Semantic annotation in collaborative document transcription: a gamified citizen science approach

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Abstract. Human or manual transcription is the task in which a person reads a handwritten document and writes in a digital environment the text they are reading. The manual transcription task is a long and time-consuming process for one person. However, the intelligence of the transcriber is provided with better results than automatic alternatives. This article introduces a collaborative transcription platform called Transcriptor, in which the community members can upload digitized manuscripts and collaborate in transcribing them, defining different transcription layers which will be represented using semantic web technologies and gamification techniques. The article provides two experimentation that shows that Transcriptor had a good acceptance and novelty.

Keywords: Transcription · Citizen Science · Semantic Web

1 Introduction

Documents digitization has become a fundamental tool for preserving, providing, and extending access to archival collections. Libraries and cultural heritage institutions provide collections of rare books, manuscripts, and old photographs that have deteriorated over time, and a physical manipulation could compromise the existence of the cultural artifact[6]. However, converting content images into machine-readable data that can be searched, sorted, and manipulated opens up a new range of difficulties and problems to be solved.

Nowadays, the automatic conversion of this data could be improved with many tools to transcribe texts digitized in static images to editable text. One of the most relevant approaches is Optical Character Recognition (OCR) [11], which has advanced significantly over the years, becoming more and more reliable and intelligent. However, the results on handwritten text are still not completely favorable regarding the diversity of languages, and handwriting styles [10].

Handwritten documents, moreover, often present marks made during and after the time of their composition (such as corrections, erasures, crossings out, calls, stamps, or marks) or details typical of the passage of time (wear, stains),

which make their legibility and interpretation more difficult. Indeed, the marks in the documents could generate a wrong transcription because such mark gives the text a context (historical, circumstantial, or emotional) in which it was written, generating situations in which these marks determine the document's meaning. In addition, other elements are related to the structure of the handwritten document: tables, lists, text in columns, text in an unconventional order, and a combination of languages. Therefore, the recognition of these types of texts remains a challenge, and depending on human supervision to ensure the quality and reliability of the obtained texts [12], the idea of using automatic recognition techniques is discarded.

Human or manual transcription is the task in which a person reads a handwritten document and writes in a digital environment the text they are reading. The manual transcription task is a long and time-consuming process for one person. However, the intelligence of the transcriber is provided with better results than automatic alternatives [2]. The semantic web[3, 15] provides technical elements that make data readable by a computer and consequently apply tools to knowledge discovery. There are initial approaches to citizen science and crowdsourcing task forces. For example, From the Page[3] is a crowd-sourcing product to transcribe, collaborate and manage transcriptions. Similarly, the Scribe Project[17] is an open-source framework created by Zooniverse[16] in conjunction with the New York Public Library, allowing easy setup and launch of crowdsourcing transcription projects, mainly aimed at obtaining structured data from handwritten materials. However, none includes a semantic web description layer, the capacity to improve the differences among transcribers by a discussion or voting element, and a gamification approach to motivate participation and engagement among projects and users.

The approaches require the availability of a space where the work of a group of people interested in the interpretation and collaboration of transcription can be organized and the necessary tools to carry it out. A citizen science model is a suitable approach for this transcription challenge. Citizen science is scientific research carried out by a sum of collaborators (scientists and professionals together) with regular people, which, in this case, is exercised in the participation of a community in handwritten transcription projects. In a collaborative approach to transcriptions, we should consider how to maintain interest and encourage people to collaborate on the projects.

This article introduces a collaborative transcription platform, Transcriptor, in which the community members can upload digitized manuscripts and collaborate in transcribing them (Shown in Figure 1), defining different transcription layers which will be represented using semantic web technologies. Furthermore, this work includes gamification elements in transcriptions so that participants face challenges in games, meet goals and thus obtain achievements and badges, enhancing and making the process more enjoyable. Also, Transcriptor includes voting alternatives defined by each transcribed phrase (Figure 2). Finally, the

[3] https://fromthepage.com accessed on 8th february 2023.

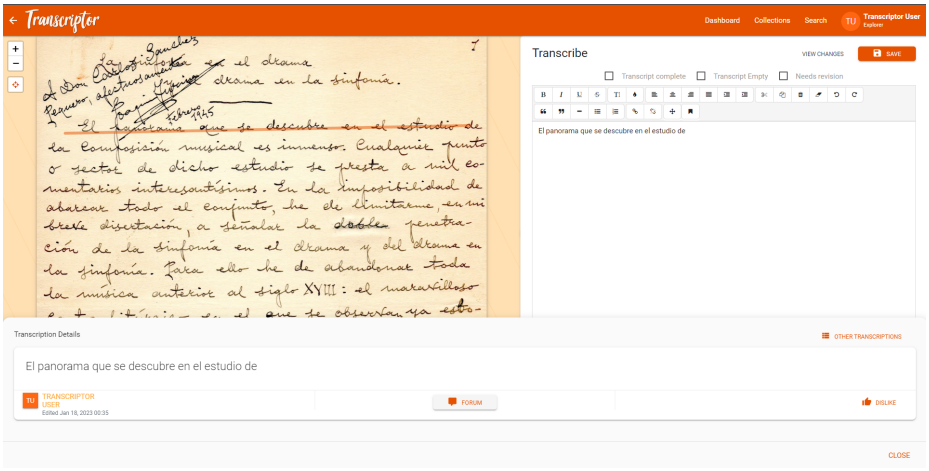

Fig. 1. Screen of Transcriptor in action.

