

Casual Learn: A Semantic Mobile Application for Learning Local Cultural Heritage

Adolfo Ruiz-Calleja^a, Pablo García-Zarza^a, Guillermo Vega-Gorgojo^{a,*}, Miguel L. Bote-Lorenzo^a, Eduardo Gómez-Sánchez^a, Juan I. Asensio-Pérez^a, Sergio Serrano-Iglesias^a, and Alejandra Martínez-Monés^b

^a *Departamento de Teoría de la Señal y Comunicaciones e Ingeniería Telemática, E.T.S. Ingenieros de Telecomunicación, Universidad de Valladolid, Valladolid, Spain*

^b *Departamento de Informática, Escuela de Ingeniería Informática, Universidad de Valladolid, Valladolid, Spain*

Abstract.

This paper presents Casual Learn, an application that proposes ubiquitous learning tasks about Cultural Heritage. Casual Learn exploits a dataset of 10,000 contextualized learning tasks that were semiautomatically generated out of open data from the Web. Casual Learn offers these tasks to learners according to their physical location. For example, it may suggest describing the characteristics of the Gothic style when passing by a Gothic Cathedral. Additionally, Casual Learn has an interactive mode where learners can geo-search the tasks available. Casual Learn has been successfully used to support three pilot studies in two secondary-school institutions. It has also been awarded by the regional government and an international research conference. This made Casual Learn to appear in several regional newspapers, radios, and TV channels.

Keywords: Semantic Web, Contextualized learning tasks, Informal learning,

1. Introduction

During the last 15 years, an increasing amount of Cultural Heritage data is available on the Web [12]. Data publishers range from public administrations to foundations, NGOs, or companies. They offer geospatial data about monuments and historical sites, thus relating them with their physical locations [15]. Part of this data has been exploited by third parties for supporting the discovery of information [3], data visualization, or serendipitously offering new knowledge to their users [12].

A few learning applications exploit geolocated Cultural Heritage data for learning purposes [9, 14, 20]. They are typically mobile applications that offer information retrieved from the Web of Data according to the learner's geolocation. For example, they may offer

the Wikipedia page of a castle when the learner is close to it. This way, learners obtain meaningful information when they are in real-life contexts, following a ubiquitous learning approach [13]. However, the pedagogical support offered by these applications is restricted, as they limit their functionality to offering textual information. Furthermore, this support is not related to the learners' formal education. We envision going beyond these limitations by offering learners a set of higher-order thinking tasks related to their learning curricula and to Cultural Heritage sites. This type of tasks is needed, as meaningful ubiquitous learning processes require learners an active role when perceiving, exploring, solving problems, or interacting with the environment [13].

Following this aim, in our previous work [19] we created contextualized learning tasks from Cultural Heritage Linked Open Data. Very briefly, we gathered Open Data about Cultural Heritage repositories in the

*Corresponding Author. E-mail: guiveg@tel.uva.es

Semantic Web and we applied a set of templates with pedagogically meaningful rules to create more than 10,000 tasks contextualized in the Spanish region of Castile and Leon. For example, we applied a template that filtered all the Romanesque churches that have modillions, and for each of them, created a task (geo-referenced in the same location of the church) that proposes the learner to take a photo of a modillion and describe the ornaments that appear on it. The pedagogical interest that these tasks have for secondary school students was validated by teachers of History of Art.

The task dataset is currently published as Linked Open Data and accessible from a SPARQL endpoint¹. Nonetheless, Semantic Web languages are not appropriate for secondary-school students. Hence, we now face the problem of how to let learners access these tasks and let them carry them out at the right place and moment. This is especially challenging, as there are few visualization tools of geospatial Linked Data for users that are not experts on Semantic Web languages [23].

With the aim of addressing this challenge, this paper presents Casual Learn, an application that proposes ubiquitous learning tasks about Cultural Heritage. Casual Learn recommends learners to approach a historical monument close to their current position and then suggests them some tasks according to their interests. Then, learners can report the tasks done by sharing them in social networks or including them in a portfolio [6]. This way, Casual Learn coherently offers publicly-available Linked Data (the tasks description) with personal data (the learner’s task realization) to bridge formal and informal learning [10]. Casual Learn is currently available in Google Play. It has been employed to support authentic learning activities related to Cultural Heritage in three pilots involving 4 teachers and 59 students.

The rest of the paper is organized as follows. Section 2 describes the open dataset exploited by Casual Learn. Next, section 3 introduces the requirements of Casual Learn. Section 4 then delves into the details of how Casual Learn was designed and implemented. Finally, this paper ends with a discussion and future research lines in section 5.

2. Casual Learn Task dataset

In our previous work [19] we gathered the data related to the Cultural Heritage of Castile and Leon that was available on the Web of Data. Specifically, we retrieved and integrated more than 2,000 descriptions of Cultural Heritage sites from DBpedia², Wikidata³ and the Open Data portal of Castile and Leon⁴. Out of these descriptions we generated a 5-star dataset [4] of learning tasks about Cultural Heritage that is currently available in a SPARQL endpoint¹. These tasks are described according to SLEek Ontology [17], whose main classes are `cl:Task` and `cl:Context`.

