by two classes (36 descriptions and 74 tasks in total). During the second part of the activity, the students formed 23 groups that carried out a total amount of 451 tasks, including 30 tasks previously existing in Casual Learn. As they submitted the tasks to the teacher, the teacher was aware of the students' progress. The teacher only needed to intervene once because Casual Learn was not available for two hours due to technical reasons. The students complained to the teacher, who asked Casual Learn developers and the issue was quickly solved.

Some partial results of this last UL situation were reported in Ruiz-Calleja et al. (2021c).

3.3.1. Data gathering and analysis

The study design follows a mixed-methods approach, and more concretely an exploratory-sequential design (Creswell, 2009) entailing the collection, analysis, and report of both qualitative and quantitative data. However, in this particular study qualitative data is predominant and used to identify general trends; quantitative data is used to confirm these trends and to enrich the data gathered from informants. According to Creswell (2009), this strategy is adequate when analyzing several groups of informants. This is the case of our study, where informants are both the teachers and learners involved in the four learning situations described in subsection 3.3.

During the study, data were collected before, during, and after the four learning situations. We triangulated the data sources, the researchers, and the data gathering and analysis techniques to increase the credibility, transferability, and confirmability of our research (Miles and Huberman, 1994; Twining et al., 2017). For the triangulation of data sources, we employed multiple informants and data sources, ensuring that each finding was obtained supporting evidence of different types. For the triangulation of data gathering and analysis techniques we employed different data gathering techniques, as summarized in Table 3. For the triangulation of researchers, we involved in the evaluation team several researchers with different backgrounds (i.e., technical or educational). They conducted independent observations, which were put together and discussed with the whole group of researchers; interviews were independently codified to ensure cross-validation. We also applied other strategies typically used in interpretive studies to increase the quality of the research process (Miles and Huberman, 1994; Twining et al., 2017): we prolonged the teacher's engagement between four and six months; we obtained feedback from teachers about the data gathered and our interpretation; we had several meetings with each teacher, so we could acknowledge their opinions; and we integrated all the collaborative observation reports in a single portfolio, so we obtained a deeper description and understanding of the phenomena under study.

Table 3: Summary of the data gathering techniques.

Teacher-generated artifacts [TGA]	Collection of electronic artifacts generated by the teachers to design and enact the learning situations. This includes a learning design done out of a template provided by the researchers, Casual Learn tasks and sites proposed by the teachers, and documents offered to the students to scaffold their learning process.
Diary of conversation with teachers [DCT]	E-mails, chat logs, and recordings of the conversations between the teachers and researchers. These conversations were carried out before and during the enactment.
Casual Learn logs [CLL]	Logs of the application Casual Learn, where the tasks carried out by the students were anonymously registered.
Student-generated artifacts [SGA]	Collection of electronic artifacts generated by the students during the enactment of the learning situations. This includes the answers to the tasks in Casual Learn and the tasks and descriptions of Cultural Heritage sites proposed by the students in S4.
Student questionnaire [SQ]	Paper questionnaire filled in by the students after the enactment of the learning situation to get their opinion about Casual Learn and the learning situation.
Teacher questionnaire [TQ]	Web-based questionnaires filled in by the teacher before and after the enactment of the learning situation. The first questionnaire collected the teacher profile. The second questionnaire was used to gather information about the orchestration of the learning situation and the teacher's opinion about Casual Learn.
Teacher interview [TI]	Semi-structured on-line interviews with the teachers. These interviews were recorded and transcribed. These interviews were used to collect the opinions of the teacher in depth after the initial analysis of the previous data sources.

We followed an anticipatory data reduction process (Miles and Huberman, 1994) to structure the data gathering and analysis. We also defined an issue as the main conceptual organizer of the evaluation process: *how do secondary-school teachers orchestrate UL situations about Cultural Heritage in their own practice using Casual Learn?* With this issue we explored the orchestration support offered by Casual Learn to ubiquitous learning situations in real settings. In order to explore the issue, we divided it into eight topics that correspond to the orchestration dimensions defined in the *5+3 aspects orchestration framework* (see Section 2.1). Then, each topic was illuminated by several informative questions. Figure 1 depicts the schema that relates the research question, the issue, the topics, and the informative questions.

Figure 2 shows the flow of data gathering for each of the four learning situations described in subsection 3.3 (labels are defined in Table 3), and the relationship between the data gathered and the evaluation topics. For each learning situation, we collected data in four different happenings. During the teacher training event, we collected the teacher's profiles and we recorded the event. During the design phase, we recorded the collaborative design event and collected the resulting artifacts (e.g., drafts of learning design); later we kept in touch with the teacher and we collected any newly emerging artifact (e.g., final learning design, tasks proposed, or e-mails exchanged). During the enactment of the learning situation, we collected Casual Learn logs, the artifacts created by the students (e.g., answers to the tasks), and by the teacher (e.g., scaffolding materials). During the enactment we also provided support to the teacher by phone and chat, calling them at least once a week to know about the state of the learning situation; we recorded all the phone calls and gathered the chat logs. After the enactment, we collected a paper-based questionnaire from the students and a web-based questionnaire from the teacher. Finally, we carried out a semi-structured interview with the teacher where they detailed their opinion about the learning situation and gave us feedback about our interpretation of the data previously collected. The interviews were coded by two coders according to the data reduction process defined in Figure 1.

RQ: how do non-technical expert teachers orchestrate UL situations about Cultural Heritage as part of their teaching practice using informal learning tools?

I: how do secondary-school teachers orchestrate UL situations about Cultural Heritage in their own practice using Casual Learn?

T8: Roles of the teachers and other actors
IQ 8.1: Does Casual Learn allow teachers to transfer part of the orchestration load to the students?

T7: Theory
IQ 7.1: Does Casual Learn enable teachers to use the organizational approaches they want to?
IQ 7.2: Does Casual Learn enable teachers to use the pedagogical approaches they want to?

T6: Alignment
IQ 6.1: How can Casual Learn be integrated into the technological environment used in the classroom?

T5: Pragmatism
IQ 5.1: How much aligned are the tasks in Casual Learn to the objectives and curriculum of the courses?
IQ 5.2: Could teachers and students solve the technical problems that may have arisen during the enactment of the UL situation?
IQ 5.3: Is the time required to design and enact the UL situation feasible for teachers?

T4: Adaptation
IQ 4.1: Was it possible to adapt Casual Learn to the needs of the UL situation?
IQ 4.2: Have the students taken advantage of unexpected learning opportunities?

T3: Awareness
IQ 3.1: To what extent does Casual Learn offer information to monitor the students' learning process?
IQ 3.2: To what extent does Casual Learn offer information useful to assess the students' knowledge?

T2: Management
IQ 2.1: How do teachers manage the progress of their students during the enactment of the UL situation?

T1: Design
IQ 1.1: Which are the main approaches when designing a UL situation using Casual Learn?
IQ 1.2: Which changes need to be done to the design of a UL situation when introducing Casual Learn?
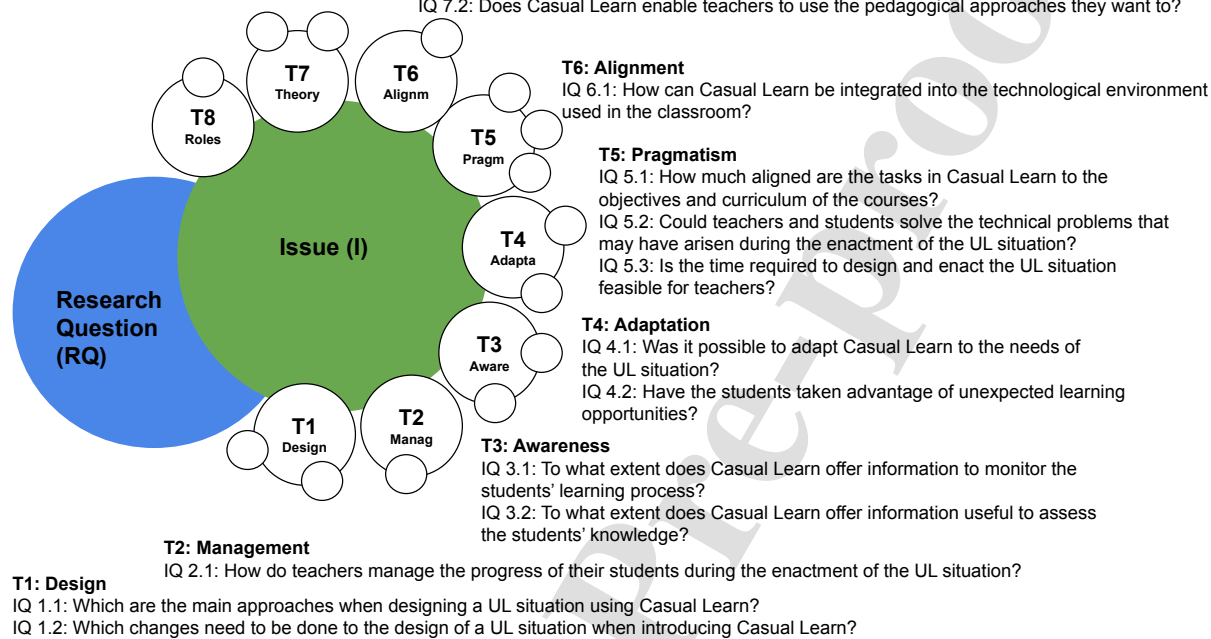
Figure 1: Anticipatory data reduction schema showing the relationships between the research question (RQ), issue (I), topics (T), and informative questions (IQ).