article also includes a usability and experience user evaluation by analyzing 19 recorded user interaction activities with Transcriptor.

The organization of this article is the following. Section 2 describes other related approaches on document transcriptions. Then, Section 3 introduces the main functionally of Transcriptor detailing the process of making a transcription with different alternatives and a brief development details. Then, an evaluation is carried out in Section 4. Finally, conclusions and further work are introduced in Section 5.

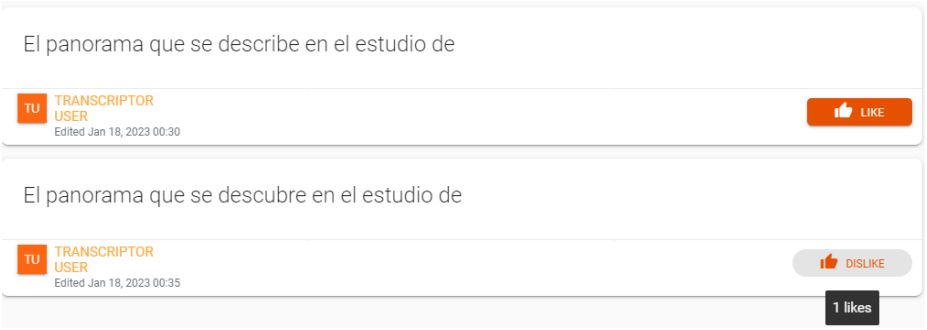

Fig. 2. Votes in Transcriptor.

2 Related Work

FromThePage[13, 14] is an open source collaborative transcription and translation website for digitized documents where community members can upload manuscripts as images or PDFS and collaborate in the transcription or translation of these documents providing the user with a simple environment to do this work. FromThePage provides the basic functionality to Transcriptor. However, Transcriptor extends with more functionality related to gamification and the use of semantic annotations.

The Scribe Project is an open source framework[4], created by both Zooniverse [5] and the New York Public Library [6], which allows working on crowdsourcing transcription projects, particularly aimed at obtaining structured data from handwritten materials or those materials that are not accessible by OCR.

3 Transcriptor

Transcriptor is a web application that allows users to manage and transcribe digitized documents using collaborative editing tools. Transcriptor's basic functionalities include managing document collections, organizing collaborative transcription projects and transcribing documents by page.

Transcriptions are performed using a collaborative textual typing tool in combination with a photographic document visualization tool. Transcription is performed at different levels allowing to transcribe information from manuscripts, images, and any photographed object. In Transcritpor, transcription is not only performed in terms of text but can also include semantic descriptions for better use of automatic processing.

Transcription Environment The Transcription environment, or transcription screen of a manuscript, is the main section within Transcriptor; this is because this is where the transcription information is materialized and generated collaboratively and where the transcription flow is accomplished.

When entering the transcription environment, several components are distinguished (see Figure 3):

- **1 Document viewer:** allows viewing the digitized document. It is possible to zoom in on the different fragments of the document, navigate it and make marks.
  - **1.1 Zoom controls:** allows controlling the zoom level on the document.
  - **1.2 Drawing Controls:** allows entering in markup mode. Allows to draw polygons over the areas to transcribe. The polygon is then transcribed as a unit.

[4] http://scribeproject.github.io , accessed on 8th february 2023
[5] http://zooniverse.org/
[6] https://www.nypl.org/

