Evaluation of a learning analytics tool for supporting teachers in the creation and evaluation of accessible and quality open educational resources

Cecilia Avila, Silvia Baldiris, Ramon Fabregat and Sabine Graf

Cecilia Avila is a professor and researcher at the Fundación Universitaria Konrad Lorenz in Bogotá (Colombia). She has a PhD in Technology from the University of Girona. Her research interests are semantic web, web accessibility, usability, learning analytics and open educational resources. Silvia Baldiris is a full professor and researcher at the International University of La Rioja, Logroño, Spain. She has a PhD in Technology from the University of Girona. She is interested in the field of technology enhanced learning and on topics such as authoring tools, open educational resources, universal design for learning and web accessibility. Ramon Fabregat is co-director of the BCDS research group in the University of Girona and is an associate professor at the Institute of Informatics and Applications (IIIA). He has a PhD in computer science from the same university. His research interests are e-learning, adaptive systems, user modeling and inclusive learning. Sabine Graf is presently a full professor (tenured) at the School of Computing and Information Systems, Athabasca University, Canada. She has a PhD from Vienna University of Technology, Austria. Her research areas are: e-learning, personalization, learning analytics and academic analytics, user modeling and game-based learning. Address for correspondence: Cecilia Avila, Faculty of Mathematics and Engineering, Fundación Universitaria Konrad Lorenz, Bogotá, Colombia. Email: cecilia.avilag@konradlorenz.edu.co

Abstract
The learning analytics (LA) field seeks to analyze data about students’ interactions, and it has been applied in the development of tools for supporting both learning and teaching processes. Recent research has paid attention on how LA may benefit teachers in the creation of educational resources. However, most of the research on LA solutions is carried out to support teachers in analyzing students’ behavior data collected as they interact with virtual learning environments. While solutions to support teachers in different virtual learning and teaching contexts have become important, to date little research has been done on how LA solutions can help teachers to create and evaluate Open Educational Resources (OERs). This study aims at presenting the evaluation of a LA tool for supporting teachers in the creation and evaluation of accessible and quality OERs considering that both processes fall within the competences that teachers can acquire and strengthen by participating as authors (creation) and evaluators (evaluation) of OERs. The study was conducted with Colombian teachers and the results obtained highlight the positive effect the tool had on the teachers’ acquisition of the competences and the positive attitude they had toward using the tool.

Introduction
The UNESCO guidelines for Open Educational Resources (OERs) in higher education promote the investment in the systematic production, adaptation and use of OER that address students’ learning needs (Commonwealth of Learning, 2011). Thus, teachers are challenged with providing OERs that meet characteristics such as web accessibility and quality as two key features of OERs, which make them suitable for all students (Almendro & Silveira, 2018; Chen, Sanderson,
Research on how to support teachers in this is limited. According to Iniesto, McAndrew, Minocha, and Coughlan (2016), “accessibility does not appear to have been considered in a consistent way when designing online learning resources”. Some studies have also stated that evaluating digital contents demands technical or specialized knowledge (Restrepo, Amado-Salvatierra, Otón, & Hilera, 2018; Vlachogiannis, Darzentas, & Koutsabasis, 2010). Moreover, authoring tools should provide feedback about the learning contents that need to be improved at design time (Chen et al., 2015).

Solutions based on learning analytics (LA) have demonstrated to be suitable for supporting teachers in designing educational resources, a process in which decision making and feedback tools (eg, dashboards) are crucial for the improvement and evaluation of learning contents and activities (Albó, Barria-Pineda, Brusilovsky, & Hernández-Leo, 2019; Hernández-Leo, Martinez-Maldonado, Pardo, Muñoz-Cristóbal, & Rodríguez-Triana, 2019; Mangaroska & Giannakos, 2017). However, most of the LA tools focus on informing teachers about students’ interaction with learning activities or contents (Brooks, Erickson, Greer, & Gutwin, 2014; Fernandez-Delgado, Mucientes, Vazquez-Barreiros, & Lama, 2014; Leacock & Nesbit, 2007) and not on tracing the activities performed by teachers while creating OERs. (Bodily, Nyland, & Wiley, 2017) pointed out that LA may help identifying improvements for OER contents and continuous improvement drives high quality contents.

The purpose of this paper, therefore, is to investigate the use of LA as an opportunity to support teachers in learning how to create and evaluate OERs by tracing their activities in these processes, all the while keeping web accessibility and quality in mind. Because this entails a learning process, we consider the creation and evaluation processes to form part of a teacher’s digital competences. The study was conducted with 19 Colombian school and university teachers and it seeks at analyzing: (1) whether the LA tool helps teachers acquire competences in the creation and evaluation of OERs, and (2) the teachers’ perceptions about the tool.