4. Results

This section reports the main findings obtained in the evaluation. The section is structured according to the topics of the anticipatory data reduction process (see Figure 1), which correspond to the eight dimensions of the *5+3 aspects orchestration framework* described in subsection 2.1. In this section, the supporting data is labelled indicating, in brackets: the data source according to the codes shown in Figure 2, the learning situations described in Section 3.3, and the informant (Te for teachers; St for students). Note that this supporting data are selections of excerpts of the data sources reported in subsection 3.3.1 since for space restrictions, not all the data collected and analyzed can be included. Also notice that all textual data (conversations, questionnaires...) were collected and analyzed in Spanish, but have been translated in this manuscript for reporting purposes.

4.1. Design (T1)

The evaluation showed that teachers could independently design and implement a UL situation using Casual Learn. All five non-technical teachers could design a UL activity for their students, of four different courses, using Casual Learn without any support from the researchers [TGA-1;S1-4;Te1-5]. In S1 Casual Learn is used as a data-gathering collection application that supports and guides students to take photos, videos, and notes, as instructed by the teacher, but the portfolio they create is for their own reflection. In S3 and S4, Casual Learn is also employed as a reporting tool, used by the students to submit the tasks done to the teachers. Finally, in S2 Casual Learn is seen as an application that suggests tasks to be done by the students.
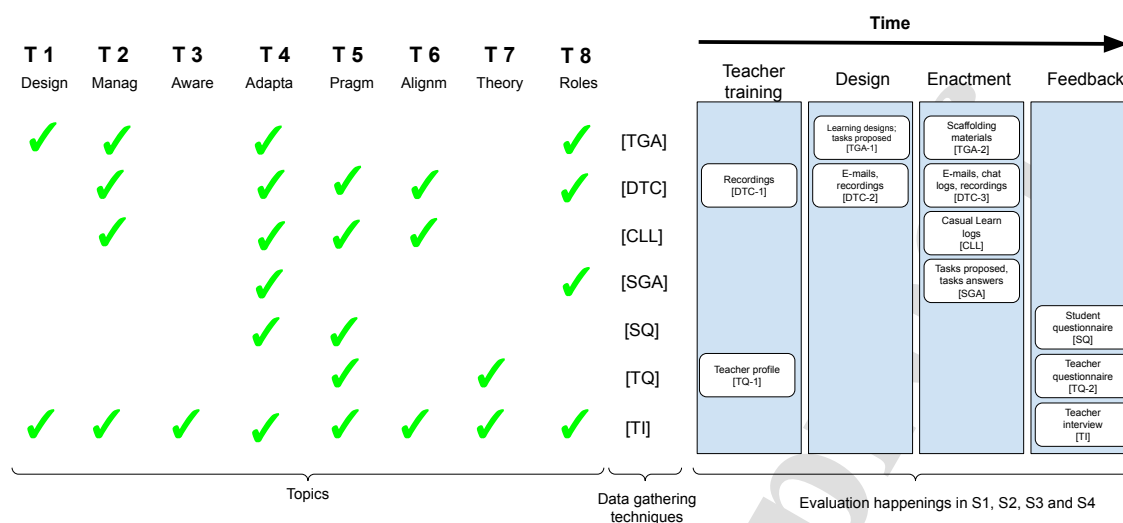
Figure 2: Relationships between evaluation happenings, topics, and data gathering techniques (see Table 3) in this evaluation.

We could also see that the UL situations proposed were related to the courses' curriculum; as a teacher said: "Everything the students have done is related to the course's curriculum." [TI;S1;Te1]. In all cases, the teachers wanted the students to learn their local Cultural Heritage, which is part of the History and History of Art curriculum. In S1, S3, and S4 teachers aimed to use the local Cultural Heritage to exemplify the topics covered in their classroom. Interestingly, in S3 and S4 the teachers also wanted to work transversal competencies, such as learning to use maps, knowing some areas of their city, or promoting a healthy lifestyle. This was explicitly mentioned by the teachers in the interviews (e.g., "Let's see if we take advantage of these resources for the kids to learn some areas of their city." [TI;S3;Te4]) and reported in some of their learning designs. Indeed, the learning competences reported in the learning designs of S3 and S4 include "using maps", "spacial orientation", "use new digital tools", "search for information online", "plan their own work", "healthy lifestyle" [TGA-1;S3-4;Te4-5]. In this sense, we can say that teachers successfully designed a formal learning activity even if Casual Learn was designed for informal learning purposes . In the case of S2, teachers took a different approach: they promoted the use of Casual Learn among their students to revise what they had already learned in previous years regarding Medieval Art. While they considered that they "cannot propose the activity as some homework related to a whole evaluation, as it does not adapt to the course's curriculum." [TI;S2;Te2], they also understood the Medieval Art as relevant for their students.

Despite Casual Learn functionality fitted into the teachers' needs, it was not always the case with the tasks it provided: all the teachers asked the researchers to include new tasks in Casual Learn [TGA-1;S1-3;Te1-4]. Tasks initially included in Casual Learn were related to the History of Art. However, the teacher in S1 wanted their students to do some specific tasks to deepen into the local Cultural Heritage and history, so the teacher needed to propose new tasks. The teachers in S2 also wanted their students to learn History of Art, but they "adapted [the activity] to the characteristics of the students, many of whom are from rural areas" [TI;S2;Te2]. These teachers thought that a very important aspect was "the connection or lack of connection that each student has, and most importantly, which Cultural Heritage surrounds the student" [TI;S2;Te3]; this restricted their design since they "could not ask them to do more than four activities because some of them do not have access to more than one or two Cultural Heritage sites" [TI;S2;Te3]. Finally, the teacher in S3 and S4 aimed to cover a different topic, so they asked researchers to add new sites and tasks in Casual Learn. They both firstly selected a set of sites and then defined tasks to be done in these sites ("I first searched for locations. Once I found the locations I proposed activities for the kids." [TI;S3;Te4]). All in all, teachers published 86 new tasks (M=21.5) and 28 new sites (M=7) in Casual Learn [TGA-1;S1-3;Te1-4]. This makes us consider the need for an interface for teachers to publish tasks in Casual Learn, which is part of our future work.

It is also noteworthy that teachers quickly understood Casual Learn potential for the students to learn History and

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Art close to the relevant site (e.g. "a good aspect of Casual Learn is that it makes the kids to see the artistic elements in place" [TI;S2;Te2]). Hence, they considered this UL situation as an alternative to school trips feasible in pandemic times (e.g. "Casual Learn arrives when I had in mind designing a project applying new technologies [...] and when you showed it I thought it was ideal for this case." [TI;S4;Te5]). Some of them complained about the time it takes to design the activity, although they admitted that once they become more skillful it should not take that much (e.g. "We carry out 50 000 activities and they all take time. [...] Among other things because you need to understand how to work with this new platform. [...] Maybe when you get more skillful you can highly reduce this time" [TI;S1;Te1]).

4.2. Management (T2)

Teachers and students managed the UL situations with almost no support from Casual Learn developers. In the four scenarios, the UL situation included in- and out-classroom activities, which were managed differently.

According to the learning designs [TGA-1;S1-4;Te1-5], in-classroom activities did not employ Casual Learn and were managed by the teacher in a similar way as any other classroom activity. In S1, S2, and S3 their in-classroom activity included an explanation by the teacher. Additionally, S1 and S3 included a wrap-up activity once the students completed the out-classroom activity. The teachers did not report any problem or remarkable event during them.