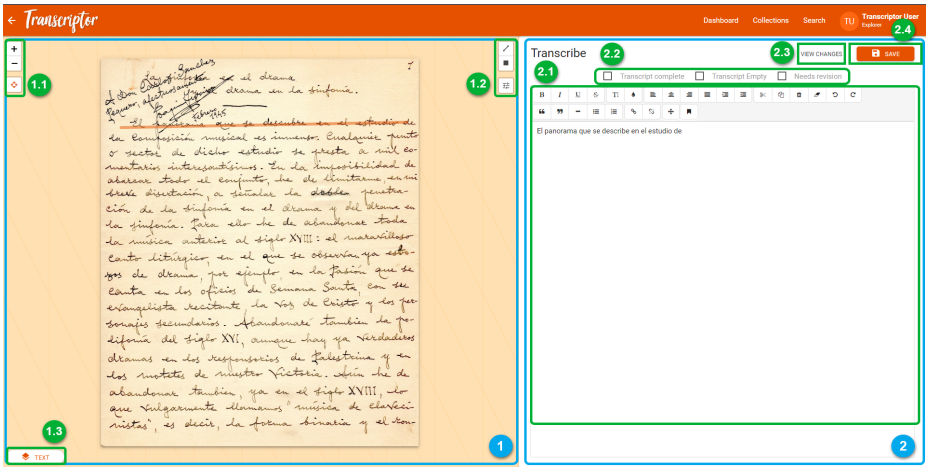

Fig. 3. Transcription environment

- **1.3 Image Adjustments:** enables controls to change the brightness, contrast, and saturation of the digitized image to facilitate the visualization of the written text.
- **1.4 Layer selector:** opens the transcription layer selection menu; from this menu it is also possible to access the layer management screen, which allows you to modify or delete layers.

– **2. Transcription Panel:** It contains the user interaction logic with that of the transcription state.

- **2.1 Text Editor:** Component destined to the entry and preview of the final text allows selecting regions of the reader to reference them to document sections. Being a WYSIWYG text editor, it has functions to apply styles to the text, bold and underlined, among others.
- **2.4 Save Button:** It executes the saving of the current state of the transcribed text. It also generates a new version. The "View Changes" button accesses the version menu of the manuscript transcription (2.3).
- **2.4 Status selector:** allows you to mark the page as "empty" or "pending revision.´´

3.1 Transcription and text generation elements

Transcriptor models transcriptions using relationships between its entities, seeking not only to represent the textual content of a manuscript but also to enrich it by associating it directly with the original document context, thus maintaining a reference between fragments of the document and the transcribed text.

Marks are entities that model a line or polygon which selects a portion of the digitized document. They have all the necessary elements for the client to

render it on the manuscript, among them, a set of coordinates relative to its digital image, which are used to be positioned and drawn in the viewer.

As for the text, two representations are handled, one directly linked to the mark, which we call Transcription, which describes the textual content transcribed by the user for a mark on the document, and another representation that is oriented to maintain the structure and overall progress of the transcription process called Transcription Template.

Transcription Templates are "Maps" of relationships used to reference the order in which the text of the marks is combined, allowing to dynamically generate the complete text of the document to be transcribed. Figure 4 shows templates transcription.

3.2 Transcription Strategies

To generate the complete transcription of the manuscript, Transcriptor implements multiple strategies to achieve this, providing the user with several ways to organize his work logic while maintaining the same objective. The transcription strategies supported by Transcriptor are:

- **Mark to load:** The user selects an area of the digitized document generating a mark, and then relates it to a new transcription.
- **Select to Mark:** from the text editor, select part of the text and relate it to a mark generated on the fly. It gives the possibility to choose between a linear, rectangular, or polygonal mark.
- **Alternative Transcription:** In this strategy, the user proposes a new transcription for an existing mark-transcription relationship, as a way of correcting its content.
- **Semantic Transcription:** Maintains the same principle as the "mark to load" method, only that the mark is related to a Semantic Transcription, using vocabularies and ontologies (detailed below).

Alternative Transcription It is possible that during the transcription process, multiple interpretations of a document fragment may arise, leading to debate. Handling these different alternatives provides a higher level of participation and encourages collaboration to improve transcription. In this way, the "Alternative Transcription" strategy allows collaborators to propose other interpretations to the one initially generated by another user. For a particular tag, Transcriptor allows listing all the transcriptions suggested by users and allows creating a new alternative transcription to the current one.

3.3 Transcription Competition

To carry out the selection process of the primary transcript, the platform uses the voting method based on likes and, based on this value, selects the primary transcript as the one with the most positive votes.