We created an instance of `cl:Context` for each Cultural Heritage site gathered. Each instance of `cl:Context` is described by selecting a set of parameters from their descriptions in the abovementioned data sources. These parameters include its name (`rdfs:label`), textual description (`rdfs:comment`), geolocation (`geo:lat`, `geo:long`), and an optional associated image (`foaf:depiction`). This way, we obtained more than 2,000 contexts. Listing 1 offers the partial description of three of them: the Palace of Fabio Nelli⁵, Palencia Cathedral^{6,7}, and Ampudia Castle^{8,9} (Table 1 lists the prefixes used in the present work and their corresponding extended URI). Context descriptions also include other parameters to state their creator and a `rdfs:seeAlso` relationship to the descriptions of the Cultural Heritage site from the original sources. Note that in some cases not all the information can be gathered. For example, the description of the Palace of Fabio Nelli offered by the Open Data portal of Castile and Leon does not include an image, so we could not state the `foaf:depiction` relationship for its corresponding context.

²<https://www.dbpedia.org/about/>

³<https://www.wikidata.org/>

⁴<https://datosabiertos.jcyl.es/web/jcyl/set/es/cultura-ocio/monumentos/1284325843131>

⁵https://es.dbpedia.org/resource/Palacio_de_Fabio_Nelli,id:25338

⁶https://es.dbpedia.org/resource/Catedral_de_San_Antolín_de_Palencia

⁷<https://opendata.jcyl.es/ficheros/cct/wtur/monumentos.json,id:23782>

⁸https://es.dbpedia.org/resource/Castillo_de_Ampudia

⁹<https://opendata.jcyl.es/ficheros/cct/wtur/monumentos.json,id:25145>

¹<https://casuallearn.gsic.uva.es/sparql>

Table 1

Prefixes used in the present work and their corresponding namespaces.

Prefix	URI
cl:	https://casuallearn.gsic.uva.es/
clc:	https://casuallearn.gsic.uva.es/context/
clo:	https://casuallearn.gsic.uva.es/ontology/
clp:	https://casuallearn.gsic.uva.es/property/
cla:	https://casuallearn.gsic.uva.es/answerType/
geo:	http://www.w3.org/2003/01/geo/wgs84_pos#
wm:	http://commons.wikimedia.org/wiki/Special:FilePath/
rdfs:	http://www.w3.org/2000/01/rdf-schema#
foaf:	http://xmlns.com/foaf/0.1/
dcterms:	http://purl.org/dc/terms/
xsd:	http://www.w3.org/2001/XMLSchema#

Listing 1: Partial descriptions of three contexts in Casual Learn SPARQL endpoint. Texts are translated into English.

```

clc:Palacio_de_Fabio_Nelli/47288889/416561111
  rdf:type clo:physicalSpace ;
  rdfs:label "Palace of Fabio Nelli" ;
  rdfs:comment "The Palace of Fabio Nelli
is the most important Renacentist build-
ing in the city of Valladolid..." ;
  geo:lat 41.656111 ;
  geo:long -4.728889 .

clc:Catedral_de_Palencia/453674/4201128
  rdf:type clo:physicalSpace ;
  rdfs:label "Palencia Cathedral" ;
  rdfs:comment "This building is charact-
erized by mixing elements from multiple
styles, including Gothic, and..." ;
  foaf:depiction wm:Catedral_de_Pal.jpg ;
  geo:lat 42.01128 ;
  geo:long -4.53674 .

clc:Castillo_de_Ampudia/4783513/41912855
  rdf:type clo:physicalSpace ;
  rdfs:label "Castle of Ampudia" ;
  rdfs:comment "The Castle of Ampudia is a
medieval fortress from the XV Century
located in Ampudia..." ;
  foaf:depiction wm:Ampudia_-_Castillo.jpg ;
  geo:lat 41.912855 ;
  geo:long -4.783513 .

```

We created tasks related to these contexts by applying a set of templates [19] to this same data. Each template includes a filter, to select a subset of Cultural Heritage sites descriptions; and a constructor, to generate a task out of each description selected. The task constructor relates each instance of `cl:Task` to an instance of `cl:Context` (`clp:hasContext`).

As represented in Listing 2, a task description includes a textual description (`clp:associatedTextResource`), its type of answer (`clp:answerType`) (e.g., text, image, multiple images, video...), the context where it should be displayed, and an optional associated image (`foaf:depiction`). Additionally, the instances of `cl:Task` obtained from DBpedia descriptions include `dcterms:subject` relationships to the Wikipedia categories of the original DBpedia description.

As an example of the process to create tasks, a template filtered each pair of Gothic temples closer than 1 km. from each other, and created a task to ask learners to compare them both. Then, out of the description of Palencia Cathedral and San Francisco Church¹⁰, we obtained the second task reported in Listing 2. Another example is a template that filters all the castles known to have a barbican. As the description of the Castle of Ampudia in DBpedia is related to the concept of Barbican¹¹, we obtained the third task reported in Listing 2. Following this procedure, we created 10,000 instances of `cl:Task`. More details are provided in [19].