The paper is structured as follows. Second section describes some theoretical background and related work on web accessibility and quality in OERs, competences and, LA. Next, third section presents an overview of the LA tool. In fourth section, the methodology of the evaluation
of the LA tool is described. Fifth section presents the results and discussion, whereas sixth section presents the threats to validity for this study. Finally, seventh section presents the conclusions and future work.

**Theoretical background and related work**

**Web accessibility and quality in OERs**

Creating OERs that address students’ diverse learning needs is a challenge for teachers who should consider characteristics such as web accessibility (to avoid barriers to content access), and quality (to make learning contents more appropriate for the learning context in which they are intended). On the one hand, quality is one of the most discussed features of OERs (Marín et al., 2019) and it is recognized to contribute to a better retrieving and sharing of OERs (Almendro & Silveira, 2018). Moreover, Moise et al. (2014) stated that the lack of quality assurance hinders the uptake and usage of OERs. On the other hand, accessible OERs contribute to flexible learning experiences for all (CAST, 2018) and this feature is also considered when evaluating quality in OERs. In their literature review about standards and trends for OERs, Cueva & Rodríguez (2010) pointed out three aspects for future research in the field of OERs, namely accessibility standards, social components and semantic web. As for accessibility standards, they highlight the use of standards such as the Web Content Accessibility Guidelines (WCAG) specification.

Most of the research on OER web accessibility and quality has been focused on evaluating the contents after their creation (Kumar & Owston, 2016; Kurilovas, Birenene, & Serikoviene, 2010; Mishra & Kanwar, 2015). However, evaluating an OER while it is still being created contributes to a better adoption once the resource is published in a virtual learning environment or in a repository (Marín et al., 2019).

**Competences**

A competence is “the proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development” (Ferguson et al., 2016). In the Information and Communication Technologies (ICT) context, digital competences are a “set of knowledge, skills, attitudes (thus including abilities, strategies, values and awareness) that are required when using ICT and digital media to perform tasks; solve problems; communicate; manage information; collaborate; create and share content; and build knowledge effectively, efficiently, appropriately, critically, creatively, autonomously, flexibly, ethically, reflectively for work, leisure, participation, learning, socialising, consuming, and empowerment” (Ferrari, 2012). In this research, the creation and evaluation of OERs are considered as part of teachers’ digital competences.

**Learning analytics and OERs**

LA is a tool for measuring, collecting, analyzing and reporting data about learners and their context (Siemens et al., 2011). Adopting LA solutions to create and evaluate educational resources, often entails providing teachers with feedback about the learning context (eg, student interaction traces) and teachers can, in turn, use this feedback to improve the learning content (Haya, Daems, Malzahn, Castellanos, & Hopp, 2015; Holtham, Martin, Brown, Jawaeher, & Dove, 2012). Some recent studies highlight the use of LA as a mean for managing learning designs (Er et al., 2019; Hernández-Leo et al., 2019; Holmes, Nguyen, Zhang, Mavrikis, & Rienties, 2019). For instance, Dyckhoff, Zielke, Bültmann, Chatti and Schroeder (2012) present a LA toolkit for teachers (eLaTI), which is a conceptual toolkit designed to support teachers in the analysis of improvements for the learning scenarios by using graphical information regarding content usage, student behavior and assessment results. Lockyer, Heathcote, and Dawson (2013) analyze how analytics
can facilitate pedagogical actions for learning designs. Another study highlights that LA may provide insights on how to assess students based on the OERs' impact (Prasad, Totaram, & Usagawa, 2016). However, Persico and Pozzi (2015) argue that most of the research in learning analytics has concentrated attention to the contribution of learning analytics during the enactment of learning experiences and not in a design phase.

Some contributions reported in the literature about using analytics to support the design of educational resources (involving processes such as the creation and evaluation) are: analytics can support teachers in decision making when completing a course design (Fritz & Whitmer, 2017); Cooper, Ferguson, and Wolff (2016) state that analytics is an approach that help identifying accessibility deficits in learning contents; reports based on analytics (usually presented in the form of dashboards) provide objective information that may be used by teachers in the design of OERs in order to improve learning contents (Bodily et al., 2017).