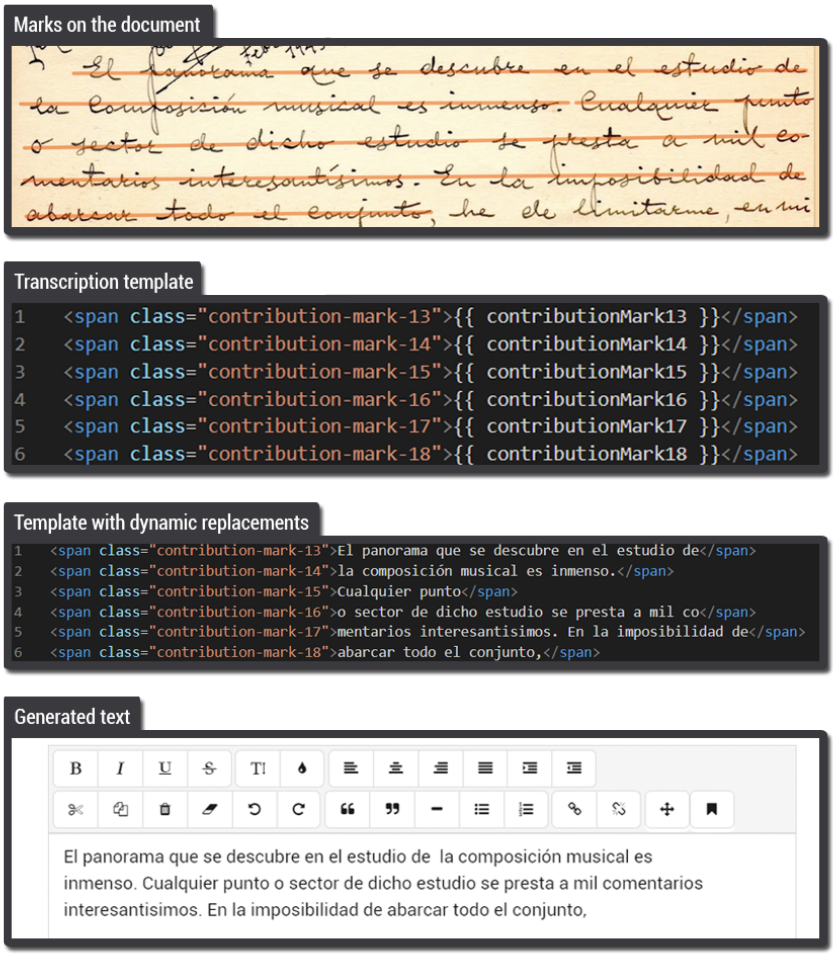

Fig. 4. Template transcription.

3.4 Version Control

Each time a change is made to the transcription of a page, Transcriptor takes a snapshot of the current state of the generated text, persisting a new version of the transcription. This feature allows the platform to maintain, as changes are made to the text, a list of changes to the document that can be traced back to who made them and when. Comparisons are made using the diff tool and can be visualized as shown in Figure 5.

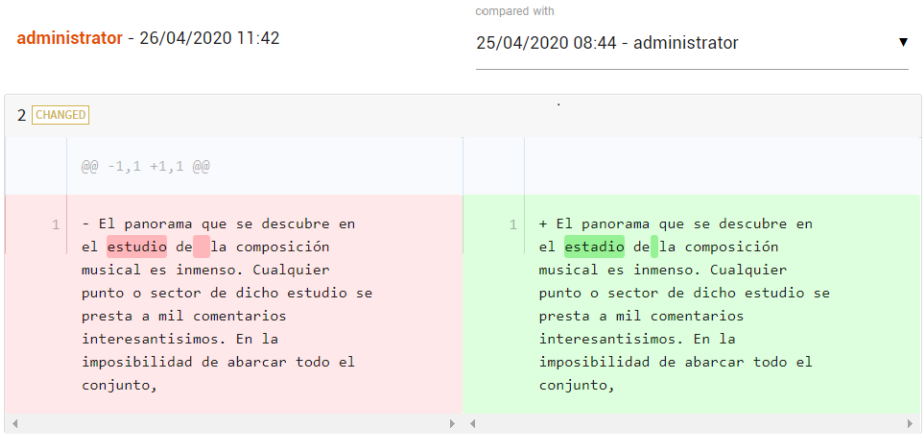

Fig. 5. Transcription diff.

3.5 Semantic Layers Definition

Semantic marks are marks that, instead of describing only text, can describe a real-world object, such as a person, an organization, a book, an event, or a place, among many others, to represent those elements that are not easy to express in a transcription.

Because of its flexibility and breadth of defined concepts, the schema.org vocabulary was used for this example, which provides a language broad enough to represent the properties of real-world objects. Schema.org [5] offers a hierarchy of data types, which starts from the type "Thing" and has as children other classes such as Action," "Place," "Person," "CreativeWorks," among others, these, in turn, have sub-classes, completing a hierarchy.

3.6 Gamification

These strategies were developed using the Metagame framework, which has a Rest API that allows registering different activities performed on the platform

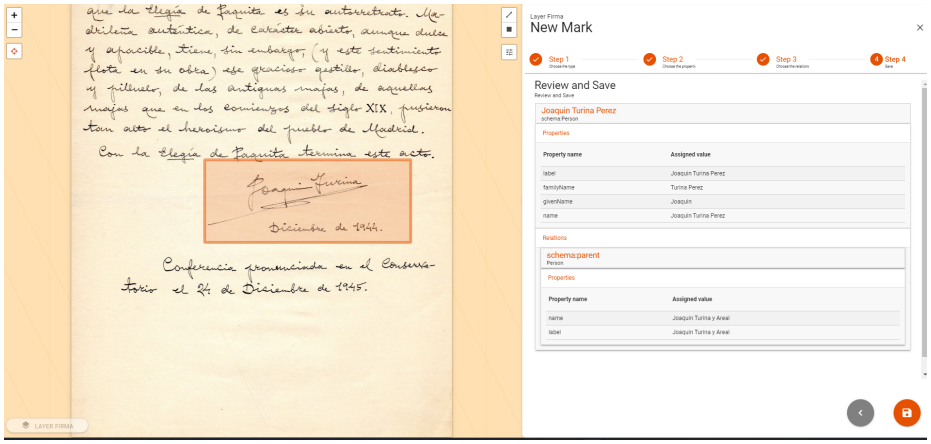

Fig. 6. Semantic annotation: the picture of a signature is annotated as an instance of schema:Person