Listing 2: Partial descriptions of three tasks in Casual Learn SPARQL endpoint. Texts are translated into English.

```

cl:25338/describeEstilo
  rdf:type clo:task ;
  clp:associatedTextResource "Which is the
main style archi tectural style of the
Palace of Fabio Nelli? Identify in it some
characteristic elements of this style." ;
  clp:answerType cla:text ;
  clp:hasContext clc:Palacio_de_Fabio_N... .

cl:Catedral_de_Palencia/MismoEstiloCercanos/77
  rdf:type clo:task ;
  clp:associatedTextResource "Close to Pale-
ncia Cathedral there are other Gothic-style
buildings, such as Saint Francisco Church.
We invite you to visit both and reflect
why there are several buildings of the
same style in such short distance" ;
  foaf:depiction wm:Iglesia_de_San_Fran.jpg ;
  clp:answerType cla:text ;
  clp:hasContext clc:Catedral_de_Palen... .

cl:Castillo_de_Ampudia/vocabul[...]/barbacana
  rdf:type clo:task ;
  clp:associatedTextResource "Can you see any

```

¹⁰[https://es.dbpedia.org/resource/Iglesia_de_San_Francisco_\(Palencia\)](https://es.dbpedia.org/resource/Iglesia_de_San_Francisco_(Palencia))

¹¹<https://es.dbpedia.org/resource/Barbacana>

```

barbican in the Castle of Ampudia? In that
case, take a photo of it" ;
foaf:depiction wm:Ampudia_-_Castillo_1.jpg;
clp:answerType cla:image ;
clp:hasContext clc:Castillo_de_Ampudia /...

```

3. Casual Learn requirements

Casual Learn is an application that lets learners access and carry out the tasks included in the dataset described above. Casual Learn requirements were defined by an iterative design process that involved 13 teachers from five secondary schools of Castile and Leon. All of them teach either History or History of Art, and are highly knowledgeable about local Cultural Heritage Sites. The following requirements emerged out of this iterative process:

R1. Mobile. Learners should be able to use Casual Learn on mobile devices when visiting or passing by Cultural Heritage sites.

R2. Task exploration. Learners should be able to explore the tasks available in an interactive map, which is a suitable visualization for geolocalized learning tasks. When exploring the tasks, learners should be able to manipulate the map by zooming, panning, or moving around it.

R3. Task and site recommendation. Casual Learn should recommend Cultural Heritage sites to visit, and tasks to carry out, taking into consideration their proximity to the learner. Task recommendation should also take into account the learner's preferences; e.g., some learners may prefer to take pictures while others may like to answer short questions. Also, if a learner has already carried out a task, the system should not recommend it again to that learner.

R4. Task visualization. Learners should be able to visualize the available tasks for each site.

R5. Task realization. Casual Learn should let learners carry out tasks if they are close to their associated Cultural Heritage Site. Tasks may require learners to write texts, take photos, or record videos. After completing a task, learners should be able to edit their answers.

R6. Task report. Learners should be able to report the tasks done in two different ways: sharing them in social media (teachers suggested Twitter, Instagram, and Yammer) or learning platforms (Microsoft Teams); and sharing a portfolio [6] built by Casual Learn out of their answers. Note that portfolios have already been used to report the outcomes of infor-

mal learning activities (e.g., what a student learns in his daily life) and relate them to formal competencies (e.g., what they are expected to learn in the classroom) [10]. Thus, portfolios are a good means to relate formal and informal learning.

R7. Hiding of semantic technologies. Learners are not expected to know any Semantic Web language or technology. Thus, the user interface should offer appropriate visualizations and metaphors to present the information according to the learners' needs.

R8. Task retrieval from SPARQL endpoints that follow the SLEek ontology. The current version of Casual Learn will retrieve tasks from the SPARQL endpoint described in section 2, but it should be extensible to other data sources that publish tasks following the same ontology.

Note that R2 and R3 determine two different modes to find a task. In one of them, the user actively browses a map and selects the tasks she wants to carry out. In the other, the application is running in the background and recommends the user to approach a site where she can carry out some tasks.

4. Casual Learn design and implementation

This section presents Casual Learn, an application that satisfies the requirements identified in Section 3. Figure 1 depicts the software architecture of Casual Learn. SPARQL queries, data retrieval, and user data management are performed by the *Casual Learn server* (subsection 4.1), while the *Casual Learn client* deals with data visualization and user interactions (subsection 4.2). This client-server architecture allows simple front-end clients –which are desirable for mobile applications (R1)– at the same time that Casual Learn offers complex functionality.

4.1. Casual Learn server

The back-end server manages the data created by Casual Learn users, provides a data gateway to coherently access *Casual Learn SPARQL* (R2, R8), obtains tasks recommendations (R3), and user-generated data (R6).

The functionality of the *Restful application server* has been divided into two modules (see Figure 1): *Task manager*, which offers tasks and contexts from *Casual Learn SPARQL* or any other compatible endpoint; and *Answer manager*, which deals with the user-generated data stored in the *Answer database*. This modularity