Therefore, we hypothesize LA may be used to provide teachers with feedback on how well they create and evaluate OERs, and how they can use the feedback to improve the learning content itself.

An overview of the ATCE tool
The Analytics Tool to trace the Creation and Evaluation of OERs (ATCE) was developed as a module in the ATutor LMS (ATutor, 2002). The ATCE tool was first introduced in the paper by Avila, Baldiris, Fabregat, & Graf (2017). However, in this section, some additional details are described.

ATCE differs from others that support teachers in OER creation and evaluation, in that it allows teachers to identify what they need to improve on their role as authors and evaluators of OERs. ATCE provides authors with visualizations to help them easily identify accessibility failures and quality items that need to be improved in each OER before its delivery in a real scenario with students, as well as feedback about their role as evaluators. Figure A1 (in supplementary material) depicts the flow diagram of the ATCE tool and its functionalities. The main functionalities of the ATCE tool are:

- **Management options**

The administrator of the tool assigns evaluators and experts and change the states of an OER. Possible states are: edit (by an author), evaluate (by an evaluator) and verify (by an expert). These states are used to ensure that an OER is not created/edited, evaluated or verified at the same time. Figure 1 depicts the management options.
- **Storing HTML elements**

The ATCE tool stores each HTML element included in the web pages of an OER as a separate record in the database. The LMS did not include this functionality because it stored the complete HTML source code of each content page. Thus, the content editor of the LMS was modified so that it could store each HTML element in a separated record.

- **Automatic accessibility evaluation**

Once the HTML elements have been stored, the ATCE tool carries out an automatic accessibility evaluation. For this automatic evaluation, we integrated AChecker (2012), which is an automatic tool to check accessibility criteria in web contents and works in accordance with different accessibility standards, among which are the WCAG (W3C-WAI, 2018). We used the API provided by AChecker which facilitates its integration in web environments. The workflow of this API is depicted in Figure 2.

- **Manual evaluation**

Teachers as evaluators use the ATCE evaluation module to evaluate the web accessibility and quality of each OER. The web accessibility is evaluated for each HTML element in a web page by using the questions presented in Table A1 and the quality is evaluated with the items presented in Table A2 (in supplementary material). Figure 3 depicts the options presented to the evaluator when answering one of the accessibility questions.

![Figure 2: AChecker API—rest service](https://www.wileyonlinelibrary.com)  
*Figure 2: AChecker API—rest service*

![Figure 3: ATCE—manual evaluation](https://www.wileyonlinelibrary.com)  
*Figure 3: ATCE—manual evaluation*
Dashboard

It provides teachers with feedback related to their role as both authors and evaluators of OERs. This information is coming from the creation and evaluation process. Figure 4 depicts the welcome interface of the dashboard (a) and the main view with information about the contents added to the OER (b). Figure 5 depicts the accessibility view with a general overview of the accessibility in the selected OER (a), the accessibility over the time (b), the percentage of accessibility reached in each principle (c) and the detail of accessibility failures (d).

Figure 4: Dashboard—main interface
[Colour figure can be viewed at wileyonlinelibrary.com]

Figure 5: Dashboard—accessibility view
[Colour figure can be viewed at wileyonlinelibrary.com]
identified in one of the principles (d). Figure 6 depicts the quality view with the general (a) and the detailed (b) results of the quality for the selected OER. Finally, Figure 7 depicts the evaluator view with information of the level reached by the teacher in the role of evaluator and comments to improve in this role for both competences accessibility evaluation (a) and quality evaluation (b). Table A3 (in supplementary material) presents a summary of the metrics and visualizations of the dashboard.

Evaluation

Method

This study was carried out as comparative experimental research using an experimental group within-subjects design, in which the same group of participants are measured in different points in time (Randolph, 2008). Thus, the purpose of this study is twofold: (1) to investigate whether
the ATCE tool benefits teachers in the acquisition of competences in the creation and evaluation of OERs and (2) to identify the perceptions teachers had with regard to the use of the ATCE tool. These objectives were addressed by answering the following research questions (RQ):

- RQ1: Does the use of the ATCE tool benefit teachers in the acquisition of competences in the creation and evaluation of OERs?
- RQ2: What are the perceptions teachers have about the use of the ATCE tool?

The research study was divided into two parts. To answer RQ1, an observational process was defined to evaluate the ATCE tool involving a training course, in which teachers learned how to create OERs in terms of web accessibility and quality. To answer RQ2, we analyzed the perceptions teachers had when using the ATCE tool.