and distinguished into "transcriptor types". As the user makes contributions on Transcriptor, they accumulate experience, which is reflected in medals and promotion of ranks. Obtaining these medals translates into promotion through the hierarchy of ranks.

3.7 Technologies Used and Implementation

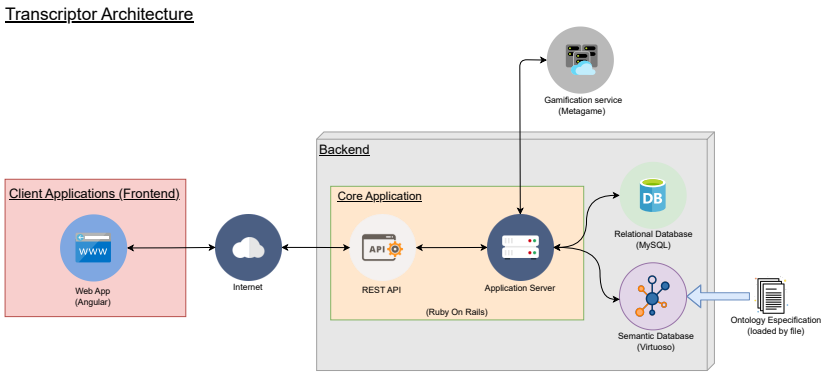

Fig. 7. Transcriptor architecture

Transcriptor is developed following a client-server architecture as is shown in Figure 7. The front-end[7] and back-end[8] parts could be downloaded from the GIT repository. Angular, Materialize, Ngx-Materialize, Leaflet, Leaflet Draw, RxJS, Ngx-Translate, Ruby On Rails, and RMagick were used in its implementation.

Particularly in gamification aspects, Metagame was a metagame system, which through the registration of activities in the application, establishes scores and assigns medals and ranks to the users who perform them. The semantic aspects were stored in a Virtuoso Universal Server, and the application code uses Ruby RDF.

Transcriptor uses MySQL as a relational database engine due to its flexibility and scalability, wide availability in operating systems, and ease of installation and use from Ruby through the mysql2 gem.

4 Evaluation

An evaluation was conducted to assess the platform's usability and user experience (UX). Two types of evaluations were conducted: a usability evaluation with end users, and a cognitive walkthrough evaluation.

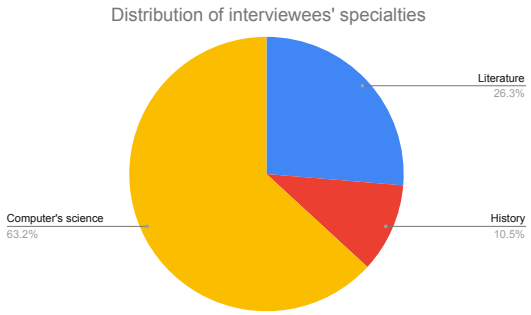

Fig. 8. Distribution of interviewees specialties

4.1 Usability Evaluation with End Users

This test seeks to obtain information about the level of ease of use of the platform to evaluate its ability to fulfill its purpose. For this, a series of activities were proposed, which are focused on the success/failure of the user to perform them and measuring the time required to execute them. To do so, the following questions will be answered:

[7] https://github.com/cientopolis/transcriptor-web accessed on 7th february 2023
[8] https://github.com/cientopolis/transcriptor-backend accessed on 7th february 2023

1. Is the platform easy to use?
2. Is it complex to learn how to use the platform?
3. Could Transcriptor be considered an innovative solution in the field of transcription?
4. Does the site and activities motivate the user to continue participating?

Additionally, a set of questions are included to capture the user's experience and level of compliance with the system's tasks and work environment. Thus, the evaluation was organized into three parts:

- Evaluation by Task: a UEQ [9, 8] test reduced by activity performed by the user, consisting of a questionnaire of five questions, which consist of pairs of opposing adjectives along with levels that mark a scale, where whoever completes the questionnaire must select which scale best represents their experience with the platform, each question refers to properties of transparency, attractiveness, and novelty.
- Overview of the platform: Short open-ended development questions on tested functionalities (5 questions).
- SUS Test: Complete in its positive version [7], which consists of ten items, with statements on a scale of 1 to 5. The participant must indicate how much they agree with such a statement, marking with one completely disagreeing and five completely agreeing.