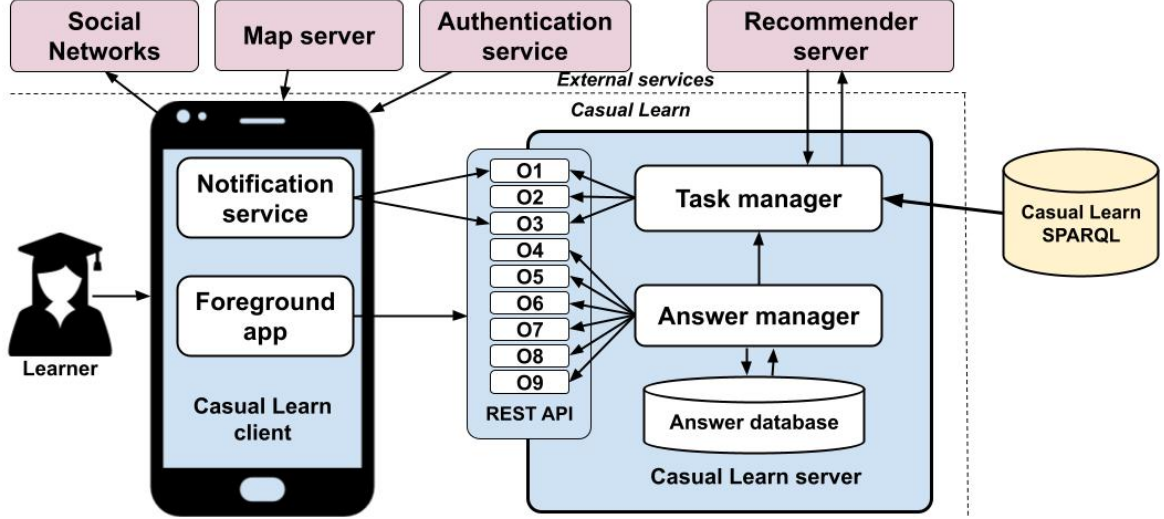


Fig. 1. Casual Learn architecture. Elements with blue background belong to Casual Learn application; elements with purple background are external services; elements with yellow background are SPARQL endpoints that publish learning tasks following the SLEek ontology.

Table 2
Restful API of Casual Learn server.

ID	Method	Resource	Meaning
O1	GET	/contexts?north={N}&east={E}&south={S}&west={W}	Retrieves the contexts in a given bounding box
O2	GET	/tasks?contextId={contextId}	Retrieves the tasks related to a context
O3	GET	/tasks?contextId={contextId}&userId={userId}	Retrieves a ranked list of tasks related to a context for a learner
O4	POST	/answers	Adds a new answer to a task by a learner
O5	PUT	/answers/{answerId}	Updates an answer by a learner
O6	POST	/portfolio	Creates a new portfolio for a learner
O7	GET	/portfolio/{portfolioId}	Retrieves a portfolio
O8	GET	/portfolio/{portfolioId}/{answerId}	Retrieves an answer in a portfolio

facilitates the integration of SPARQL endpoints and third-party services (e.g., recommender services). It also facilitates Casual Learn maintenance in case service providers need to be changed or new services need to be added (R8).

The back-end server manages four types of resources, all of them defined by SLEek Ontology [17]: *context*; *task*; *answer*; and *portfolio*. Table 2 lists all the operations defined by the *Restful API* of *Casual Learn server*. The rest of this subsection provides further details of the REST operations supported.

Operation O1 is controlled by the *Task manager* and retrieves the contexts of a specific area. As con-

texts have points as geometries (see section 2), a query needs to obtain the contexts included in a bounding box. This bounding box is defined as a rectangular area by the parameters of the URI invoked. When invoking O1, the *Casual Learn client* obtains the contexts available in the area that the learners are visualizing (R2) or those close to them (R3). Each context is partially described by its geolocation, its label, and the number of tasks related to it. This data is useful for *Casual Learn client* to inform learners when they browse the contexts available in the map, or to notify them of nearby contexts when they walk. Listing 3 shows a parameterized SPARQL query to retrieve contexts in a given area.

Listing 3: Parameterized SPARQL query to retrieve the contexts available in a given bounding box.

```
SELECT ?cont ?lat ?long ?label (count(?task)
as ?nT) WHERE {
  ?cont geo:lat ?lat ;
        geo:long ?long ;
        rdfs:label ?label .
  ?task clp:hasContext ?cont .
  FILTER (
    (xsd:decimal(?lat) > <S>) &&
    (xsd:decimal(?lat) < <N>) &&
    (xsd:decimal(?long) > <W>) &&
    (xsd:decimal(?long) < <E>) ).
} GROUP BY ?cont ?lat ?long ?label
```

Note that O1 does not retrieve the tasks associated to the contexts to avoid data overload. As an example, a learner who browses the tasks available in a historical city may obtain tens of contexts related to hundreds of tasks (see Figure 2a for a view of the city center of Valladolid). For this reason, we separated the step of obtaining contexts (O1), and obtaining tasks related to a context (O2). Thus, we improve the scalability of the system.

Operation O2 is controlled by the *Task manager* and retrieves the tasks associated with a given context. *Casual Learn client* invokes O2 when a learner is exploring the tasks available (R2) and selects a context to visualize the tasks associated with it (R4). Each task is described by its text description, its answer type, and, if available, its image. Listing 4 shows a parameterized SPARQL query to obtain the tasks associated with a given context.

Listing 4: Parameterized SPARQL query to obtain the tasks related to a given context.

```
SELECT ?task ?aTR ?img ?aT
WHERE {
  ?task clp:hasContext <context> ;
        clp:associatedTextResource ?aTR .
  OPTIONAL {
    ?task foaf:depiction ?img .
  }
  OPTIONAL {
    ?task clp:answerType ?aT .
  }
}
```

Operation O3 is managed by the *Task recommender* and retrieves a ranked list of tasks related to a given context for a specific learner. Hence, O3 is invoked when the *Casual Learn client* aims to recommend a task to a learner (R3). To provide the requested information the *Task recommender* gathers a set of task descriptions from *Casual Learn SPARQL* (in a similar

way as in O2), and obtains their rank from the *Recommender server*.