Materials

The following materials, tools and systems were used for this study:

- Initial questionnaire: This questionnaire gathered data related to demographic information and the background teachers had in the use of ICT tools. The questionnaire consisted of four parts: (1) demographic information, (2) ICT experience and skills, (3) specific use of ICT and (4) ICT in the creation of educational resources as part of teaching practices. This questionnaire was created using Google forms.
- Training course about the creation of OERs: This virtual training course aimed at teaching teachers how to create OERs contemplating web accessibility and quality. The course included four units. Three units with theoretical foundations related to OERs (Unit 1: Inclusive Learning, Unit 2: Universal Design for Learning and Unit 3: Open Educational Resources). As part of Unit 3, teachers learned how to add an open license to their OERs in the ATutor LMS using a Creative Commons License. Unit 4 was about web accessibility and quality.
- ATutor LMS and the ATCE tool: ATutor LMS was the platform used to deliver the content of the training course on creating OERs and integrating the ATCE tool.
- Final questionnaire: The final questionnaire consists of two parts: questions from the LAAM (Learning Analytics Acceptance Model) instrument (Ali, Asadi, Gašević, Jovanović, & Hatala, 2013) and some open questions to collect the opinions the teachers had about the ATCE tool. The authors of LAAM suggest that the questions can be adapted according to the LA tool being assessed. Some open questions were also included in the questionnaire for gathering additional feedback about the functionalities of the ATCE tool such as the ATCE dashboard (comments about the dashboard), the ATCE web editor used for creating the web pages (comments about the web editor) and the ATCE evaluation module (comments about the evaluation module).

Participants

Initially, 35 Colombian university and school teachers volunteered to participate in this study, although only 19 teachers completed the study. The reason for this experimental mortality was that participants who dropped out of the study, stated that they did not have enough time to finish the activities in the research study.

According to the answers given to the initial questionnaire, all the participants have teaching experience in fields such as Arts, Accounting, Biology, English, Ethics, Informatics, Literature, Management, Math, Social sciences and Technology. In terms of ICT use and experience, the teachers had participated in courses related to: how to use a computer (74%), Microsoft Office tools (89%), management of virtual learning environments (32%), creation of web pages (58%), inclusion of ICT in education (21%) and web accessibility (16%). Besides that, all the participants
reported that they had participated in at least one activity related to the creation of educational resources: they had asked experts for help (42%), organized the content by themselves (74%), created the content by themselves (53%), shared the content with others (53%), used a methodology to create the educational resources (5%), used a license to share educational resources (5%), published resources on the Internet (11%), evaluated web accessibility (5%) or evaluated content quality (26%).

The teachers participated as authors and evaluators of OERs, while the researchers of this study participated as experts by carrying out additional evaluations of the OERs created and verifying the evaluations carried out by teachers.

Procedure

Figure 8 depicts the research design to answer RQ1 and RQ2. The evaluation process encompassed five phases in which the teachers participated as OER authors and evaluators. The teachers took part in a training course on the creation of OERs during phases 2 and 3. In all the phases, the participants used the web editor and evaluation module of ATCE. In phase 5, both authors and evaluators used the ATCE dashboard. For measurements 1 and 2, an expert used the ATCE verification module to verify how well the teachers had created and evaluated the OERs (in phases 4 and 5).

The activities carried out in the evaluation process are described as follows:

- **Initial questionnaire**: At the beginning of the evaluation process, teachers were asked to answer the initial questionnaire.
- **Creation phase 1**: Before starting the training course, each teacher in their role of author was asked to create an OER (OER1i, where i identifies the author) as a virtual course in the ATutor LMS using the ATCE web editor.
- **Evaluation phase 1**: Each teacher, in their role of evaluator, was asked to evaluate the web accessibility and quality of an existing OER (evaluation_OER) entitled, The Kingdoms of Nature using the ATCE evaluation module.
- **Training course part**: The teachers were asked to read the first three units of the training course: (1) Unit 1: Inclusive Learning, (2) Unit 2: Universal Design for Learning and (3) Unit 3: Open Educational Resources.
- **Creation phase 2**: After reviewing the aforementioned units, each teacher in their role as author, was asked to create a new OER (OER2i, where i identifies the author) using the ATCE web editor.
- **Evaluation phase 2**: Each teacher, in their role as evaluator, was asked to once again evaluate the web accessibility and quality of the evaluation_OER. By this stage, the teachers possessed more knowledge on what criteria to consider when evaluating the web accessibility and quality of the OER.
- **Training course part 2**: The teachers were asked to read Unit 4: Web accessibility and quality.
- **Creation phase 3**: After reading Unit 4, teachers were asked to develop some exercises focused on creating accessible contents using the ATCE web editor. To do these practical exercises each teacher created another OER (OER3i).
- **Creation phase 4**: Each teacher, in their role as author, was asked to continue editing the OER2i created in creation phase 2.
- **Evaluation phase 4**: Each teacher, in their role as evaluator, was asked to once again evaluate the web accessibility and quality of the evaluation_OER.
- **Measurement 1**: An expert used the ATCE evaluation module to evaluate the OERs edited by the teachers in creation phase 3 and the ATCE verification module to verify the evaluations made by teachers in evaluation phase 4.
Figure 8: Phases of the research design