4.2 Metrics

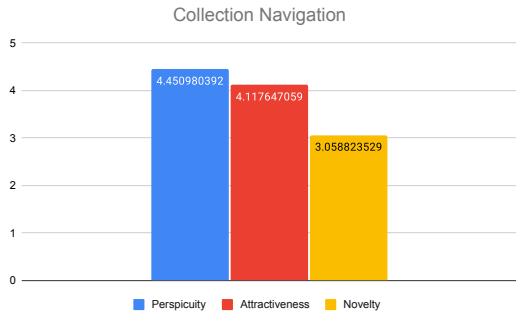

Fig. 9. Collection navigation EQ

The following metrics were considered to answer the questions listed in the previous section:

- Question 1 (Is the platform easy to use?) and question 2 (Is it complex to learn how to use the platform?)

- The SUS score will be compared with the scale defined by Bangor, Kortum, and Miller (2008) [1]. That scale specifies that, with a SUS score between 0 and 20.3, the level of usability would be the "worst imaginable", between 20.3 and 37.7 would be "bad", and between 37.7 and 50.9 is "regular", between 50.9 and 71.4 is "acceptable", between 71.4 and 81.5 "good", between 81.5 and 90.1 "excellent" and between 90.1 and 100 the usability would be the "best imaginable". To meet the questions posed, the SUS score is expected to be above 70 points, which would reach the "acceptable" level. In addition to these points, we will use the UEQ coefficients of "transparency" that allow us to determine how simple the platform is to communicate and achieve the objectives set out; if the average of these is above 3 points could be considered as the system is transparent and confirm the questions initially presented.

– Question 3 (Could Transcriptor be considered an innovative solution in the field of transcription?).
  - To confirm this question, the UEQ indicator of "novelty" will be used, denoting the level of innovation presented by the system's functionalities. Comparing the average calculated between the system's main characteristics, it is expected that this scale exceeds 3 points.
– Question 4 (Does the site and activities motivate the user to continue participating?).
  - In the same way that for question 3, the "novelty" indicator was used to establish compliance, the UEQ scale of "attraction" will be used for this approach. This average allows us to develop the level of interest that the system's functionalities arouse in the users. Obtaining an average score higher than three among all the features would corroborate this point.

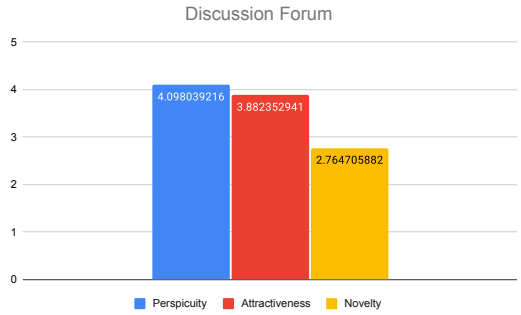

Fig. 10. Discussion Forum EQ

Evaluation Setup An open call was launched for users interested in testing the platform. The proposal was to conduct one-hour individual virtual interviews, which were recorded to keep a record of the participants' reactions during the evaluation. The interviews followed the explain-do modality, so a moment was given to explain and perform the activity. After each interview, the developed questionnaire was sent to the participants by e-mail, which they completed anonymously through Google Forms.

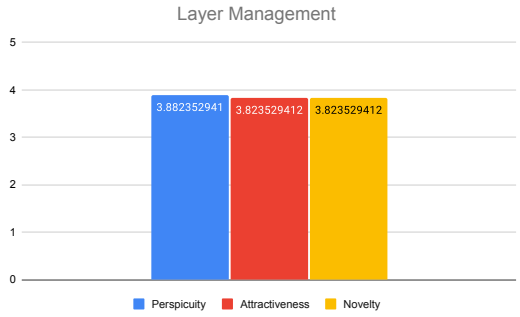

Fig. 11. Layer management EQ

Nineteen interviews were conducted with the participation of people of different ages, levels of study, and professionals, including computer specialists, historians, philologists, and researchers in the field of literature (see Figure 8).

Results The 19 questionnaires submitted by the test participants were tabulated and analyzed by separating each test section (UEQ test, open-ended questions, and SUS test).

For the UEQ test, the values were totaled by functionality, and an average was calculated for each of the scales corresponding to the pairs of properties used. In this way, a value between 1 and 5 was obtained, which we can define as the level of compliance with this scale, where 1 represents non-compliance with the scale, and 5 illustrates total compliance with it. Based on these results, bar graphs compared the rankings by functionality. Figure 9 describes the values for Collection Navigation task, Figure 10 shows the values for Disussion forum task, Figure 11 the values for Layer management task, Figure 12 shows the Semantic annotation management task.

