

ATCE - An Analytics Tool to Trace the Creation and Evaluation of Inclusive and Accessible Open Educational Resources

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ABSTRACT

The creation of Inclusive and Accessible Open Educational Resources (IA-OERs) is a challenge for teachers because they have to invest time and effort to create learning contents considering students' learning needs and preferences. An IA-OER is characterized by its alignment with the Universal Design Learning (UDL) principles, the quality on its contents and the web accessibility as a way to address the diversity of students. Creating an IA-OER with these characteristics is not a straightforward task, especially when teachers do not have enough information/feedback to make decisions on how to improve the learning contents. In this paper we introduce ATCE – an Analytics Tool to Trace the Creation and Evaluation of IA-OERs. This tool focuses in particular on the accessibility and quality of the IA-OERs. ATCE was developed as a module within the ATutor Learning Management System (LMS). An analytics dashboard with visualizations related to the teachers' competences in the creation and evaluation of IA-OERs was included as part of the tool. This paper also presents a use case of the visualizations obtained from the creation and evaluation of one IA-OER after using our analytics tool.

CCS Concepts

• **Human-centered computing** → **Accessibility design and evaluation methods** • **Applied computing** → **Education** • **Information systems** → **Data analytics**.

Keywords

Learning Analytics; Open Educational Resources; Web Accessibility; Quality; Teachers; Competences.

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1. INTRODUCTION

One of the statements declared in the guidelines for Open Educational Resources (OERs) in higher education promotes the use and adoption of tools to “facilitate the creation and use of adaptable, inclusively designed educational resources” [6] to address students' diverse needs. However, according to Prasad and Usagawa [13] inadequate trainings, uncertainties about copyright, and difficulties to select appropriate and high-quality educational resources, are some of the teachers' perceived barriers to use OERs. Thereby, teachers should develop competences for addressing the diverse needs and preferences of their students. Based upon these ideas, one of the challenges for today's teachers is to create inclusive and accessible learning contents to support students in the development of all tasks requested by the learning process itself and to address the diversity of students' learning needs and preferences. Consequently, teachers are expected to be able to create Inclusive and Accessible Open Educational Resources (IA-OERs) which are digital resources with a pedagogical purpose that are accessible and available so that all students independent of their learning needs can use them and that other authors can revise, reuse, remix or redistribute them [4].

When it comes to create an IA-OER, that addresses the diversity of students' learning needs and preferences, teachers should consider characteristics such as the accessibility to avoid content access barriers, and the quality to make learning contents more appropriate to the learning context for which the IA-OER is intended. Such creation process also entails an evaluation process to ensure that an IA-OER meets such characteristics. Both the creation and evaluation are part of the teacher's competences. Since IA-OERs can be created as virtual courses which include web pages with different HTML elements, the main issue in this context is that teachers require technical knowledge to identify problems on the accessibility and quality of the IA-OERs. Thereby, teachers require tools that support them in the creation and evaluation of IA-OERs and also in the decision-making process to improve their learning contents. Thus, in our approach the creation and evaluation processes are focused on the web accessibility and the quality of the IA-OERs which are described as follows.

Web accessibility means that all people can perceive, understand, navigate, and interact with the web [1]. Thus, international

accessibility recommendations such as the Web Content Accessibility Guidelines 2.0 (WCAG 2.0) ¹ provide a set of best practices to make web contents more accessible for all people. Thereby, IA-OERs should be created taking into account a standard such as the WCAG 2.0.

Quality is referred to as the set of inner properties of a product or service which enables to meet the design specifications [9] and thus it makes IA-OERs appropriated for a learning context. To evaluate the quality of IA-OERs we adopted LORI (Learning Object Review Instrument) [11] which has been widely used to evaluate the quality of learning objects [15].

In a previous exploratory study, we reported results in the creation and evaluation of 72 IA-OERs [2]. The creation process was carried out using a model for the Co-Creation of IA-OERs named CO-CREARIA [4], and the evaluation process was carried out using a tool which included two web instruments (online questionnaires) we developed to evaluate the web accessibility and the quality of each IA-OER. Moreover, the tool provided teachers with some feedback with the answers given by evaluators and some visualizations related to the accessibility of the IA-OERs. Findings from that study emphasized the need of extending our tool to do learning analytics on the teachers' competences in the creation and evaluation of IA-OERs.