In the current version of Casual Learn, the *Recommender server* is configured to offer personalized and social recommendations. First, the *Recommender server* promotes those tasks that the learner has not done yet. Second, it promotes those tasks highly rated by other learners that have similar preferences. Third, it promotes those tasks whose `cl:answerType` is the same as those highly rated by the learner. This results in the ranked list of tasks that is returned.

Operations O4 and O5 are managed by the *Answer manager* and are needed to report the tasks done by the learners (R6). They are invoked when the learner completes a task or updates her answer. These operations accept a JSON file that includes the user ID, the task ID, the textual answer (if any), the ID of the image or video answer (if any), and the user rating of the task (if any). Taking this information, the *Answer manager* stores the answer in the *Answer database*.

Textual answers are stored in the *Answer database*, but this is not the case with image and video answers. The reason is that Casual Learn is expected to be used by minors and both images and videos can potentially contain personal data (e.g., if the learner takes a selfie). Hence, we opted for only storing image and video IDs, while the images and videos themselves are stored locally on the users' devices.

If the learner rates the task, the *Answer manager* calls the *Task manager* for it to submit the rating to the *Recommender server*. Thus, the *Recommender server* can use this information to improve its future recommendations.

Operations O6, O7, and O8 are managed by the *Answer manager* and deal with reporting the answers using portfolios (R6). When invoking O6 the *Answer manager* generates a portfolio for a learner and relates it to a new URL that is accessible from any web browser. Anyone who accesses such URL (O7) will obtain the list of answers by this learner, either in HTML or JSON format. It is also possible to obtain only one specific answer (O8) in JSON format.

4.2. Casual Learn client

Casual Learn client is designed as a mobile application (R1). It should hide the underneath data complexity (R7) while allowing learners to explore (R2), get recommendations (R3), visualize (R4), and carry out (R5) the tasks available in *Casual Learn SPARQL*

Table 3
Examples of invocations of Casual Learn.

ID	Operation	Method	Resource
I1	O1	GET	/contexts?north=41.66247&east=-4.70605&south=41.63707&west=-4.73145
I2	O2	GET	/tasks?contextId=clc:Palacio_de_Fabio_Nelli/4728793/41656063
I3	O2	GET	/tasks?contextId=clc:Catedral_de_Palencia/453674/4201128
I4	O2	GET	tasks?contextId=clc:Castillo_de_Ampudia/4783513/41912855
I5	O4	POST	/answers
I6	O1	GET	/contexts?north=41.66897&east=-4.70605&south=41.66572&west=-4.7093
I7	O3	GET	/tasks?contextId=clc:Palacio_de_Fabio_Nelli/4728793/41656&userId=Dbm00zh0HKR2
I8	O7	GET	/portfolio/MaKLNE9KjQ
I9	O8	GET	/portfolio/MaKLNE9KjQ/RhNhdzyoNs

or any other compatible endpoint, as well as reporting their answers (R6).

Learners can access the tasks available in *Casual Learn SPARQL* by exploration (R2) or by recommendation (R3). To let the learner explore the dataset, *Casual Learn client* presents an interactive map as its main component, which is loaded from the *Map server*. This map is displayed on full screen, and panning and zooming are supported. It also includes a textbox for searching for municipalities (loaded in *Casual Learn client* from the open data portal of Castile and Leon¹²).

When the learner zooms in the map and visualizes an area whose diagonal is smaller than 5 km., the contexts available in that area are represented. For this purpose, *Casual Learn client* divides the space in bounding boxes of 0.0254 degrees¹³ and invokes operation O1 for each bounding box that is visible (or partially visible) in the screen. Then, it depicts over the map the contexts retrieved.

As an example, invocation I1 in Table 3 is used to query the contexts available in an area located in the city center of Valladolid. *Casual Learn client* represents the map in Figure 2b out of the data retrieved. The map includes an icon with the number of tasks available for each context. If the user zooms out the map and visualizes a wider area of the city of Valladolid, several invocations will be submitted and *Casual Learn client* will represent the map in Figure 2a. The bounding boxes of these several invocations are obtained by adding 0.0254 to a central

point. As queries are prone to repeat, *Casual Learn* can greatly exploit the cache of *Casual Learn SPARQL*.

When the learner selects a context, *Casual Learn client* invokes O2 to obtain the descriptions of the tasks related to such context. Some examples are invocations I2, I3, and I4 in Table 3. Then, the learner gets access to the list of tasks available, together with their images and an icon that represents their task type. For example, Figure 2c and Figure 2d depict the graphical representation after invocation I2 and I3, respectively. Note that Figure 2d represents images for each task, but this is not the case in Figure 2c (it represents generic icons instead). The reason is that, during the creation of the tasks out of the Web of Data, we did not gather an image for the tasks and the context related to the Palace of Fabio Nelli, as explained in Section 2.