Analyzing the graphs in Figure 13, it is possible to notice relationships between scales. For example, between that novelty and transparency, while in the most common functions of the platform (present in other systems, such as "Discussion forums"), the novelty index is lower than that of transparency. On the other hand, in the functions more linked to business logic, such as "Document

transcription mechanism," these scales are more equal, with a lower transparency index but a higher novelty. This allows us to deduce that the initially mentioned features represented less innovation and are easier to learn to use; on the other hand, the own functionalities have been more innovative but supose a more significant challenge to the user. Without experience from previous systems, the learning curve would be steeper.

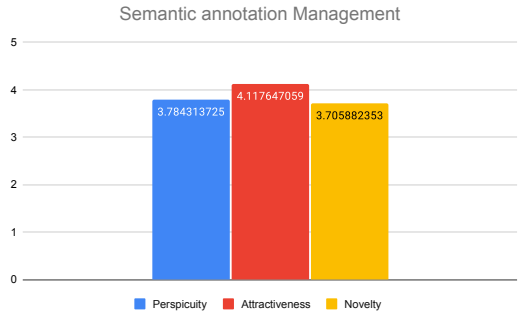

Fig. 12. Semantic annotation management EQ

The attractiveness index generally falls between transparency and novelty, indicating a dependency between these scales and reinforcing the idea that "if it is easy to use and novel in a certain aspect, then it is attractive". Based on the above metrics, Transcriptor is considered an innovative solution in its field with an average UEQ coefficient of the novelty of 3.39 which exceeds the acceptance value for question 3. Similarly, for question 4, given that the average UEQ coefficient of attractiveness was 3.96 points, the acceptance threshold was exceeded, confirming an acceptable level of motivation for collaboration between users.

As for the SUS test, it obtained the average total value per question as shown in Figure 14. The final average SUS score is 71.6. Bangor, Kortum, and Miller (2008) [1] define in their study a scale based on seven adjectives that correspond directly to intervals in the scoring metric used in SUS. Using this scale of adjectives, the score obtained was compared by placing the platform's user experience at a "Good" level, which assumes that the user experience is within the 70th percentile of the sites analyzed in the study above. This means that the user experience is remarkable and that the user will have no significant problems interpreting the site's content.

Considering the results obtained, it was concluded that the platform is simple to use and easy to learn. This is justified since the average SUS score exceeded the acceptance threshold set at 70 points. The same is true for the UEQ coefficient for transparency, which was 4.11 (see figure 13), which exceeds the acceptance value set at 3.

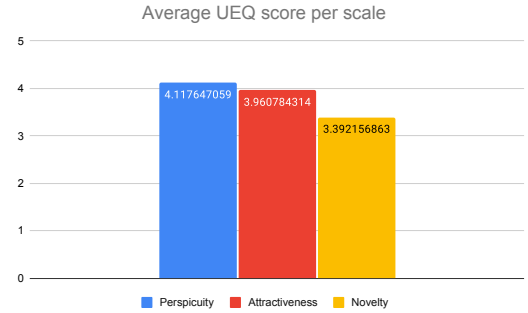

Fig. 13. Average UEQ scores.

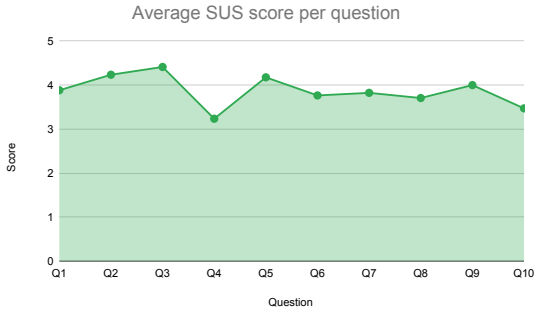

Fig. 14. Average SUS score per question

For the open-ended questions, the participants agreed that they considered the purpose of the transcriber to be useful, emphasizing the ease of use, the collaboration between users, the novelty of the information curation system, and the possibility of describing elements semantically. As a unanimous response, respondents indicated that the platform enhances collaboration, mentioning that this quality is due to the tool's framework for a repetitive and complex process, such as the transcription of manuscripts. Ninety percent of the interviewees responded that they had no problems using the platform. The remaining 10 % reported minor bugs that did not prevent them from using the system, such as forms that did not clear and problems viewing certain lines of the manuscripts when selecting them with the "line selection" tool.

Teniendo en cuenta las preguntas "Do you find the transcription mechanism intuitive to use? Would you change anything?", users agreed that the mechanism is attractive and easy to use. Still, they generally needed a guide to use it for the first time, especially the semantic transcription functionality. In this context,

most proposed establishing an initial walkthrough mechanism to introduce them to the tools and workspace available when making a transcription.