In this paper we introduce ATCE – an Analytics Tool that traces the activities done by teachers when they create and evaluate IA-OERs. Preliminary results on the information delivered by the analytics tool are described by means of a use case of one of the IA-OERs created and evaluated with ATCE.

The remainder of the paper is organized as follows: section 2 gives an overview of learning analytics in the creation of educational resources, section 3 presents our approach in the creation and evaluation of IA-OERs and an overview of ATCE, section 4 describes the functionalities of ATCE, and section 5 presents an use case to describe some of the visualizations obtained after using ATCE.

2. LEARNING ANALYTICS IN THE CREATION OF EDUCATIONAL RESOURCES

Most of the research in learning analytics solutions is carried out to support teachers in the analysis of student behavior data (e.g. [5, 7, 8]). There are some studies into learning analytics or monitoring solutions focused on supporting the decision-making of teachers at the creation or design time but in the field of learning design and not particularly in the creation of OERs.

For instance, Lockyer, Heathcote and Dawson [12] analyze how checkpoint and process analytics can facilitate pedagogical action on learning designs. Such analytics provide teachers information about student engagement which is used to redesign the learning contents when they run a course again or in a different context. Rodríguez et al. [14] propose a script-aware monitoring process to support teachers in defining scripts enriched with monitoring information related to the behaviors of students in the enactment of learning contents. As a result, teachers could identify improvements for their learning designs. Karkalas, Mavrikis and Labs [10] designed and developed a Reflective Designer Analytics Platform (RDAP) aimed to support authors on the design of their learning materials (e-books) and on how they meet

the original learning objectives. This tool has a dashboard aimed to increase authors' awareness so that they can redesign and improve the e-books. Bakharia et al. [3] presented a learning analytics conceptual framework aimed to support teachers in the evaluation of learning designs. This framework was implemented in a tool called Loop which includes a dashboard with temporal, comparative, tool specific, cohort dynamics and contingency analytics of the learning events so that teachers adapt the learning designs by analyzing learning interactions.

Overall, these studies highlight the need for providing teachers with information that help them to improve their learning contents or activities. However, there is a lack of research on how learning analytics solutions support teachers in creating educational resources to address students' needs and preferences. We found learning analytics as an opportunity to provide teachers with a supporting tool in the creation but also in the evaluation of IA-OERs considering the accessibility and quality characteristics.

3. TRACING THE CREATION AND EVALUATION OF IA-OERs

3.1 Creation and Evaluation of IA-OERs

As mentioned in the introduction, in a previous exploratory study we reported results in the creation and evaluation of 72 IA-OERs created by teachers. Teachers participated in a training course about the creation of IA-OERs including topics such as: inclusive learning, Universal Design for Learning (UDL), OERs, the CO-CREARIA model, and web accessibility. Then, teachers created the IA-OERs by following the phases of CO-CREARIA (Analysis, Design, Development, Evaluation and Implementation) [4]. In the development phase each teacher took the role of author to create an IA-OER in the form of a virtual course upon the ATutor LMS. Moreover, the content editor of ATutor was used by teachers to add web pages in the IA-OER by including different HTML elements (texts, images, links, videos, etc.). For the evaluation phase, we defined an evaluation model which involves a peer-review process to promote collaboration among teachers. Thereby, each teacher took the role of evaluator to evaluate an IA-OER created by other teacher. To do so teachers used a tool we developed with two web instruments to evaluate the IA-OERs in terms of web accessibility (21 questions based on the WCAG 2.0) and quality (8 questions based on the LORI) (for more detail on the questions included in those instruments see [2]). Once the IA-OERs were evaluated, teachers could access to a text-based report with the answers given by evaluators and some visualizations related only to the accessibility of the IA-OER.

As a result of using the tool in that exploratory scenario, we found that it would be important to extent the tool to do learning analytics on the teachers' competences in the creation and evaluation of IA-OERs. Thus, we developed ATCE – an Analytics Tool that Traces the activities done by teachers when they create and evaluate IA-OERs.

3.2 ATCE: Analytics Tool to Trace the Creation and Evaluation of IA-OERs

In line with recent research on monitoring solutions to support teachers at the creation or design time, as discussed in section 2, we developed ATCE an analytics tool that supports teachers in the creation and evaluation of IA-OERs taking into account their accessibility and quality characteristics.

The main purposes of ATCE are: 1) to store actions performed by teachers during the creation and the evaluation of IA-OERs and 2)

¹ <https://www.w3.org/TR/WCAG20/>

to inform teachers about the accessibility and quality of the IA-OERs created (as indicators of the creation competence) as well as the competence level reached in the evaluation competence.