The in-classroom activity in S4 was far more complex: during a three-week-long period, the teacher expected the students to propose tasks for their colleagues. The teacher reported two types of management problems. First, as their classroom was not equipped with computers, the students should move to another room, which the students understood as a "reason for party and excitement" [TI;S4;Te5]. Second, the teacher had to further scaffold students offering them more sources and motivating them to deepen their analysis because of their lack of critical thinking ("[many groups of students] took a couple of sources and wrote a brief summary out of them" [TI;S4;Te5]). These two problems made the activity last three weeks instead of the planned two weeks.

Out-classroom activities were mainly orchestrated by the students. In the four cases, teachers gave students some instructions and enough freedom to organize their own activities. For example, a teacher mentioned "I wrote in Microsoft Teams the timeline, what they should do, what buildings they should visit, the number of activities they have to do. All this I wrote in Teams and then we talked in the classroom how the activity evolved and how they were using the tool" [TI;S2;Te2], while other said "I even have the date when they did the task. As it was not a compulsory activity, I gave them freedom: I do not care whether they did it on a date or on another" [TI;S3;Te4]. The students were autonomous using Casual Learn and doing the activity. There was only a group of students who asked the teacher for support because Casual Learn was not available at a certain moment [DTC-3;S4;Te5]. After the teacher contacted Casual Learn developers, the problem was solved in a few minutes [CLL;S4;St93].

4.3. Awareness (T3)

During the outdoor activity, the combination of Casual Learn and Microsoft Teams gave teachers awareness mechanisms for tracking the students' progress. In S2, S3, and S4, the students sent their answers to the teachers either by sending them through Microsoft Teams or sharing their portfolios with the teacher. These mechanisms were enough for teachers to be aware of the students' progress e.g., "I even have the date when they did the task" [TI;S3;Te4]; "I got notifications, so I knew that a group was dealing with some tasks" [TI;S4;Te5]. However, the teachers did not intervene anyhow while students were doing the tasks. Instead, they made some comments later at the classroom (e.g. "I told them to send the answers to me and that was it. [...] I talked to them when we were in the classroom. Some of them sent me the portfolio and others the photos and the answers" [TI;S3;Te4]).

Teachers reported two problems related to Casual Learn awareness mechanisms. First, a teacher who participated in S2 considered that the information provided by Casual Learn through Microsoft Teams was not enough for assessing the students' work ("What they sent me is not enough [for assessment] in the sense that anyone could have taken that photograph. Well, you can see that the photos are distorted or there is a car passing by. But, otherwise, they can be any image from the Web. There is no proof that the student was in that place taking that photograph" [TI;S2;Te3]). It should be noted that the assessment of the S2 UL situation was done only by reviewing the answers submitted by the students through Microsoft Teams. Hence, the teacher did not have any real proof of the authorship of these answers. Second, the scalability of the awareness mechanism: S4 involved 80 students, so it was difficult for the teacher to be aware of their progress only by getting messages through Microsoft Teams. The teacher suggested developing a teacher's dashboard for Casual Learn ("A dashboard, like the one we have in Moodle makes [our work]

easier [...][because] it provides a summary of what is going on" [TI;S4;Te5]); thus teachers would obtain a graphical representation that allowed them to visually grasp the progress of their students. Developing such a dashboard is part of our future research lines.

4.4. Adaptation (T4)

The evaluation process showed that both teachers and students could adapt to the UL situations according to their needs. The teachers in S1, S2, and S3 asked researchers to add new tasks in Casual Learn before the out-classroom activity started [DTC-2;S1-3;Te1-4]. They did not modify anything while the out-classroom activities were taking place; therefore, it was not possible to assess the adaptation dimension in these UL situations.

In S4 the teacher needed to extend the duration of the UL activities, which could be done with no further problems or consequences [TGA-1 DTC-3;S4;Te5]. Interestingly, the students proposed 74 tasks and 36 descriptions of Cultural Heritage sites, which could be successfully published in Casual Learn [SGA;S4;St61-139]. This makes us think that it would have also been possible to add or modify the tasks in Casual Learn for the other three scenarios.

Furthermore, some students extended the learning goals of the out-classroom activity adapting them to their own interests. The students carried out a total amount of 85 tasks previously existing in Casual Learn (i.e., not directly related to the learning situation designed by the teacher) [CLL;S1-4;St1-139]. Other students reported learning outcomes that were not initially considered by the teachers, such as learning culture from their city, learning to take a bus, or socializing with their classmates (e.g. "This activity was a good excuse to learn culture from Palencia" [SQ;S1;St5]; "What I liked the most is that I learned to take a bus and I enjoyed some time with my friends" [SQ;S1;St23]).

It is also noteworthy that several teachers mentioned that the students' learning experience, and the artifacts they created, can well be used to support future lessons (e.g. "[The student's experience using Casual Learn will be useful to] remember or to be used as examples during the classes. Reminding experiences that worked properly is part of our common teaching practice" [TI;S1;Te1]; "I am going to relate it [the activity] to the content covered in the classroom. They have been in Cultural Heritage sites and the learning there is more visual." [TI;S2;Te2]; "The students took a photo and could send it to me through Teams. Then, if I want to, I can use it in the classroom" [TI;S3;Te4]). So, future in-classroom activities may be adapted to further exploit the lessons learned in these UL situations. This is very interesting, as in-classroom learning activities can influence out-classroom learning activities, and also the other way around.

4.5. Pragmatism (T5)

This evaluation shows that five non-ICT expert teachers and 139 secondary-school students successfully carried out four authentic UL situations. In these situations, the students completed a total amount of 640 tasks (M=4.6) in out-classroom physical spaces using Casual Learn [CLL;S1-4;St1-139]. None of the teachers, nor the students, had any previous experience in UL or using mobile technology in the classroom [TQ-1;S1-4;Te1-5].

The time employed in the activity was the most important pragmatic restriction. This was critical in S1 and S2, since the whole curriculum of their courses focuses on the topics prescribed for the University admission exams, and the local Cultural Heritage is not part of them "Take into account that the time dedicated to each topic is very short" [TI;S1;Te1]; "This is not going to be asked in the University admission exam. Our schedule is very tight to cover what is going to be asked, and it is also a matter of time" [TI;S2;Te2]; "We are in a hurry with these students who have to pass the University admission exam" [TI;S2;Te3]. Additionally, it was very difficult for teachers to foresee the time it would take for their students to complete the out-classroom tasks. Indeed, some students complained that it took too much time for them to go through all the Cultural Heritage sites "What I enjoyed the least was the distance among Cultural Heritage sites" [SQ;S3;St59]; "Several students complained that they had to walk for six hours. Others did the tasks during two afternoons instead of one. [...] I did not expect it to be so long" [DTC-3;S4;Te5]. In any case, the time employed in the classroom to carry out the UL situations was considered reasonable by teachers (Mdn: agree) [TQ-2;S1-4;Te1-5].

Other pragmatic problems were due to the technical limitations of Casual Learn, which were all easily solved by the students. A limitation reported by several students is that Casual Learn is not currently available for iOS devices [TI;S3;Te4]; [SQ;S4;St124, S136]. Hence, when forming groups to do the out-classroom activity, the students organized themselves so in each group there was at least a student with an Android device. In other cases, the integration between Casual Learn and Microsoft Teams did not work properly or was too complex for the students

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(teachers did not know which were the problems found by the students). Hence, the students collected the artifacts created and sent them to the teacher by other means ("It was planned that they send me the answers by Teams, but there were some difficulties, so they did it in another way: they created a Microsoft Word document with the answers and they sent me the document through Teams as a message" [TI;S2;Te3]). Finally, a student in S2 reported that there were no tasks located in his village, so the student had to go to other villages to carry out some tasks [SQ;S2;St12]. This problem happened despite the effort of S2 teachers to define tasks located in the villages where their students lived.

In the case of S2, some students made some negative comments about Casual Learn at the very beginning of the UL situation. These comments discouraged their colleagues and, as it was an optional activity, most of them decided not to do it ("I proposed the activity and some of them tried out the tool. The following day they told me that it was not working properly and it had many issues. This, of course, was known by other students. [...] They were disappointed." [TI;S2;Te2]). This was also disappointing for the teachers, as a UL activity that took time and effort, was not as fruitful as they expected ('But I find that trying to use Casual Learn for formal learning, as a tool or an activity in the classroom was not such a good idea for me. It was not a good experience in this sense, because in the end not many of them wanted to do the activity, and those who did found a lot of problems... and because of the time, in my case. Suggesting it in other courses, in other circumstances, it may be a good idea. But, in a general sense, I think that the concept is alright" [TI;S2;Te3]).