If a task is selected, *Casual Learn client* provides a full description of the task. It also checks the learner's geolocation and compares it with the geolocation of the context associated to that task. If the learner is closer to 0.001 degrees (150 meters), then *Casual Learn* enables the learner to realize it (R5). Otherwise, *Casual Learn client* notifies that the task will be available when the learner is closer to the context. *Casual Learn client* provides access to the mobile camera if the task requires taking any photograph or video. An example is represented in Figure 2e. When the learner completes the task represented in Figure 2e, *Casual Learn client* invokes I5 posting a JSON file. Such file contains the ID of the task, the ID of the user, the learner's answer, and the rating she gave to the task (if she did).

Learners can also access tasks by recommendations triggered by proximity (R3). When running in the background, *Casual Learn client* suggests the learner to get closer to a context every configurable period of time (three hours by default). For this recommenda-

¹²<https://analisis.datosabiertos.jcyl.es/explore/dataset/registro-de-municipios-de-castilla-y-leon/>

¹³In the latitude of Castile and Leon 0.0254 degrees correspond to 4 kilometers, using the approximation given by the Cosine-Haversine formula [16]

tion, *Casual Learn client* invokes operation O1, such as in invocation I6, defining a square bounding box with a side of 0.00325 degrees (725 meters). Again, this bounding box is defined by adding 0.00325 to a central point. If there is any context close to the learner, the client shows a notification suggesting the learner to get close to such context. If the learner accepts the notification, *Casual Learn client* invokes O3, such as in invocation I7, and retrieves a ranked list of tasks related to the context. Then, *Casual Learn client* represents the context information together with the ordered list of tasks, in a similar way as in Figures 2c and 2d.

Once a learner has completed her first task, she can create a portfolio in her configuration menu (R7). In that case, *Casual Learn client* invokes operation O6. After that, the learner can visualize the list of tasks she answered (see Figure 2f). Then, *Casual Learn client* invokes O7, such as in I8 to obtain the user portfolio. It can also invoke O8, such as in I9, if the learner aims to look at a specific answer for a task. Finally, the learner can also share any task carried out in a social network (R6). In that case, *Casual Learn client* invokes the API of that social network and submits the required information.

4.3. Implementation

Casual Learn client is developed as an Android application. It is compatible with Android 4.4 or higher. So in February 2021, it is compatible with 98.1% Android devices, according to Android Developer Platform¹⁴. For its development, we used Volley¹⁵, a well-known HTTP library for Android applications. For the *Map server* we used OpenStreetMap¹⁶, a well-known open-source map service. As *Authentication service* we used Firebase¹⁷, which is extensively used in Android applications. The development effort was highly reduced by the integration of other libraries. They include osmdroid¹⁸ to manage the maps, and photoview¹⁹ and picasso²⁰ to manage the images. As requested by the teachers (see Section 3), we also integrated Casual Learn with three social networks (Twitter, Instagram, and Yammer) and a learning platform

(Microsoft Teams) for learners to share the tasks they carried out.

Casual Learn server is coded in Java 8, using the Restlet 2.4.3 library²¹. The answer database is implemented using Mongo DB²². We used Recombee²³ as the recommender server.

The source code of Casual Learn is available as open source in GitHub²⁴. It is also available in Google Play for anyone who wants to use it²⁵. Casual Learn is currently only available in Spanish, as it is mainly conceived for secondary school students in the Spanish region of Castile and Leon.

We calculated the latency of Casual Learn server out of its logs. For each operation, we analyzed all the entries of February 2021 (8,500 entries). When Casual Learn server offers contexts (operation O1 in Table 3), the average response time is 27.51 ms with a standard deviation of 15.69 ms. When it offers tasks related to a context (O2), its average response time is 25.82 ms with a standard deviation of 8.08 ms. Finally, when it offers an ordered list of tasks related to a context (O3), its average response time is 616.04 ms with a standard deviation of 102.49 ms. Note that the response time in operation O3 is higher because Casual Learn server not only retrieves data from the task repository (as in O1 and O2) but also uses Recombee to rank them. In any case, the latencies reported are low and acceptable for an interactive application.

5. Casual Learn in practice

We released a preliminary version of Casual Learn in August 2020. Soon, the scientific community and the Spanish Open Data community showed their interest in it. Indeed, Casual Learn was awarded in September 2020 as the best demo in the 2020 European Conferences on Technology Enhanced Learning [18]. In November 2020 it was also awarded as the best didactic resource in the IV Open Data Competition organized by the Regional Government of Castile and Leon²⁶.

The awards obtained attracted the attention of the local media. The communication board of Universi-

¹⁴<https://developer.android.com/about>

¹⁵<https://developer.android.com/training/volley>

¹⁶<https://www.openstreetmap.org/>

¹⁷<https://firebase.google.com/>

¹⁸<https://github.com/osmdroid/osmdroid>

¹⁹<https://github.com/Baseflow/PhotoView>

²⁰<https://github.com/square/picasso>

²¹<https://restlet.talend.com/downloads/past/>

²²<https://www.mongodb.com/>

²³<https://www.recombee.com/>

²⁴<https://github.com/gsic-emic/casual-learn>

²⁵<https://casuallearnapp.gsic.uva.es/>

²⁶https://datosabiertos.jcyl.es/web/jcyl/RISP/es/Plantilla100/1285004455821/_/_/_