On the other hand, the interpretation of visualizations depends on an understanding of the context in which the data are collected [12]. In ATCE, visualizations and text-based reports are connected with the creation and evaluation of IA-OERs and have a simple design to facilitate the interpretation of the data collected and analyzed. Moreover, as ATCE was developed as a module in ATutor, it can be deactivated without affecting the other functionalities ATutor and it was also translated into two languages (English and Spanish). ATCE was designed thinking of teachers as the main users; however the tool can be used by anyone interested in creating or evaluating IA-OERs. Following descriptions correspond with the roles of the users who interact with ATCE.

- Author: person who adds web pages in an IA-OER.
- Evaluator: person who carries out the manual evaluation of an IA-OER in terms of web accessibility and quality.
- Expert: person who verifies if the answers given by evaluators in the evaluation process are correct or not. An expert can also take the role of evaluator.
- Tool administrator: person managing the management options in the analytics tool.

4. FUNCTIONALITIES OF ATCE

ATCE is being used in the context of a training course in which teachers learn how to create and evaluate IA-OERs. In that context, ATCE is used when teachers create IA-OERs in the form of virtual courses in the ATutor LMS and also when the IA-OERs are evaluated. Each IA-OER is formed by a set of web pages that can be edited with the web editor of ATutor. Figure 1 shows the main steps on the life cycle of the analytics tool considering the actions taken by each role.

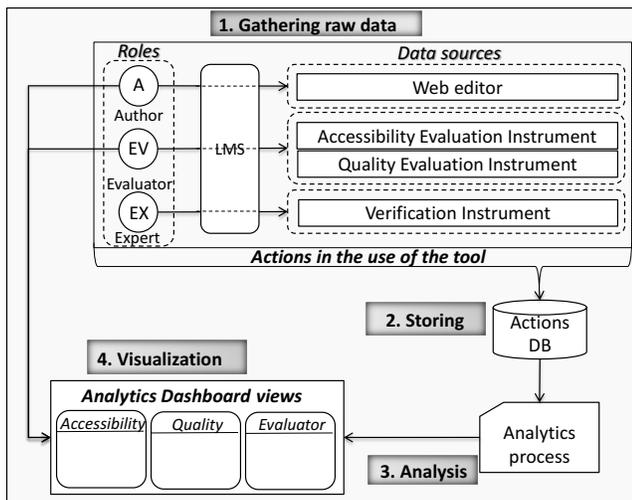


Figure 1. Life cycle of the analytics tool

The four main steps are:

1. Gathering raw data: data related to the HTML elements added through the web editor, the answers and the clickstream obtained from the manual accessibility and quality instruments, and answers given by experts in the verification instrument are gathered as raw data.

2. Storing: all data related to the actions in the use of the web editor, the accessibility and quality evaluation instruments and the verification instrument are stored in a database. The user who is performing the action and the timestamp are also stored for subsequent analysis of actions in a specific date.
3. Analysis: data collected from the actions done by the different roles are analysed to generate the information that is included in the reports presented in the visualizations.
4. Visualization: an analytics dashboard is provided to inform authors and evaluators about the accessibility and quality of the IA-OERs (as indicators of the creation competence) and the level reached in the evaluation competence.

Following subsections describe main functionalities of ATCE.

4.1 Management options

The tool administrator can access to the following options: assignment of evaluators, assignment of experts and an option to change the states of an IA-OER. Possible states are: edit (by author), evaluate (by an evaluator), and verify (by an expert).

4.2 Storing of HTML elements

To generate some of the visualizations of the dashboard, ATCE needs to store the HTML elements. This is an automatic process in which the HTML elements added in each web page of the IA-OERs (text, links, images, videos, etc.) are stored in the database. This process is executed once the author saves the changes in the web page. Although the web editor stores the whole HTML code in a single record, ATCE takes that source code and then by using the Document Object Model (DOM) structure of the page it extracts and stores the types of elements and the position of each HTML element in such structure. Information stored contains the detail of the elements added including the username of the author and the modification date. Each HTML element is controlled by means of four states: created, modified, moved, or deleted.