[Colour figure can be viewed at wileyonlinelibrary.com]
• Creation phase 5: The teachers were introduced to the ATCE dashboard. After that, each teacher in their role as author, was asked to continue editing OER2i but this time using the ATCE web editor and the information provided through the author’s view of the ATCE dashboard.
• Evaluation phase 5: The teachers were asked to participate in a peer-review process in which each teacher assumed the role of evaluator and evaluated an OER created by another teacher (OER5ij, where i identifies the evaluator and j the OER’s author) using the ATCE evaluation module and the feedback provided in the evaluator’s view of the ATCE dashboard.
• Measurement 2: An expert evaluated the OERs edited by the teachers in creation phase 4 and also verified the evaluations made by the teachers in evaluation phase 4.
• Final questionnaire: The teachers were asked to answer the final questionnaire with questions based on the LAAM instrument and some open questions.

Data analysis
The methods used to analyze the data to answer the two research questions are described as follows:

RQ1: Does the use of the ATCE dashboard benefit teachers in the acquisition of competences in the creation and evaluation of OERs?

The dependent variables for RQ1 are:
• Accessibility (creation): This variable shows how well authors can create accessible OERs in terms of their competence level (from 0 to 100).
• Quality (creation): This variable shows how well authors can create quality OERs in terms of their competence level (from 0 to 100).
• Accessibility (evaluation): This variable shows how well evaluators can evaluate the web accessibility of OERs in terms of their competence level (from 0 to 100).
• Quality (evaluation): This variable shows how well evaluators can evaluate the quality of OERs in terms of their competence level (from 0 to 100).

To answer RQ1, the results obtained in measurements 1 and 2 were compared, considering the dependent variables. A t test was applied to compare the variables with a normal distribution and the Mann–Whitney U test for those with a non-normal distribution. The Excel tool was used to organize the data collected, the RStudio tool to carry out the statistical tests and the G*Power tool to calculate the effect size and power.

RQ2: What are the perceptions teachers have about the use of the ATCE tool?

To answer RQ2, the answers given by the teachers to the final questionnaire were analyzed. Mean and standard deviation were calculated for the answers given to the questions of the LAAM instrument and a qualitative description was applied for the answers given to the open questions. The Excel tool was used to organize the data collected and to calculate the descriptive statistics.

Results and discussion
On the one hand, this section presents general results about the web accessibility and quality of the OERs created by teachers and, on the other hand, results from both RQ1 and RQ2.

Overview of web accessibility and quality
Figure 9 shows results of web accessibility of OERs in the second expert evaluation. The level of web accessibility by type of HTML element varies between 79% and 98%.
Since web accessibility was addressed using the WCAG guidelines, the level of accessibility for each one of the three WCAG principles considered in the ATCE tool (Perceivable, Operable and Understandable) was also analyzed. The robust principle was not included here because criteria in this principle are related to the HTML source code of the web pages and the teachers do not work directly with the source code of the web pages. Figure 10 shows the level of web accessibility reached for each principle. These results revealed that the web accessibility of the OERs still need to be improved but the level obtained in each principle was good (higher than 75% in all three principles).

Figure 11 shows the results for the OERs’ level of quality. These results represent the rounded average value of stars obtained by each OER in all the quality items. According to these results, most OERs created in creation phase 4 reached between 4 and 5 stars. These results suggest that the level of quality in most of the OERs was good (3 to 5 stars) with and none of them obtaining 1 or 2 stars.

At the end of the evaluation process, the ideal situation would be that, in the last measurement, all the OERs reached 100% in the level of accessibility and 5 stars in the quality rating for all OERs. That said, the results for the accessibility by type of HTML element and by WCAG principle revealed a good level of web accessibility (higher than 75%) and, in terms of quality, the OERs obtained a good level with 4 and 5 stars for almost all of them.