Finally, we should mention that these UL situations are considered a learning process for the teachers. Designing and enacting these UL situations required a significant effort for them (e.g. "[About the number of hours they spent] A lot, a lot. I cannot quantify them [...] but talking about this specific project, I am thinking about it since the beginning of this term [...] The most intense period was this last month and a half when I was practically working full time for it" [TI;S4;Te5], but they understood it as a way to learn new teaching methods and techniques despite their own lack of time e.g. "It took me some time... but this time is part of my own research. This is something good, it takes time but I learn and I like it. It is OK" [TI;S3;Te4]; "lot of work is needed, but I understand that this type of methodologies, using new methods, allow advancing in a different and deeper type of learning" [TI;S4;Te5]; "In this moment the amount of information and new tools are so high –especially during the pandemic– [...] They are all very nice, but you feel saturated" [TI;S1;Te1]. They also learned some lessons about the pragmatic problems when enacting UL situations, so they will avoid them in future similar situations ("the next time I use this application I will do it better and I will make the students work better, so we will not waste so much time" [TI;S3;Te4]).

4.6. Alignment (T6)

During the enactment of the UL scenarios, Casual Learn and Microsoft Teams facilitated the connection between different physical and virtual spaces by enabling the artifact flow among them. Microsoft Teams is highly used in the schools of Castile and Leon as a communication channel between teachers and students. This is why the teachers considered very positive the integration of these two applications (e.g. "This school is using Microsoft Teams for almost everything. So it is very positive that I do not need to have a look [at the student's progress] in another application. If they [Casual Learn and Microsoft Teams] could be merged in a single application it would be the ideal situation" [TI;S1;Te1])..

Microsoft Teams not only was used by the students to send the answers of the tasks carried out in physical spaces to the teacher but also by the teachers to send activity instructions to the students (e.g. "I wrote in Microsoft Teams the timeline, what they should do, which buildings they should visit, the number of activities they have to do.") [TI;S2;Te2]. In S3 and S4, the teachers gave the students the option of sharing with them their Casual Learn portfolio instead of sending the tasks through Microsoft Teams. However, teachers were not satisfied with this alternative solution ("In the future years I will not use the portfolio. I will ask the students to send me the answers directly through Teams" [TI;S3;Te4]).

Further development will be needed in Casual Learn to facilitate this alignment. On the one hand, the current integration method is not natural for some students, who preferred to use alternative methods ("the problem is that they sent me the answers through Teams, but not using Casual Learn. I mean, they took photos and they did the tasks, and instead of linking it [the answer] with Microsoft Teams as the application suggests, some of them saved the photos and added them in a PowerPoint, others in a Microsoft Word document, others sent me the photographs through Teams... but I would say that none of them followed the procedure [suggested by Casual Learn]. [...] They told me that it [sending the answers in the way Casual Learn suggests] was more difficult for them" [TI;S2;Te3]). On the

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other hand, in S4 the students proposed some tasks to be carried out by their colleagues later on using Casual Learn. These tasks were collected by the teacher and then published in Casual Learn by the researchers [DTC-3;S4;Te5]. This process would have been facilitated if Casual Learn counted with a task publication interface also suitable for students.

Casual Learn was also integrated into Yammer, Instagram, and Twitter. These are highly used social networks that can well be used to share a personal learning experience with personal acquaintances. However, the students did not use them in any of the four learning situations [CLL;S1-4;St1-129].

4.7. Theory (T7)

The pedagogical aims of the UL situations were not transformed, but enriched, by connecting physical and virtual contexts using Casual Learn. Even if teachers did not have previous experience designing and enacting UL situations, they all agreed that it is convenient to relate in- and out-classroom learning about Cultural Heritage. Indeed, three teachers agreed, and two fully agreed, with the sentence "It is convenient to relate in- and out-classroom learning about Cultural Heritage" (Mdn: agree) [TQ-2;S1-4;Te1-5]. Some of them also mentioned previous school trips with their students that were somehow replaced by this UL situation (e.g. "I used to go with the students to the Oriental Museum in Valladolid" [TI;S1;Te1]). This is especially true in S4, where the teacher used to do a school trip every year, but it was not possible in 2021 because of the pandemic. Hence, the teacher replaced the school trip by a collaborative UL situation ("the local government used to organize some cultural trips around the city. One of them was about the Bourgeoisie in Valladolid. We used to go to this visit as we cover the Spanish XIXth Century in the course, so the students also get to know better their own city. [...] This year the activity emerged from the experience of the visits done in previous years. We use the materials of these visits and an exhibition in the local archive that I visited [years ago]" [TI;S4;Te5]).

Teachers considered that, for them, the most important goal is "to cover in the year the whole curriculum defined by the regional government since "this is what they are demanded for" [TI;S1;Te1]. The UL situations are clearly related to this curriculum , but what students learned from local Cultural Heritage using Casual Learn could have been explained much faster in the classroom, according to a teacher's opinion. Despite this, teachers consider the UL situation interesting since it promotes transversal competences and values, in a similar way as school trips do ("If you see the activity in absolute terms you say 'for what they will learn about what the Canal of Castile is, I can explain it in the classroom and that's it. But, as an activity, I think it is interesting since they walk around this or another part [of the city]. I think it is interesting that they do it. And from what the students told me, I think they liked it also" [TI;S3;Te4]; "I like to show the importance of our local Cultural Heritage. [...] I try that the kids appreciate this Cultural Heritage" [TI;S1;Te1]; "the time spent with students out of the classroom [school trips] is a time to be together, but at the same time to gain knowledge and promote the enthusiasm for acquiring new knowledge" [TI;S4;Te5]).

4.8. Roles of the teacher and student (T8)

During the study, teachers transferred part of the orchestration load to the students. In-classroom activities were designed and orchestrated by the teacher. On the contrary, out-classroom activities were also designed by the teacher but orchestrated by the students.

In the four UL situations, the teachers gave instructions about the activities the students should do and their expected outcome but gave freedom to students to form groups, organize themselves, and do the tasks as they considered (e.g. "[what they did during] the task [with Casual Learn] was not so relevant for me, as the students had to present the results" [TI;S1;Te1])). This was not a problem for the students. Indeed, they carried out the tasks proposed by the teacher [DTC-3;S1-4;Te1-5], they adapted their own learning process (see section 4.4), and they solved the pragmatic issues that emerged (see section 4.5). This student's orchestration did not require any previous training of the students, so it did not have any negative consequence on the teachers' load.

The researchers also played a role in the orchestration of the four UL situations analyzed: Casual Learn did not count with a task publication interface suitable for non-technical expert teachers. Hence, it was the researchers who published in Casual Learn the 86 tasks proposed by teachers [TGA-2;S1-3;Te1-4] and the 74 tasks proposed by students [SGA;S4;St60-129]. As we mentioned in subsection 4.1, it is part of our future work to propose a task publication interface for Casual Learn, so teachers and students can assume this task.

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5. Discussion

Section 4 explored the issue "how do secondary-school teachers orchestrate UL situations about Cultural Heritage in their own practice using Casual Learn?" by analyzing the orchestration of four UL situations carried out in public secondary schools of Castile and Leon. In this section, we discuss our original research question out of this issue's findings.

Teachers could design and orchestrate four very different UL situations about Cultural Heritage adapted to their needs. These UL situations differ in the course in which they are contextualized, the city where they are enacted, or the number of participating students. These differences had an important impact on the design of the UL situations: those proposed in Palencia focus on Medieval Art, while those in Valladolid focus on XIXth Century History. Further, those teachers who have students from rural areas had to locate some tasks in the villages where their students live. We can see how the physical access to Cultural Heritage restricts the design of the UL situation and the topics it can cover; this is an intrinsic restriction when learning in physical spaces that does not appear when using virtual reality (Ch'ng et al., 2020).

All the UL situations required the inclusion of additional tasks, defined by the teachers, to the Casual Learn dataset. Despite Casual Learn counted with 10 000 tasks related to Cultural Heritage sites and teachers considered them interesting (they all suggested their students do some of them), they requested to include additional tasks to adapt Casual Learn to their specific learning needs (S1, S3, and S4) or to the student's context (S2). The reason behind this is the need to contextualize the UL situation for their particular students, and not so much the fact that the tasks available in Casual Learn were semi-automatically created out of data from the Web. Indeed, Mettis and Väljataga (2020) reported two UL situations using applications that contained tasks created by experts, and the teachers still proposed their own learning tasks.