4.3 Automatic accessibility evaluation

The purpose of the automatic accessibility evaluation is to automatically identify as many accessibility failures as possible (without the intervention of a human evaluator) to save time and work. In this context, ATCE takes advantage of the AChecker² which is an automatic accessibility validator. After the storing of the HTML elements, ATCE carries out an automatic accessibility evaluation which is performed by the AChecker API. Each accessibility failure is related to an accessibility question and it is therefore stored in the database as an automatic answer to the corresponding accessibility evaluation question.

4.4 Manual evaluation

The purpose of the manual evaluation is that a human evaluator answers questions related to the accessibility (questions that cannot be answered in the automatic way) and questions related to the quality of the IA-OER. The manual evaluation is carried out once an IA-OER is assigned to an evaluator.

In the manual accessibility evaluation the evaluator answers different questions according to the type of HTML elements added in the each page of an IA-OER (images, videos, links, etc.). Possible answers are: Yes, No or Not applicable and a space to add comments on each question. As mentioned in section 3.1, accessibility questions are based on the WCAG 2.0 principles. Questions appear in a tooltip with a button to see the information

² <http://achecker.ca/>

of the element revised and a button to access help information of each question.

In the quality evaluation the evaluator uses the quality instrument. As mentioned in section 3.1, the quality instrument is based on LORI. It evaluates nine aspects including accessibility, but as we have a separate instrument for accessibility our quality instrument considers: content quality, learning goal alignment, feedback and adaptation, motivation, presentation and design, usability, reusability, and standards compliance. An evaluator assigns from one to five stars to each category and adds comments on each one.

The clickstream in the use of those instruments together with the verification of an expert on the answers given by an evaluator, are used to analyze and obtain the level reached by an evaluator in the evaluation competency.

4.5 Dashboard and visualizations

The dashboard informs teachers about the accessibility and quality of the IA-OERs created (as indicators of the creation competency) as well as the competence level reached in the evaluation competency. The dashboard has three views:

- The *Accessibility view* presents information about the teacher’s activity and the accessibility of the IA-OERs created.
- The *Quality view* presents information about the quality of the IA-OERs created; and
- The *Evaluator view* presents information about the competency in the evaluation of IA-OERs evaluated.

Results in the *Accessibility* and *Quality* views are indicators of the creation competence. This information is used by the teacher to make decisions of improvements in the IA-OERs. Results in the *Evaluator view* are indicators of the evaluation competence. Moreover, the *Accessibility* and the *Quality* views present information from all or one specific IA-OER. Visualizations obtained after using ATCE are described in Section 5.

5. USE CASE: THE KINGDOMS OF THE NATURE

This use case is intended to describe some of the visualizations obtained in the dashboard after using the ATCE tool.

The kingdoms of the nature is an IA-OER created as a virtual course in ATutor using ATCE. This IA-OER has three web pages: 1) Introduction, 2) Kingdoms (biology), and 3) Activities. Those pages include different HTML elements (texts, headings, images, etc.). This IA-OER was created in four stages: a) A teacher (author), who took the training course in the creation of IA-OERs, created the IA-OER. Meanwhile, the tool stored all HTML elements added by the author and carried out the automatic evaluation. b) Another teacher (evaluator) evaluated the accessibility and quality of the IA-OER (manual evaluation). c) An expert verifies the evaluation. And d) the author used the information provided in the Accessibility and Quality views of the dashboard to improve the IA-OER. Likewise the evaluator received feedback through the Evaluator view. Visualizations described below correspond to the Accessibility view.

The *Accessibility view* includes: elements added in the IA-OER (*Your activity* – Figure 2); general accessibility and accessibility by type of element (*General* – Figure 3); an IA-OER’s accessibility history (*Accessibility history* – Figure 4); and the accessibility by WCAG principles (*WCAG principles* – Figure 5).

Each principle in the WCAG principles tab has an information button which allows author to go into the detail of the accessibility failures identified in the IA-OER.