RQ1: Teacher Competences in the Creation and Evaluation of OERs
The results obtained from the measurements 1 and 2 revealed that teachers’ competences in OER creation and evaluation improved. Data used for answering RQ1 come from measurements...
carried out in the evaluation process before teachers used the ATCE dashboard (measurement 1) and after they used it (measurement 2). The results for RQ1 were calculated based on statistical tests conducted for each of the four dependent variables defined and are described as follows:

- **Accessibility (creation):** Data collected about how well authors can create accessible OERs in measurement 1 (ACM1) and measurement 2 (ACM2) was normally distributed according to the Shapiro–Wilk test with \( p > 0.05 \) (ACM1 \( p = 0.08746 \); ACM2 \( p = 0.569 \)). The standard parametric \( t \) test was used to identify if there was any difference when teachers did not use the ATCE dashboard (ACM1) and when they did use it (ACM2). Results from the \( t \) test revealed that the level of web accessibility in ACM2 (\( M = 85.46 \); \( SD = 4.19 \)) was significantly higher than in ACM1 (\( M = 65.98 \); \( SD = 4.19 \)), with \( t(18) = -6.0638, p < 0.05 \). The effect size was large, Cohen’s \( d = 1.43 \), and the Power was 1.

- **Quality (creation):** Data collected for how well authors can create quality OERs in measurement 1 (QCM1) and measurement 2 (QCM2) was not normally distributed according to the Shapiro–Wilk test with \( p < 0.05 \) (QCM1 \( p = 0.003226 \); QCM2 \( p = 0.02163 \)). The Wilcoxon signed-rank test was used to identify if there was any difference when teachers did not use the ATCE dashboard (QCM1) and when they did (QCM2). Results from the Wilcoxon test revealed a significant difference between QCM1 and QCM2: \( V = 0, p < 0.001 \). The sum of ranks assigned to the differences with positive sign 0, and the sum of ranks with negative sign was 210. The effect size was large, \( r = 3.65 \), and Power was 1.

- **Accessibility (evaluation):** Data collected for how well evaluators evaluated the web accessibility of the OERs in measurement 1 (AEM1) and measurement 2 (AEM2) was normally distributed according to the Shapiro–Wilk test with \( p > 0.05 \) (AEM1 \( p = 0.9362 \); AEM2 \( p = 0.2351 \)). The standard parametric \( t \) test was used to identify if there was any difference when teachers did not use the ATCE dashboard (AEM1) and when they did use it (AEM2). Results from the \( t \) test revealed that the level of web accessibility in AEM2 (\( M = 79.99 \); \( SD = 10.16 \)) was significantly higher than in AEM1 (\( M = 68.97 \); \( SD = 11.47 \)), with \( t(18) = -5.1136, p < 0.05 \). The effect size was large, Cohen’s \( d = 1.11 \), and the Power was 1.

- **Quality (evaluation):** Data collected for how well evaluators evaluated the quality of the OERs in measurement 1 (QEM1) and measurement 2 (QEM2) was not normally distributed according to the Shapiro–Wilk test with \( p < 0.05 \) (QEM1 \( p = 0.001224 \); QEM2 \( p = 0.0002435 \)). The Wilcoxon signed-rank test was used to identify if there was any difference when teachers did not use the ATCE dashboard (QEM1) and when they used it (QEM2). Results from the Wilcoxon test revealed a significant difference between QEM1 and QEM2: \( p < 0.001 \). The sum of ranks
assigned to the differences with positive sign 0 and the sum of ranks with negative sign was 153. The effect size was large, \( r = 1.74 \), and Power was 1.

Differences observed in the two measurements were positive and statistically significant. These results suggest that teachers might benefit from using the ATCE dashboard because their competences improved after they used the feedback provided through the dashboard. These results are consistent with the findings of other studies that found feedback from dashboards guides users in their progress and performance in learning activities (Aljohani & Davis, 2013; Corrin & de Barba, 2014; Na & Tasir, 2017).

RQ2: Teacher Perceptions on the Use of the ATCE Tool

The results from the answers given by teachers \( (N = 19) \) for both parts of the final questionnaire (LAAM instrument and open questions), revealed the positive perceptions the teachers had toward the use of the ATCE tool.