All this makes us consider the need for an application for teachers to include tasks in Casual Learn dataset, which is currently published in the Web of Data (Ruiz-Calleja et al., 2021a). This consideration can be extended to any mobile application expected to be used to support UL situations since teachers will likely find the set of built-in UL tasks does not exactly meet their learning goals. But we can see that current mobile applications that support informal learning about Cultural Heritage do not include a task publication interface (Abril-López et al., 2021; Fermoso et al., 2015). This can be problematic if these tools are used to support formal learning processes. In our case, this problem was solved by the researchers, who assumed part of the orchestration load publishing the tasks in Casual Learn. In any case, it is part of our future work to develop a task publication application that allows a community of teachers to publish tasks in Casual Learn dataset, thus facing the problems of social-semantic annotations (Gruber, 2008). Further, this dataset can take advantage of the recommendations and guidelines in (VIGIE 2020/654, 2022) for ensuring the consistency and long-term sustainability of CH annotations.

The pragmatic restrictions did not hinder the enactment of the four learning situations. But, in a similar way as other research works (Muñoz-Cristóbal et al., 2017; Pérez-Sanagustín et al., 2014), we detected that time was the most important pragmatic problem. In our case, time was a especially strict restriction for the second course of "Bachillerato" (S1 and S2), since the whole course curriculum focused on preparing the students for the University admission exams. In this sense, using an informal learning application, such as Casual Learn, was an advantage since teachers and students required little training to understand its functionality and use it. Indeed, students were not trained in any of the four UL situations, and yet they could autonomously use Casual Learn and assume part of the orchestration load. In other cases where educational technology was employed, university students required some training to share the orchestration load (Muñoz-Cristóbal et al., 2017). In general, the teachers confirmed that time restrictions and the need to prepared students for standardized external assessment are relevant concerns that hinder the adoption of new technologies to support UL about Cultural Heritage.

Concerning the awareness of the learning process, Casual Learn offered information about the students' progress, but some issues were detected. As other informal learning applications (Abril-López et al., 2021; Fermoso et al., 2015; Ruotsalo et al., 2013) Casual Learn does not define the roles of teachers and learners, so there is no user that has special privileges to obtain further information of what other users are doing. Hence, teachers can only obtain from a learner the information that such learner voluntarily shares with them. As this study shows, this is enough for those UL situations where the teacher wants to be aware of the students' out-classroom learning progress, but it may not be enough for those where the teacher wants to assess such progress. Additionally, Casual Learn awareness mechanisms are not suitable for large cohorts of students. More convenient features, such as a teacher dashboard, would be much

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more appropriate. This is a difference with UL situations supported by formal educational tools, which define roles for teachers and students and offer further information to the teachers, sometimes including a dashboard (Mettis and Väljataga, 2020). Some research works showed that the information offered by these educational tools is enough for awareness (Muñoz-Cristóbal et al., 2017; Pérez-Sanagustín et al., 2014), but further evaluation is required to show whether it is useful for assessment.

Regarding the alignment, the integration of Casual Learn with Microsoft Teams was key for the artifact flow from out- to in-classroom activities, thus connecting these physical spaces. Casual Learn did support such artifact flow, but some students searched for alternative solutions to send their answers to the out-classroom tasks to the teacher (e.g., writing their answers in a document and sending it to the teacher). This suggests that many users did not perceive such integration as natural. Indeed, in the four pilots, teachers and students understood Casual Learn and Microsoft Teams as independent applications that do not belong to the same technological ecosystem. While this does not need to be a negative perception, it highly differs from how users perceived the UL tools employed in other studies that use educational applications (Pérez-Sanagustín et al., 2014), because they were intentionally developed to support formal learning. In general, tools developed for informal learning may be perceived more like amusement, and thus, besides the technological integration, an effort should be made to appropriate their educational use.

The reader should note that Casual Learn is an application developed and maintained by the authors. Using Casual Learn instead of another similar informal learning application, such as Smart Zoos (Väljataga and Mettis, 2018) or Smart Tourism (Fermoso et al., 2015), gave us full control on the application used in the evaluation. This highly facilitated the design, enactment and assessment of the evaluation: we could integrate Casual Learn to the technological environment used in the classroom; we could react to any technical problem that arose during the enactment; and we avoided collecting any personal data from the students. While these characteristics were essential to make the evaluation possible, they may have introduced a positive bias in the perception of teachers and students about Casual Learn and its potential to support UL situations.

It should also be noticed that the four UL situations reported were carried out during the COVID-19 pandemic. This contextual characteristic did not have a big influence on the design or the enactment of the UL situations. It nevertheless offered extra motivation for the teachers as they understood these situations as alternatives to school trips, which were not allowed. On the contrary, it influenced our research methods, since we could not access the schools to do observations. This limitation was overcome by weekly interviewing the teachers about the classroom progress, and by triangulating data sources, researchers, and data gathering and analysis techniques, so we could obtain more credible and transferable results.

All in all, we can see that non-technical-expert secondary-school teachers could design and orchestrate UL situations about Cultural Heritage using an application initially developed to support informal learning. The orchestration of these four UL situations was not so different from others where they used technology specifically developed for educational purposes: time was the most important pragmatic restriction, and the role of students was key to assume part of the orchestration load. We found that adapting the functionality of the application to the UL situation needs can be more challenging when using informal learning applications. Moreover, the flow of learning artifacts and information between in- and out-classroom activities can also be problematic. On the other hand, we found out that little training is needed for teachers and students to use Casual Learn in real scenarios. It is still to be explored whether other informal learning applications also require less training than educational-specific ones.

Some recommendations for the design of mobile application for the orchestration of UL can also be derived from this study. It is important that they provide a task publication interface for both teachers and students in order to enable the support of a wider range of situations while distributing among them the load associated to this task. A dashboard should also be provided to adequately support the teachers' awareness of the progress of their students (e.g., adapting UL-related HCI design guidelines already proposed by the CL research team in [(Muñoz-Cristóbal et al., 2018)]). Moreover, special attention should be paid to the integration to the application with the learning environments that are already employed in the educational institution in order to facilitate the flow of learning artifacts and information between in- and out-classroom activities.

6. Conclusions, limitations and future work

This paper presented a study aimed at exploring the orchestration challenges that arise when non-technical expert teachers orchestrate informal–learning tools to support UL activities about Cultural Heritage. With this aim, it ana-

lyzed four UL situations where non-technical expert teachers and secondary-school students used Casual Learn. With very little training, the teachers designed UL situations that were connected to the formal curriculum of their courses. Then, these activities were enacted and orchestrated for several weeks or months. These findings are significant from a teacher training point of view, since they suggest that only short introductory sessions (two one-hour sessions in this study) would be needed before teachers are capable of designing and enacting their own UL situations.

This study also enlarges the scarce empirical base of orchestration of UL situations. It provides additional evidence that include contextual characteristics that are under-explored in the literature: the UL situations happened in secondary education, covered topics related to Cultural Heritage, and were supported by an informal learning tool. These findings suggest that it is feasible to design and enact UL situations without the need of specifically developed technical solutions, such as those employed in the recent literature (Muñoz-Cristóbal et al., 2017; Mettis and Väljataga, 2020). Indeed, the presented study suggests that secondary-education teachers are capable of repurposing an existing mobile application in formal education contexts, an approach that is particularly suitable in the Cultural Heritage domain, since there already exist several of such applications.

We used the *5+3 aspects orchestration framework* to structure the evaluation. As in other similar evaluations, time restriction was the most important pragmatic problem. In this sense, using Casual Learn alleviated this problem because it was not needed to train the students in order to use the application and to assume most of the orchestration load in the out-classroom activities. However, the alignment of Casual Learn with the technological environment used in the classroom was a problem. Even if we integrated Casual Learn with Microsoft Teams, the artifact flow between in- and out-classroom activities required user proactivity that was not always found. We also detected that the information that Casual Learn offers about student's out-classroom activities was enough for the teachers to be aware of the student's progress, but not enough for assessing them. These findings underline significant technical requirements that can be considered when selecting existing mobile applications to be repurposed for formal educational goals, or when developing or customizing mobile applications specifically aimed at supporting UL. In this sense, we derived some design recommendations regarding the importance of a task publication interface, a dashboard for teacher awareness, and the integration of learning environments already employed in the educational institution in order to provide a better support for the orchestration of UL. We believe these are significant practical lessons learned for both researchers in UL and developers of UL mobile solutions. These practical implications are in line with what has been demanded by the UL research field (see, e.g., Virtanen et al. (2018)).

The study has several limitations: 1) the teachers that participated in the study were volunteers among those who took part in the training workshops, and even those workshops were not compulsory. As underlined by other research works (see, e.g., Albirini (2006)), volunteering teachers are more prone to show positive attitudes towards innovative educational ICT tools and pedagogical approaches; 2) Casual Learn is an application developed and maintained by the authors, originally conceived for supporting informal learning. This allowed the researchers to, e.g., react to technical problems (this only happened once), or to publish new learning tasks defined by the participating teachers, thus avoiding teachers a time-consuming responsibility. Obviously, this would not have been possible if a different mobile application, not developed by the researchers, had been repurposed. We acknowledge that these circumstances may have introduced a positive bias in the perception about Casual Learn. Nevertheless, and despite these limitations, we believe that the thick description of the context of this study, and the triangulation of data sources and analysis techniques, can facilitate the transferability of the results to other similar educational context (Guba, 1981; Saldaña, 2021).