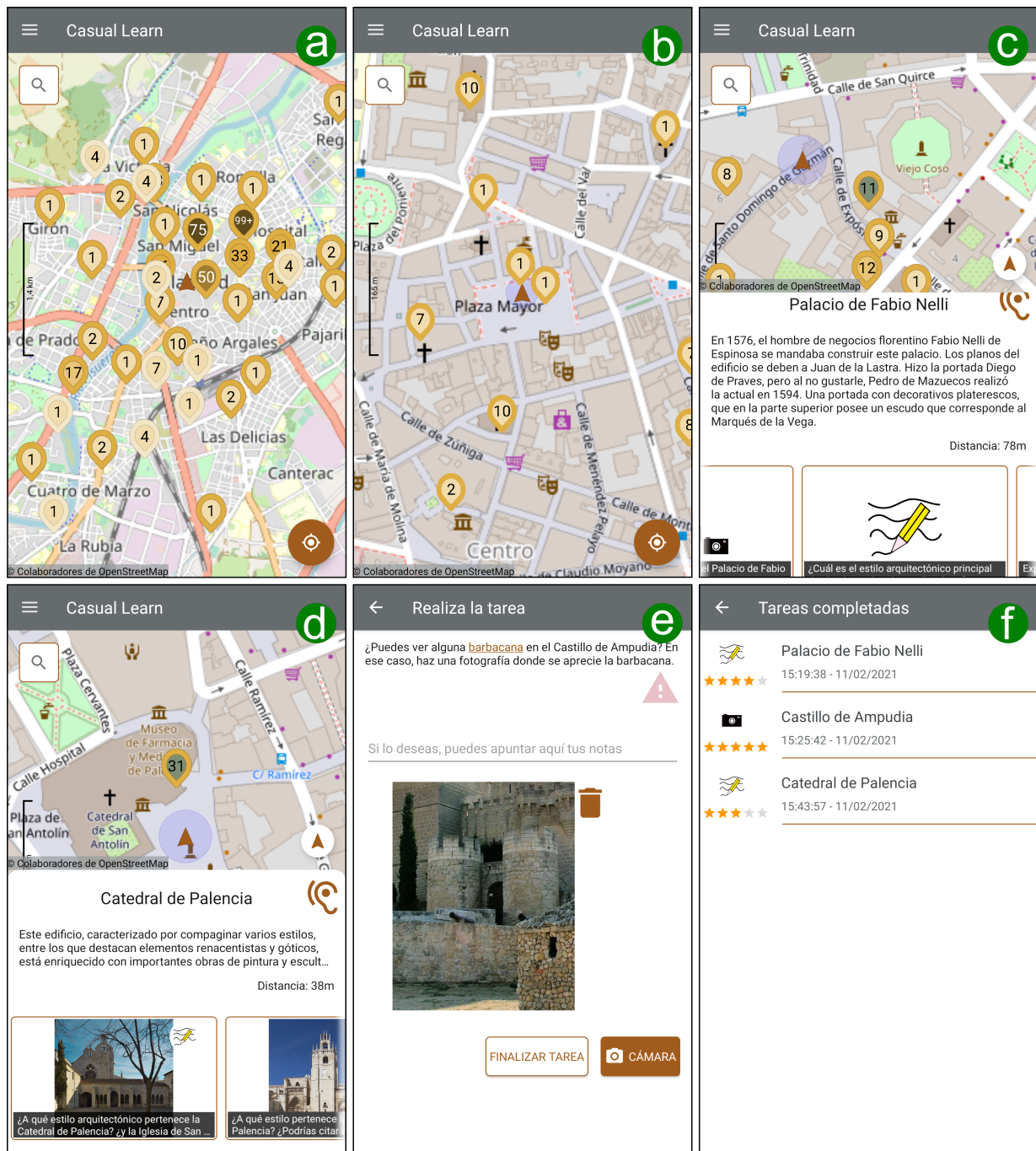


Fig. 2. Snapshots of the user interface of Casual Learn. (a) View of the city of Valladolid with pins showing the position of Cultural Heritage sites (numbers inside pins represent the number of available tasks related to the corresponding site). (b) View of the city center of Valladolid with pins showing the position of Cultural Heritage sites (numbers inside pins represent the number of available tasks related to the corresponding site). (c) Description of the context of the Palace of Fabio Nelli (Palacio de Fabio Nelli). The view includes a map of the surroundings of the Palace of Fabio Nelli (upper part); a textual description of the palace (middle part); and the list of tasks related to this context (lower part). (d) Description of the Cultural Heritage Site of Palencia Cathedral (Catedral de Palencia). The view includes a map of the surroundings of the Palencia Cathedral (upper part); a textual description of the cathedral (middle part); and the list of tasks related to this context (lower part). (e) Description of a task related to the Castle of Ampudia. The view includes the task textual description in its upper part (“Can you see a barbican in the Castle of Ampudia? If you can, take a photo in which the barbican is depicted.”); then it provides access to the camera, so the learner can take a photo. (f) View of the learner portfolio where three answers are listed.

dad de Valladolid prepared a press release about Casual Learn for each of the awards obtained. Then, four regional newspapers, two radios, and one TV channel covered the news. These news were also shared on social media by at least five educational institutions, including the Provincial Department of Education of Valladolid, the one from Palencia, and the official Twitter account of the educational department of the Regional Government of Castile and Leon.