Table 1 shows the descriptive statistics for the answers given to the LAAM instrument. The possible answers for each question range from 1 to 5, where 1 indicates very low agreement with the statement and 5 indicates very high agreement. It is important to note that Q8 is a reverse question, which means that the question is a negatively worded question and the numerical scoring scale runs in the opposite way. For the Q8, the result obtained in the mean score (2.17) is equivalent to 3.84 so that it can be compared to the other questions.

The mean scores of all the questions in the questionnaire were greater than 3. Overall, this indicates that participants reported positive perceptions on the use of the tool. The highest score among the questions was 4.84 in Q1a. This result suggests that the information presented in the accessibility section of the Author’s view of ATCE, seems to be the most remarkable feature of the tool which is related to the web accessibility of OERs. The lowest scores were in Q8 (3.84) and Q13 (3.84). A potential explanation for this result might be that some of the teachers may have used other similar tools which are more intuitive in feedback provisioning and less overwhelming. This might suggest that some teachers did not fully understand the visualizations and information presented in the dashboard. However, in the comments they gave to the open questions, the teachers seemed to be satisfied with the information presented in the dashboard.

Qualitative feedback on the use of the ATCE tool was gathered through the comments provided for each of the open questions included in the final questionnaire, main comments from teachers are described next and a complete description of this qualitative feedback is presented in the supplementary material:

- Comments about the dashboard: The dashboard allowed teachers to “… observe the evolution of the creation process”, and that “the analytics dashboard is an ideal and excellent tool with which to obtain data that allow us to improve the quality of our resources”.
- Comments about the evaluation module: The evaluation module served to help teachers improve as OER evaluators (eg, “at the beginning for me it was difficult to understand some questions or categories presented in the evaluation module but little by little I was able to understand them”).
- Comments about the ATCE web editor: Teachers found the web editor to be an adequate support tool to improve the OER’s web accessibility (eg, “an excellent tool that allows us to improve the webpages of the OERs and also to improve their accessibility”).
<table>
<thead>
<tr>
<th>Category</th>
<th>Questions in the questionnaire</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived value of visualizations presented in the ATCE dashboard</td>
<td>Q1a: I use the information presented in the accessibility section of the Authors view of ATCE as feedback to support my process as an author of OERs</td>
<td>4.84</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td>Q1b: I use the information presented in the quality section of the Author’s view of ATCE as feedback to support my process as an author of OERs</td>
<td>4.58</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td>Q1c: I use the information presented in the Evaluator’s view of ATCE as feedback to support my process as an evaluator of OERs</td>
<td>4.58</td>
<td>0.51</td>
</tr>
<tr>
<td>Perceived usefulness (usage belief) of the tool for improving the OERs’ web accessibility and quality</td>
<td>Q2: ATCE enables me to gain insight into my process in the creation and evaluation of OERs</td>
<td>4.74</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>Q3: The information ATCE provides helps me identify what needs to be improved in my OERs</td>
<td>4.68</td>
<td>0.48</td>
</tr>
<tr>
<td></td>
<td>Q4: ATCE provides relevant information regarding the accessibility and quality of my OERs</td>
<td>4.47</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td>Q5: The information provided by ATCE helps me determine how to improve in my role of author and evaluator of OERs</td>
<td>4.63</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>Q6: ATCE helps me identify the main accessibility and quality issues in my OERs</td>
<td>4.68</td>
<td>0.48</td>
</tr>
<tr>
<td>Perceived GUI (ease of use) of the tool</td>
<td>Q7: ATCE’s GUI (Graphical User Interface) is intuitive enough</td>
<td>4.37</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>Q8: ATCE’s GUI is overburdened with information. (reverse question)</td>
<td>2.17 (3.84)</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td>Q9: ATCE’s GUI has a good design</td>
<td>4.37</td>
<td>0.50</td>
</tr>
<tr>
<td>General perception of the tool</td>
<td>Q10: All in all, I found ATCE a handy tool for feedback provision</td>
<td>4.63</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>Q11: I would like to be able to use ATCE in my teaching practice</td>
<td>4.74</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>Q12: ATCE provides me with more useful feedback than other similar tool(s) that I have used/tried</td>
<td>4.21</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>Q13: ATCE is more intuitive than the other tools capable of feedback provision that I have used/tried</td>
<td>3.84</td>
<td>0.83</td>
</tr>
</tbody>
</table>
Our observations are in agreement with prior research on teachers’ behavioral intentions when using a LA tool (Papamitsiou & Economides, 2015) because the information provided through the tool was perceived by the users as useful and easy-to-use and users declared their intention to use the tool in the future.