The finding that teachers would value being able to create their learning tasks is helping us to shape our ongoing work. LocalizARTE (García-Zarza et al., 2021), an evolution of Casual Learn that again focuses on Cultural Heritage, and Educawood (Andrade-Hoz et al., 2021), which focuses on environmental education, are also learning applications that can be used informally, and address this issue offering a task publication interface, so teachers and learners will be able to publish new tasks, in case they were to be adopted for formal learning. They also integrate a teacher dashboard, so the teachers' awareness will improve. We are developing LocalizARTE and Educawood as web applications, so they can be used both by Android and iOS devices. In the near future, we plan to carry out new pilots with LocalizARTE in secondary education and with Educawood in higher education. Thus, we will further explore the orchestration problems of UL situations.

Acknowledgements

References

Abril-López, D., Morón-Monge, H., Morón-Monge, M., López Carrillo, M., 2021. The learning to learn competence in early childhood preservice teachers: An outdoor and e/m-learning experience in the museum. Future Internet 13, 25. doi:10.3390/fi13020025.

Albirini, A., 2006. Teachers' attitudes toward information and communication technologies: the case of syrian efl teachers. Computers & Education 47, 373–398. doi:10.1016/j.compedu.2004.10.013.

Alkhafaji, A., Fallahkhair, S., Cocea, M., 2019. Design challenges for mobile and wearable systems to support learning on-the-move at outdoor Cultural Heritage sites, in: Proceedings of the 17th IFIP Conference on Human-Computer Interaction, Springer, Paphos, Cyprus. pp. 185–207. doi:10.1007/978-3-030-29387-1_11.

Alkhafaji, A., Fallahkhair, S., Haig, E., 2020. A theoretical framework for designing smart and ubiquitous learning environments for outdoor Cultural Heritage. Journal of Cultural Heritage 46, 244–258. doi:10.1016/j.culher.2020.08.006.

Andrade-Hoz, J., Vega-Gorgojo, G., Ruano-Benito, I., Bote-Lorenzo, M.L., Asensio-Pérez, J.I., Bravo, F., Ordóñez, C., 2021. Educawood: a socio-semantic annotation system for environmental education, in: Proceedings of the 16th European Conference on Technology Enhanced Learning (EC-TEL 2021), Springer, Bolzano, Italy. pp. 368–372. doi:10.1007/978-3-030-86436-1_37.

Berners-Lee, T., 2006. Linked Data - Design Issues. Available at: http://www.w3.org/DesignIssues/LinkedData.html, last visited July 2021.

Chalmers, M., Maccoll, I., 2003. Seamful and seamless design in ubiquitous computing, in: Proceedings of Workshop At the Crossroads: The Interaction of HCI and Systems Issues in UbiComp. 2003.

Ch'ng, E., Li, Y., Cai, S., Leow, F., 2020. The effects of VR environments on the acceptance, experience, and expectations of Cultural Heritage learning. Journal on Computing and Cultural Heritage 13, 7. doi:10.1145/3352933.

Council of Europe, 2005. Council of Europe Framework Convention on the Value of Cultural Heritage for Society. Treaty No. 199. Technical Report. Council of Europe. URL: https://www.coe.int/en/web/conventions/full-list/-/conventions/treaty/199?module=treaty-detail\&treatynum=199. Accessed December 2021.

Creswell, J., 2009. Research design: Qualitative, quantitative, and mixed methods approaches. 3rd ed., SAGE Publications Inc., Thousand Oaks, CA.

Cárdenas-Robledo, L., Peña-Ayala, A., 2018. Ubiquitous learning: A systematic review. Telematics and Informatics 35, 1097–1132. doi:10.1016/j.tele.2018.01.009.

Delgado-Kloos, C., Hernández-Leo, D., Asensio-Pérez, J.I., 2012. Technology for learning across physical and virtual spaces. Journal of Universal Computer Science 18, 2093–2096.

Dillenbourg, P., Nussbaum, M., Dimitriadis, Y., Roschelle, J., 2013. Design for classroom orchestration. Computers & Education 69, 485–492. doi:10.1016/j.compedu.2013.04.013.

Erickson, H., Watson, A., Greene, J., 2022. An experimental evaluation of culturally enriching field trips. Journal of Human Resources In press. doi:10.1145/3352933.

Fermoso, A., Mateos, M., Beato, M.E., Berjón, R., 2015. Open Linked Data and mobile devices as e-tourism tools. A practical approach to collaborative e-learning. Computers in Human Behavior 51, 618–626. doi:10.1016/j.chb.2015.02.032.

García-Zarza, P., Ruiz-Calleja, A., Bote-Lorenzo, M., Vega-Gorgojo, G., Gómez-Sánchez, E., Asensio-Pérez, J., 2021. Towards the annotation and enactment of ubiquitous learning tasks in the context of History of Art, in: Proceedings of the XV Journeys of Telematic Engineering, La Coruña, Spain. pp. 164–167. (In Spanish).

Greene, J., Kisida, B., Bowen, D., 2014. The educational value of field trips: taking students to an art museum improves critical thinking skills, and more. Education Next 14, 78–86.

Gruber, T., 2008. Collective knowledge systems: Where the Social Web meets the Semantic Web. Web Semantics: Science, Services and Agents on the World Wide Web 6, 4–13. doi:10.1016/j.websem.2007.11.011.

Guba, E., 1981. Criteria for assessing the trustworthiness of naturalistic inquiries. Educational Technology Research and Development 1981, 5. doi:10.1007/BF02766777.

Hwang, G.J., Tsai, C.C., 2011. Research trends in mobile and ubiquitous learning: A review of publications in selected journals from 2001 to 2010. British Journal of Educational Technology 42, E65–E70. doi:10.1111/j.1467-8535.2011.01183.x.

Kharrufa, A., Balaam, M., Heslop, P., Leat, D., Dolan, P., Olivier, P., 2013. Tables in the wild: Lessons learned from a large-scale multi-tabletop deployment, in: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Association for Computing Machinery, New York, NY, USA. p. 1021–1030. URL: https://doi.org/10.1145/2470654.2466130, doi:10.1145/2470654.2466130.

Lachand, V., Jalal, G., Michel, C., Tabard, A., 2018. Toccata: An activity centric orchestration system for education, in: Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems, Association for Computing Machinery, New York, NY, USA. p. 1–6. URL: https://doi.org/10.1145/3170427.3188484, doi:10.1145/3170427.3188484.

Lambton-Howard, D., Olivier, P., Vlachokyriakos, V., Celina, H., Kharrufa, A., 2020. Unplatformed design: A model for appropriating social media technologies for coordinated participation, in: CHI '20: Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems, pp. 1–13. doi:10.1145/3313831.3376179.

Lucas-Palacios, L., 2018. The teaching of Cultural Heritage and citizen behavior in the subject of social science: A case study in the Spanish Secondary Education. Ph.D. thesis. Department of Science and Philosophy Didactics. Universidad de Huelva. Huelva, Spain. In Spanish.

Marsick, V.J., Watkins, K.E., 2001. Informal and incidental learning. New directions for adult and continuing education 2001, 25–34. doi:10.1002/ace.5.

Martinez-Maldonado, R., Dimitriadis, Y., Clayphan, A., Muñoz-Cristóbal, J., Kay, J., Prieto, L., Rodríguez-Triana, M., 2013. Integrating orchestration of ubiquitous and pervasive learning environments, in: Proceedings of the 25th Australian Conference on Computer-Human Interaction, ACM, Adelaide, Australia. pp. 189–192. doi:10.1145/2541016.2541076.

McGookin, D., Tahiroğlu, K., Vaittinen, T., Kytö, M., Monastero, B., Carlos Vasquez, J., 2019. Investigating tangential access for location-based digital cultural heritage applications. International Journal of Human-Computer Studies 122, 196–210. doi:10.1016/j.ijhcs.2018.09.009.

Mendes Gabriel Pedro, L., de Oliveira Barbosa, C., das Neves Santos, C., 2018. A critical review of mobile learning integration in formal educational contexts. International Journal of Educational Technology in Higher Education 15, 10. doi:10.1186/s41239-018-0091-4.