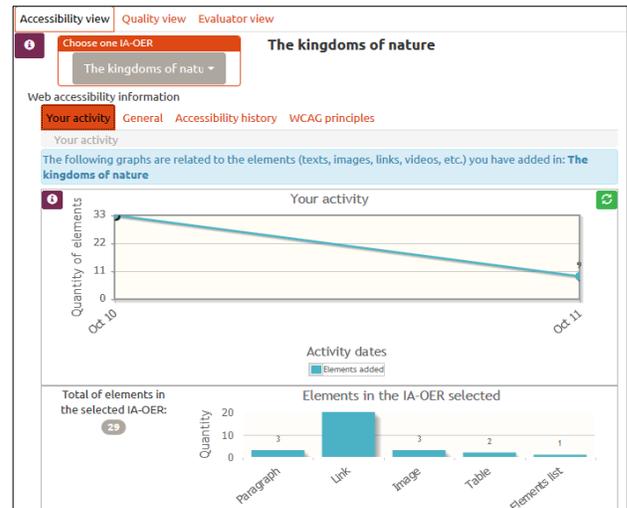


Figure 2. Accessibility view - Your activity

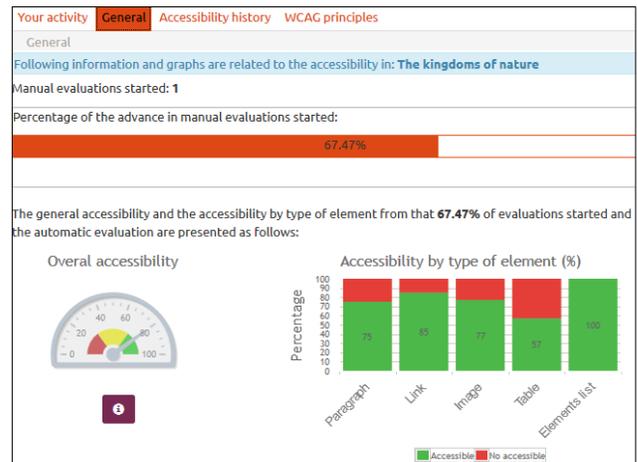


Figure 3. Accessibility view- General

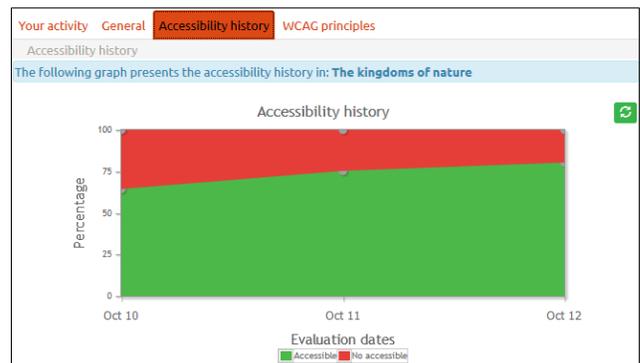


Figure 4. Accessibility view - Accessibility history

As can be seen in the visualizations, the IA-OER has different types of HTML elements (paragraphs, links, images, tables, elements list) (Figure 2); the level of accessibility of this IA-OER is about 80% (Figure 3); the chart of the accessibility history indicates that this IA-OER has improved over time (Figure 4); and

it has some failures in the Perceivable, Operable and Understandable WCAG principles (Figure 5).

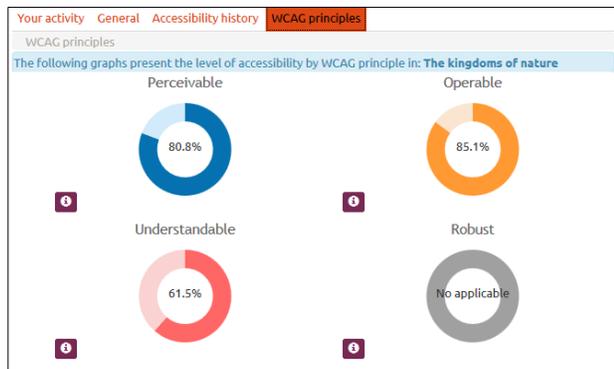


Figure 5. Accessibility view- WCAG principles

6. CONCLUSIONS

In this paper we introduced ATCE – an Analytics Tool to Trace the Creation and Evaluation of IA-OERs. Main functionalities of the tool include: the automatic storing of HTML elements added by authors, an automatic accessibility evaluation, options to support the manual evaluation of the accessibility and quality of the IA-OERs (including the clickstream in the manual evaluation and the input of the experts who verify the answers given by evaluators). With the data collected (HTML elements stored with the web editor, results from the accessibility and quality evaluation, and results from the verification done by experts on the answers given by an evaluator), the tool performs an analytics process to generate the visualizations to be included in the dashboard. Some of the visualizations were described by means of a use case of one IA-OER created and evaluated using ATCE. This tool takes advantage of the learning analytics approach to support teachers in decision-making at the creation time as well as to provide information related with their competences in the creation and evaluation of IA-OERs. Further research needs to be conducted on the support that this tool provides to teachers and the acceptance of the tool.

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