We also carried out three pilot studies between November 2020 and January 2021 in two secondary-school institutions from Palencia and Valladolid (both are cities in Castile and Leon). Four History of Art teachers and 59 students (aged 16-18) participated in the pilots. We had three meetings with teachers. During these meetings, they learned to use Casual Learn and designed a ubiquitous learning activity for their students. All the teachers designed learning activities for their students to know their local Cultural Heritage and relate them to the topics covered in the classroom. For example, a teacher who covered the Industrial Revolution suggested several tasks for his students to visit and reflect on the XIX Century factories that still remain in the city of Valladolid. Another teacher who covered Gothic art proposed his students a set of tasks contextualized in the Gothic churches of Palencia, so they identified several architectural elements and reflected on the social aspects related to these buildings.

We interviewed the teachers after the experience. Their students had successfully carried out the recommended tasks, as well as some others of their own choice. Teachers had also assessed the results of the experience. According to them, Casual Learn not only suggests learners Cultural Heritage Sites to visit and offers information about them but also lets students carry out higher-level thinking tasks and report them to the teacher. The students completed a survey where we asked for their opinion about Casual Learn. Many of them found Casual Learn an interesting and funny application, useful to learn about the Cultural Heritage of their own city. Surprisingly, many of them encouraged us to exploit it for touristic purposes.

We also carried out a usability study using System Usability Scale (SUS) [5] where both teachers and students participated. The SUS score obtained is 60.6. While this score is an “OK” result according to [2], this evaluation helped us to detect several issues that were used to improve Casual Learn’s usability as part of the iterative approach we are using to implement the tool. These improvements are included in the version described in section 4.

By the end of February 2021 Casual Learn has been installed by 374 users. These numbers should be understood taking into account that, up to now, Casual Learn is an application with only a regional scope and conceived for a specific group of potential users.

6. Discussion

Since the advent of the Web of Data, one major challenge has been providing non-technical users with graphical representations and adequate abstractions that let them explore RDF data [8]. Some Cultural Heritage data has been offered through data portals (e.g., the Prado Museum [21]) that allow their users to easily obtain information. In other cases, Cultural Heritage data is browsed or searched using mobile applications that support geo-search (e.g., [1, 14, 20, 22]). These applications typically present a map that marks some sites and offers information about them when the marks are clicked. Other Cultural Heritage applications, such as [14, 20, 22], offer recommendations to their users. These recommendations typically take into account the user’s location and her preferences. A good example is SmartMuseum [20], which offers outdoors (e.g., Cultural Heritage sites) and indoor (e.g., elements inside a museum) recommendations according to the user profile. Interestingly, the authors found more evident value when using Linked Data for outdoor recommendations than for indoor recommendations. But all these examples just reproduce information available on the Web of Data for the users to read it.

Urbanopoly [7] is an application that goes beyond this limitation. It is a location-based game with a purpose that allows its users to curate geospatial data. Urbanopoly lets users perform some tasks to acquire or validate the data. For example, it may ask whether a photograph corresponds to a building next to them, or whether smoking is allowed in a certain restaurant. As seen, Urbanopoly tasks are limited to the collection and validation of data. These tasks are simple, have a limited pedagogical value, and no explicit connection to Cultural Heritage sites.

Other mobile applications exploit data from the Web to offer services for touristic and informal learning purposes. We can cite Smart Tourism [9], where data from DBpedia, Flickr, and the Regional Government of Castile and Leon is combined to provide information about cultural sites. Smart Tourism shows that the combination of these data sources is useful to support

informal and collaborative learning processes. However, Smart Tourism functionality is again limited to offering information. Moreover, Smart Tourism does not support bridging between formal learning in the classroom and informal learning outdoors.

Other learning applications do support this connection. For example, [11] proposes a ubiquitous-learning game to learn about local culture. However, this game—as many other ubiquitous learning applications—is not based on Semantic Web technologies, and is thus tied to its own dataset. As a consequence, it suffers from data maintainability problems. This also limits its scalability and its potential support to informal learning processes [19].

Casual Learn goes beyond these limitations. It is a learning application that proposes ubiquitous learning tasks about Cultural Heritage sites obtained from the Web of Data. Learners can browse or geo-search these tasks without the need to know SPARQL language or understanding the semantic technologies underneath. Furthermore, Casual Learn lets learners perform the tasks, as well as manage and report their answers. The pilot studies carried out show that Casual Learn is a usable application that supported ubiquitous learning processes to bridge formal and informal learning contexts.

So far, Casual Learn attracted the attention of learners and educational institutions in the Spanish region of Castile and Leon. In the future, we plan to take advantage of the modular architecture of Casual Learn to scale it up. More specifically, we plan to integrate other task datasets related to other Spanish regions; as its code is published with an open license, we hope that Casual Learn can also be applied to other countries and latitudes. Casual Learn adoption will also increase by developing an iOS version, and a web application for a community of teachers to publish additional tasks described with the SLEek ontology. We also plan to further exploit the data collected from the Web that is currently available in Casual Learn SPARQL. Specifically, we plan to improve the task recommendations by exploiting the relationships of the learning tasks to DBpedia categories. As DBpedia categories are organized in taxonomies, we can detect which learning tasks are related to similar topics. Casual Learn can take this information into account to recommend tasks according to the learners' personal interests.

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