Mettis, K., Väljataga, T., 2018. Get out! helping teachers orchestrate outdoor game-based learning activities, in: Proceedings of the 15th International Conference on Cognition and Exploratory Learning in Digital Age (CELDA 2018), Budapest, Hungary. pp. 3–10.

Mettis, K., Väljataga, T., 2020. Orchestrating outdoor location-based learning activities, in: Isaias, P., Sampson, D., Ifenthaler, D. (Eds.), Technology Supported Innovations in School Education. Springer, pp. 143–156. doi:10.1007/978-3-030-48194-0_8.

Miles, M., Huberman, A., 1994. Qualitative data analysis. An expanded sourcebook. SAGE Publications Inc., Thousand Oaks, California, USA.

Milrad, M., Wong, L.H., Sharples, M., Hwang, G.J., Looi, C.-K.and Ogata, H., 2013. Seamless learning: An international perspective on next-generation technology-enhanced learning, in: Handbook of Mobile Learning. Routledge, Abingdon, UK, pp. 95–108.

Mortara, M., Catalano, C., Belloti, F., Fiucci, G., Houry-Panchetti, M., Petridis, P., 2014. Learning Cultural Heritage by serious games. Journal of Cultural Heritage 15, 318–325. doi:10.1016/j.culher.2013.04.004.

Muñoz-Cristóbal, J., Gallego-Lema, V., Arribas-Cubero, H., Martínez-Monés, A., Asensio-Pérez, J., 2017. Using virtual learning environments in bricolage mode for orchestrating learning situations across physical and virtual spaces. Computers & Education 109, 233–252.

Muñoz-Cristóbal, J.A., Rodríguez-Triana, M.J., Gallego-Lema, V., Arribas-Cubero, H.F., Asensio-Pérez, J.I., Martínez-Monés, A., 2018. Monitoring for awareness and reflection in ubiquitous learning environments. International Journal of Human–Computer Interaction 34, 146–165. URL: https://doi.org/10.1080/10447318.2017.1331536, doi:10.1080/10447318.2017.1331536, arXiv:https://doi.org/10.1080/10447318.2017.1331536.

Orlikowski, W., Baroudi, J., 1991. Studying information technology in organizations: Research approaches and assumptions. Information systems research 2, 1–28. doi:10.1287/isre.2.1.1.

Phiri, L., Meinel, C., Suleman, H., 2016. Streamlined orchestration: An orchestration workbench framework for effective teaching. Computers & Education 95, 231–238. doi:10.1016/j.compedu.2016.01.011.

Pimmer, C., Mateescu, M., Grühbiel, U., 2016. Mobile and ubiquitous learning in higher education settings. A systematic review of empirical studies. Computers in Human Behavior 63, 490–501. doi:10.1016/j.chb.2016.05.057.

Pishtari, G., Rodríguez-Triana, M., Sarmiento-Márquez, E., Pérez-Sanagustín, M., Ruiz-Calleja, A., Santos, P., Prieto, L., Serrano-Iglesias, S., Väljataga, T., 2020. Learning design and learning analytics in mobile and ubiquitous learning: A systematic review. British Journal of Educational Technology 51, 1078–1100.

Prieto, L.P., Dimitriadis, Y., Asensio-Pérez, J.I., Looi, C.K., 2015a. Orchestration in learning technology research: Evaluation of a conceptual framework. Research in Learning Technology 23, 28019.

Prieto, L.P., Sharma, K., Wen, Y., Dillenbourg, P., 2015b. The Burden of Facilitating Collaboration: Towards Estimation of Teacher Orchestration Load using Eye-Tracking Measures, in: Proceedings of the 11th International Conference on Computer Supported Collaborative Learning (CSCL 2015), pp. 212–219.

Prieto-Pariente, J., 2016. The management of teaching/learning activities under the curricular model of basic competences in the era of technology. Ph.D. thesis. School of Education and Social Work. Universidad de Valladolid. Valladolid, Spain. (In Spanish).

Pérez-Sanagustín, M., Hernández-Leo, D., Santos, P., Delgado-Kloos, C., Blat, J., 2014. Augmenting reality and formality of informal and non-formal settings to enhance blended learning. IEEE Transactions on Learning Technologies 7, 118–131. doi:10.1109/TLT.2014.2312719.

Ruiz-Calleja, A., Bote-Lorenzo, M., Vega-Gorgojo, G., Serrano-Iglesias, S., García-Zarza, P., Asensio-Pérez, J., Gómez-Sánchez, E., 2020. Casuallearn: A smart application to learn history of art, in: Proceedings of the European Conference on Technology Enhanced Learning (ECTEL), Springer, Heidelberg, Germany. pp. 472–476.

Ruiz-Calleja, A., García-Zarza, P., Vega-Gorgojo, G., Bote-Lorenzo, M., Gómez-Sánchez, E., Asensio-Pérez, J., Serrano-Iglesias, S., Martínez-Monés, A., 2021a. Casual Learn: A semantic mobile application for learning local Cultural Heritage. Semantic Web Journal (Pre-press. doi:0.3233/SW-212907.

Ruiz-Calleja, A., Vega-Gorgojo, G., Bote-Lorenzo, M., Asensio-Pérez, J., Dimitriadis, Y., Gómez-Sánchez, E., 2021b. Supporting contextualized learning with Linked Open Data. Journal of Web Semantics 70, 100657. doi:10.1016/j.websem.2021.100657.

Ruiz-Calleja, A., Villagrá-Sobrino, S., Bote-Lorenzo, M., Serrano-Iglesias, S., García-Zarza, P., Alonso-Prieto, V., Asensio-Pérez, J., 2021c. Orchestrating an ubiquitous learning situation about Cultural Heritage with Casual Learn, in: Proceedings of the Sixteenth European Conference on Technology Enhanced Learning (EC-TEL), Springer, Bolzano, Italy. pp. 332–336. doi:10.1007/978-3-030-86436-1_30.

Ruotsalo, T., Haav, K., Stoyanov, A., Roche, S., Fani, E., Deliai, R., Mäkelä, E., Kauppinen, T., Hyvönen, E., 2013. Smartmuseum: A mobile recommender system for the Web of Data. Journal of Web Semantics 20, 50–67. doi:10.1016/j.websem.2013.03.001.

Saldaña, J., 2021. The coding manual for qualitative researchers. 4th ed., SAGE Publications Inc., London, UK.

Sharples, M., Scanlon, E., Ainsworth, S., Anastopoulou, S., Collins, T., Crook, C., Jones, A., Kerawalla, L., Littleton, K., Mulholland, P., O'Malley, C., 2015. Personal inquiry: Orchestrating science investigations within and beyond the classroom. Journal of the Learning Sciences 24, 308–341. doi:10.1080/10508406.2014.944642.

Song, Y., 2021. A review of how class orchestration with technology has been conducted for pedagogical practices. Educational Technology Research and Development 69, 1477–1503. doi:10.1007/s11423-021-10001-y.

Sonkoly, G., Vahtikari, T., 2018. Innovation in Cultural Heritage: For an Integrated European research policy. Technical Report. European Commission, Publications Office (Luxembourg). URL: http://openarchive.icomos.org/id/eprint/2323/1/KI0118044ENN.en\%20\%281\

%29.pdf. Accessed December 2021.

Tchounikine, P., 2013. Clarifying design for orchestration: Orchestration and orchestrable technology, scripting and conducting. Computers & Education 69, 500–503. doi:http://dx.doi.org/10.1016/j.compedu.2013.04.006.

Twining, P., Heller, R., Nussbaum, M., Tsai, C., 2017. Some guidance on conducting and reporting qualitative studies. Computers & Education 106, A1–A9. doi:10.1016/j.compedu.2016.12.002.

VIGIE 2020/654, 2022. Study on quality in 3D digitisation of tangible cultural heritage: mapping parameters, formats, standards, benchmarks, methodologies, and guidelines. Technical Report. European Commission. URL: https://ec.europa.eu/newsroom/dae/redirection/document/86092. Accessed July 2022.

Virtanen, M.A., Haavisto, E., Liikanen, E., Kääriäinen, M., 2018. Ubiquitous learning environments in higher education: A scoping literature review. Education and Information Technologies 23, 985–998. doi:10.1007/s10639-017-9646-6.

Väljataga, T., Mettis, K., 2018. Turning zoos into smart learning ecosystems. IxD&A Interaction Design & Architecture(s) , 114–133.

Winter, T., 2013. Clarifying the critical in critical heritage studies. International Journal of Heritage Studies 19, 534–545. doi:10.1080/13527258.2012.720997.