**Threats to validity**

There are some threats to validity of the evaluation conducted. While teachers learn about OERs and the use of the tool, they participated in different moments of creation and evaluation of OERs. Sometimes using the same OER. However, the measurements focused on what teachers did in the phase 4 (measurement 1) and the phase 5 (measurement 2). On the one hand, for the creation process in phase 4 teachers improved the OER created in phase 2 (OER2i), which was not modified in phase 3. The OER was improved based on what they practiced and learned in previous phases. They did the same in phase 5 but focusing on the feedback given through the dashboard, which was used by teachers only in phase 5. On the other hand, the fact that teachers evaluated the same OER in phase 1, phase 2 and phase 4 made teachers to be more focused on what they needed to improve each time they evaluated the OER and this might have influenced the results obtained in measurement 1 for the competency of evaluating accessibility and quality of OERs. However, in phase 5 teachers evaluated a different OER considering the recommendations given through the evaluator’s view of the dashboard.

In relation to the LAAM instrument, the instrument was adapted in this study by considering the information given to teachers through the ATCE tool about their role as authors and evaluators of OERs. Since the evaluation was conducted in a Spanish speaking country, questions were translated into Spanish by a native speaker with English as a second language. Then, he and one more person discussed each translated question in order to verify their understandability. Then, another person translated the questions again into English to compare them with the original version of the instrument and make the corresponding revisions.

**Conclusions**

This study sought to analyze whether the ATCE tool helped teachers in their acquisition of creation and evaluation competences in the context of OERs, and to analyze the perceptions they had about using the ATCE tool. The general results from the evaluation of the ATCE tool suggest that the OERs created reached a good level of accessibility and quality. Moreover, the use of the ATCE dashboard furthered teachers in their acquisition of the competences and they also had positive perceptions about using the ATCE tool. The use of ATCE also allowed teachers to improve in their OER creation and evaluation competences. As authors, teachers were informed about how to improve the web accessibility and quality of their learning content and, as OER evaluators, they were informed about how to improve their evaluation in terms of web accessibility and quality.

As discussed by Navarrete and Luján-Mora (2017), people with disabilities are faced with barriers when they try to access OERs. They also state that one way to deal with this issue is to create authoring tools and learning contents that cope with such barriers. In line with this need, support tools like the one evaluated here can make teachers more aware of and can contribute to the creation of OERs with learning content that foster an equal access for all students.

Based on the study conducted, some benefits that can be highlighted in the use of LA in an authoring tool to create and evaluate OERs are:

- Storing the detail of each element added or modified in the OERs allows to better analyze the traces of activities done by teachers when creating and evaluating OERs.
• Supporting the manual evaluation with an automatic evaluation of web accessibility and quality drives better analyses of content elements that may present issues.
• Teachers are given with feedback about improvements needed for an OER (eg, in terms of web accessibility and quality) before it is delivered in real scenarios with students or in a public repository.
• The feedback is shown through visualizations in a dashboard that is updated as teachers add or modify contents.

Future work may involve an evaluation focused on teachers integrating their OERs into real scenarios, so as to observe the effect providing students with accessible and quality OERs has on their learning process. Another future research direction is to foster collaborative work among teachers and stakeholders in the creation and evaluation of OERs and the trace actions coming from such collaborative work.

Acknowledgements
Authors acknowledge to all teachers taking part in this process. Cecilia Avila and Ramon Fabregat acknowledge the support from the BCDS research group (ref. GRCT40), which is part of the DURSI consolidated research group Smart IT Engineering and Services (SITES) (ref. 2017 SGR-1551). Cecilia Avila had financial support under the grant BR2014 of the University of Girona. Silvia Baldiris acknowledges the support from the School of Engineering and Technology from the International University of La Rioja. Sabine Graf acknowledges the support from NSERC.

Statements on open data, ethics and conflict of interest
This research was approved by the Broadband Communications and Distributed Systems group from the University of Girona.

The involved participants were given with the informed consent for their participation in this study. Data can be accessed for research purposes upon request to the corresponding author.

No conflict of interest declared.

References


Learning analytics for creating and evaluating OER


Mishra, S., & Kanwar, A. (2015). *Quality assurance for open educational resources: What’s the difference? (Pre-print).*


Siemens, G., Gasevic, D., Haythornthwaite, C., Dawson, S., Shum, S. B., & Ferguson, R. (2011). Open learning analytics: An integrated & modularized platform Proposal to design, implement and evaluate an open platform...

**Supporting Information**

Additional supporting information may be found online in the Supporting Information section at the end of the article.