4.3 Cognitive Walkthrough

The objective of this evaluation is to obtain information about the level of ease of use and learning of the platform through the usability inspection method called Cognitive Walkthrough, which consists of a group of experts exploring the user interface, performing previously defined actions to evaluate the ease of learning of a platform design, in this case, the ease of use of Transcriptor. For the development of the test, the model defined by Granollers [4] was taken into account, which defines three steps for the creation of a cognitive path:

Data definition: The characteristics of the users are identified and documented. The description of the users will include the specific accumulated experience and acquired knowledge as determining factors for the verification of the "cognitive" factor during the tour. Then the prototype to be used in the evaluation is described. This prototype does not need to be highly detailed. Next, specific tasks to be performed are listed. Finally, for each task, implement a set of activities to carry them out.

Walk through the actions: The evaluators perform each task determined above by following the specified steps and using the detailed prototype. In this process, the evaluator will use information from the user's cognitive factors (experience and acquired knowledge) to check if the interface is suitable for the user. This review must be thorough for all the actions specified to accomplish the task.

To do this, the evaluator at each action will critique the system by answering the following questions: Will the users do the right thing at this step? If they do, will they know if they did the right thing and are progressing toward the goal?

Document the results: The evaluator will note for each action the system responses and annotations. The output is a Usability Problem Report Sheet.

The following sections will describe the definition of each of these tasks applied in Transcriptor.

Data definition: An analysis of the user profile of the platform was carried out. Taking into account its objective and functionalities, it can be concluded that, although Transcriptor is available to all users who want to contribute to the transcription of manuscripts, most of the profiles may be linked to digital humanities, philology, or history activities. These are fields that are familiar with the loading of forms, the handling and loading of digital documentation, and the handling of semantic data about concepts.

This user archetype was used to establish the series of tasks to be analyzed during the tour. Each task was further subdivided into actions, which are the steps to complete the objective of the task. These are listed below:

- Browse collections, projects, and pages

- Adding a new transcript layer
- Perform a basic transcription
- Perform a transcription with markup
- Perform a Semantic transcription
- Post a comment in the discussion forum
- Vote for a transcription
- Export the data of a collection

Walk through the actions: A server was set up with the platform on which several documents were uploaded for transcription. In this context, a meeting between computer specialists was organized, and the system was run together, performing the tasks defined in the section 4.3. For each action that composes the task, the pair of questions given by the model were answered. These are: Will the user do the right thing in this step? If he does, will he know if he did the right thing and if he is progressing toward the goal? As the data for each response was obtained, it was recorded for later analysis.

Results documentation: Based on the data obtained, a table with the answers given was created to simplify the analysis of the responses. Furthermore, this analysis aims to detect potential usability problems in the covered functions. Based on this study, a report was prepared with the usability problems found, classifying them by severity and proposing a possible solution. These problems are detailed in Figure 15.

Task	Action	Issue	Severity	Solution alternative
Transcription with markup	Click on the first line of the image begins and click on the end of the line.	Depending on the text it is complex for the user to correctly select the beginning and/or end of the line and the mark is drawn in an incorrect section of the manuscript.	1 (slow)	1) Add a reference grid over the manuscript to act as a marking guide for the lines. 2) Automatically recognize the lines through image processing so that the user can click on them to load the markup.
Basic transcription	Save changes	If the user forgets to click on save changes to the transcript when exiting the transcript screen, the progress made so far will be lost.	3 (middle)	1) Add a confirmation when exiting the transcription screen if you have unsaved changes. 2) Notify the user that they have unsaved changes. 3) Alternatively, implement an automatic save of changes every certain amount of time.

Fig. 15. Cognitive walkthrough results

5 Conclusion and Further Work

Transcriptor provides a simple workflow, that enable to collaborate in a project all those persons insterested (of any educationa level), view, vote and comment other user's transcriptions. This presents an efficient solution to problems in the automated recognition of handwritten text, promoting initiatives such as crowdsourcing and citizen science.

On the other hand, the loss of positional and graphic information that affects the transcription of manuscripts is resolved by the platform through the use of a marking system. This system allows the creation of positional marks and semantic labels that help to preserve the positional context of the original corpus and describe graphic elements in the physical document.

Based on the objectives initially set as well as the evaluations carried out on the platform, it is considered that Transcriptor is an effective solution to the current problems of manuscript transcription. Transcriptor generates a workspace in which both specialists and amateurs can collaborate on real transcription projects promoted by organizations in the field.

The generated interaction between participants promotes the exchange of knowledge, benefiting both those responsible for the project and each collaborator, enriching themselves with the experience and stimulating continuous learning in collaboration and transcribed content, providing the community with easy-to-read, search and use material without losing the essence and details that exist in an original manuscript.

As further work, several extension to the platform are planned. It can be mention the inclusion of automatic assisted transcription tools by recognition methods such as OCR or progress recognition. The semantic aspects could be extended by an easy manner to import other ontologies and vocabularies, even when the back-end is ready for that. The gamification model can be improved by the use of adaptive gamification which proposes a particular gamification activity according to each user profile and behavior in the Transcriptor use.

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