Appendix A. Casual Learn usage details

Casual Learn (Ruiz-Calleja et al., 2020, 2021a) is a mobile application currently available for Android devices in Google Play[1]. Casual Learn lets learners access its more than 10 000 geolocalized tasks in two different modes:

- When Casual Learn is used in passive mode, learners get recommendations of Cultural Heritage sites to visit and tasks to carry out. When a learner is close to a Cultural Heritage site, Casual Learn triggers a notification (the frequency of notifications is a configurable parameter). If the learner accepts the notification, they will see a description of the Cultural Heritage site (e.g., Figure A.3(b,c)). If the learner gets closer than 150 meters from the Cultural Heritage site, they can do the tasks related to such site (e.g., Figure A.3(d,e)).

- When Casual Learn is used in active mode, learners browse and select the tasks to carry out. Casual Learn offers a map where the learner can visualize the location of Cultural Heritage sites and the number of tasks available in each of them (see Figure A.3(a)). When the learner selects a site, they will obtain its description and the tasks related to it (e.g., Figure A.3(b,c)). If a task is selected, the learner will see its description (e.g., Figure A.3(d,e)), but they will only be able to carry it out if their distance to the Cultural Heritage site is less than 150 meters.

Casual Learn tasks may ask the learner to read a text, to take some notes, to take one or several photographs, and/or to record a video. After a task is complete, the learner can share it in social networks (in its current version Casual Learn integrates Twitter, Instagram, and Yammer) and also in Microsoft Teams. The learner can also build a portfolio that lists the tasks carried out (see Figure A.3(f)) and share the portfolio with anyone they please.

As a distinguishing characteristic, Casual Learn is an application based on Linked Open Data (Berners-Lee, 2006). It counts with an initial dataset of more than 10 000 tasks geolocalized in Cultural Heritage sites of Castile and Leon, and automatically created out of data from the Web (Ruiz-Calleja et al., 2021b). This initial dataset can be enriched by adding new tasks. Additionally, Casual Learn enables the definition of collections of tasks. For example, the borders of the icons to represent Cultural Heritage sites in Figure A.3(a) have three different colors, thus indicating three different collections of tasks that can be easily distinguished: the icons with a yellow border are sites with tasks related to History of Art; the icons with an orange border are sites with tasks related to XIXth Century History; the icons with an ivory border are sites with tasks related to the industrialization of the city of Valladolid.

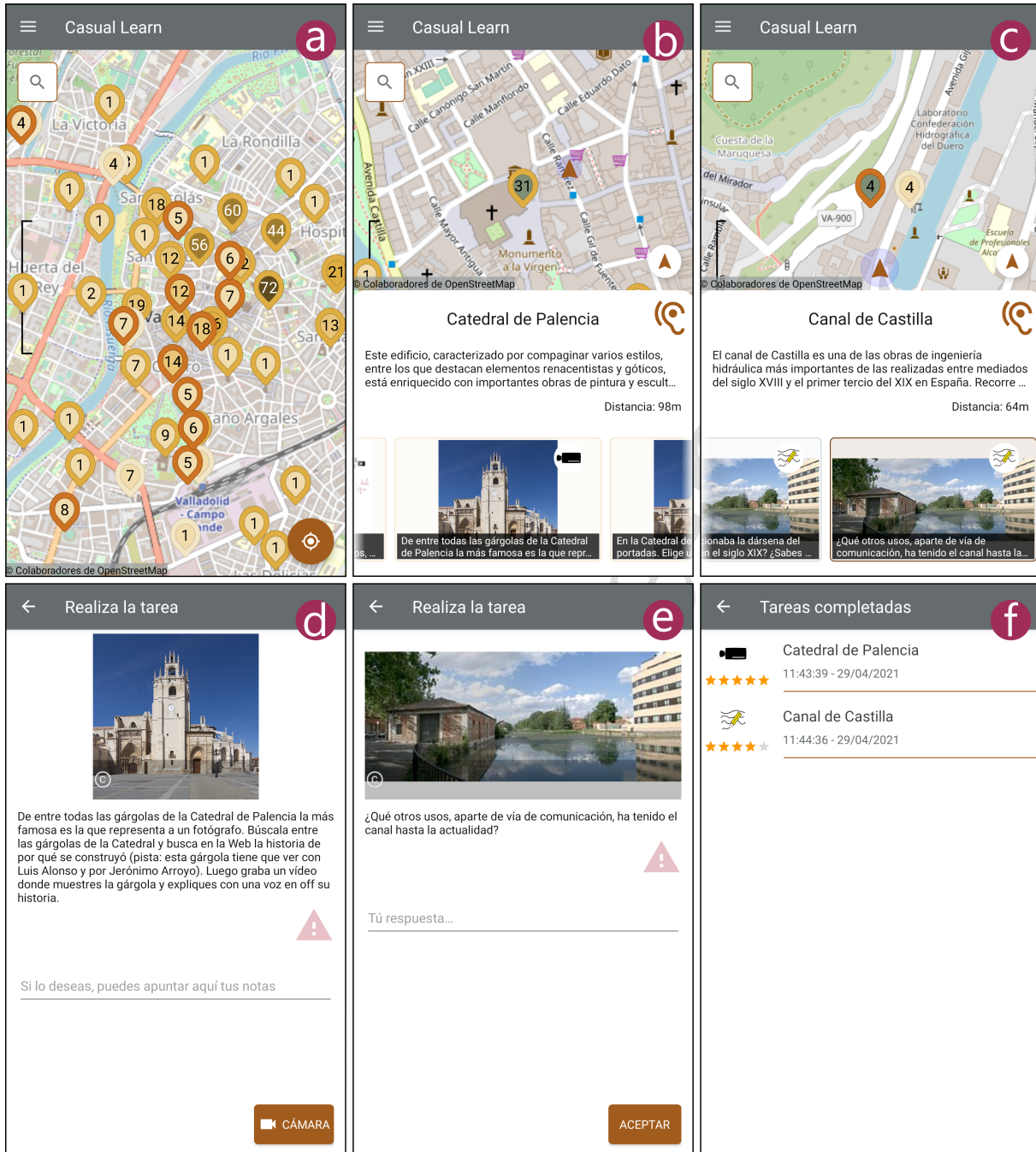
[1] https://casuallearnapp.gsic.uva.es/

Figure A.3: Snapshots of the user interface of Casual Learn. a) view of the city center of Valladolid; icons represent Cultural Heritage sites where a number of tasks are located. b) description of the Palencia Cathedral. c) description of the Canal of Castile in Valladolid. d) task related to Palencia Cathedral; the textual task description is: "Among all the gargoyles of the Palencia Cathedral, the most famous is the one that represents a photographer. Find it and look up on the Web the reason why it was built (clue: this gargoyle has to do with Luis Alonso and Jerónimo Arroyo). After that, record a video where you show the gargoyle and you explain its history". e) task related to Canal of Castile; the textual task description is: "Which uses, other than a communication channel, has the Canal of Castile had?". f) portfolio.

Highlights

Orchestrating ubiquitous learning situations about Cultural Heritage with Casual Learn mobile application

- We studied the challenges that arise in the orchestration of ubiquitous learning situations about Cultural Heritage when it is supported with a mobile application designed for informal learning.

- The study involved 5 teachers and 139 secondary-school students that used Casual Learn mobile application in 4 ubiquitous learning situations that involve both in-classroom and out-classroom activities.

- Teachers were able to design and orchestrate situations adapted to their needs.

- Teachers transferred most of the orchestration load of out-classroom activities to students.

- The flow of learning artifacts and information between in- and out-classroom activities is a critical issue.

CRediT author statement

Adolfo Ruiz-Calleja: Conceptualization, Methodology, Software, Investigation, Data curation, Formal analysis, Writing - original draft, Writing - review & editing, Visualization. **Miguel L. Bote-Lorenzo:** Conceptualization, Methodology, Writing - review & editing, Supervision, Project administration, Funding acquisition. **Juan I. Asensio-Pérez**: Conceptualization, Methodology, Writing - original draft, Writing - review & editing, Supervision. **Sara Villagrá-Sobrino:** Conceptualization, Methodology, Investigation, Formal analysis, Writing - original draft, Writing - review & editing. **Víctor Alonso-Prieto**: Investigation, Data curation, Formal analysis, Writing - review & editing. **Eduardo Gómez-Sánchez:** Conceptualization, Writing - review & editing, Supervision. **Pablo García-Zarza:** Software, Investigation, Data curation, Writing - review & editing, Visualization. **Sergio Serrano-Iglesias:** Software, Investigation, Data curation, Writing - review & editing. **Guillermo Vega-Gorgojo:** Conceptualization, Writing - review & editing, Supervision.

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: